International Journal of Entomology and Nematology Research
Vol.2, No.1, pp.25-34, March 2018
Published by European Centre for Research Training and Development UK (www.eajournals.org)

A REVIEW ON SWEET POTATO BREEDING FOR QUALITY TRAITS

Yirga Belay

ABSTRACT: *Sweet potato is both a staple and a vegetable crop, containing a significant amount of proteins, provitamin A, B, and C and minerals such as Ca, Fe and Na. Both tuber and shoot can serve for human consumption, livestock feed and for the prevention of skin cancer, indicating the importance of this crop. The tuber is also used for the industrial production of starch, sugar and alcohol. Good quality sweet potatoes should be smooth and firm, with uniform shape and size, be free from mechanical damage, and have a uniform peel color typical of the variety. There are four U.S. Grades for sweet potato (U.S. Extra No. 1, U.S. No.1, U.S. commercial and U.S. No. 2), and grades are based on degree of freedom from defects (dirt, roots, cuts, bruises, growth cracks, decay, insects, and diseases), but also size and weight categories. Biofortification is technically feasible and breeding for micronutrient concentrations that can have biological impact, without compromising agronomic traits, has been demonstrated. There are three methods of breeding 1st Collecting, evaluating, and selecting from the local germplasm. 2nd Importing cultivars that have been bred in other parts of the world and evaluating them under your conditions.3rd breeding cultivars in your own Programme.*

KEYWORDS: Sweet Potato, Biofortification, Quality

INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) is among the important food crops in the world, after wheat, rice, maize, Irish potato, and barley and it ranks second following Irish potato in the world's root and tuber crops production and third after Irish potato and cassava in consumption in several parts of tropical Africa (Lenne', 1991 and Talekar, 1987). Sweet potato is both a staple and a vegetable crop, containing a significant amount of proteins, provitamin A, B, and C and minerals such as Ca, Fe and Na (Alvarex, 1986; Sorensen, 1987; Gass and Kekunze, 1990; Lenne', 1991). Both tuber and shoot can serve for human consumption, livestock feed and for the prevention of skin cancer, indicating the importance of this crop. The tuber is also used for the industrial production of starch, sugar and alcohol. In the tropics, sweet potato can be planted at any time of the year from vine cuttings which is not normally used for food and can be harvested from three to six months after planting (Talekar, 1987). Sweet potato (*Ipomoea batatas* (L.) Lam.) is one of the most important food crops in the world, especially in developing and undeveloped countries, where the sweet potato yields are the greatest. Sweet potato is enriched in vitamins, proteins and carbohydrates, and so represents good nutritional source. Appropriately, it is used widely a as a food, feed, source of starch and as a dietary supplement (Woolfe, 1992).

Sweet potato (*Ipomoea Batatas Lam)* is the seventh most important food crop in the world. It is grown in many tropical and subtropical regions. Among the world's major food crops, sweet potato produces the highest amount of edible energy per hectare per day (Horton and Fano, 1985) Among the root and tuber crops, sweet potato is the only one that has a positive per capita annual rate of increase in production in sub-Saharan Africa (Bashaasha and Mwanga, 1992). Because of its distinct properties, the use of sweet potato flour in the

Print ISSN: 2399-1151, Online ISSN: 2399-116X

preparation of bread is restricted. Most of the research results reported in this aspect found a substitution level of 10 – 15% for wheat flour on a dry weight basis as the most acceptable (El-sahy and Siliha, 1988) and when this proportion increased to about 20%, bread loaf volume significantly decreased (Kun-Lun, 2009). Options for the use of sweet potato in the formulation of different food products are numerous, and based on recent diagnostic assessments carried out in developing countries; dried chips, starch, and flour were identified as among the most promising (Collins, 1989).

Sweet potato is essentially a warm weather crop. However, its production occurs on a wide range of agro-ecologies. In Ethiopia, sweet potato was first established in lowland and mid elevation areas (Doku, 1989). It is planted in altitudes between 800 and 1900 m asl and also grows below and above the minimum and maximum altitude mentioned. Cooler temperatures, however, prolong the plant's vegetative cycle and tend to diminish yields. Optimal average growing temperature is about 25 oC, with well-distributed rainfall between 750-1250 mm (FAO, 1988). The best soil for sweet potatoes is sandy loam. Poorly drained, poorly aerated or saline soils tend to retard tuber development. Growth is best at the pH of 6; alkaline soils result in poor yields (Onwueme and Sinha, 1991). In most Ethiopia, Kenya, Tanzania, Madagascar, Angola, and southern Africa, the diet is based on grains, primarily maize. Sweet potato is an important secondary food crop. It is playscritical roles in rural diets in certain areas during shortage of grain crops like maize, when drought occurs. Most African households plant sweet potatoes as a food security or famine prevention crop. Sweet potatoes are viewed in this instance as a form of insurance in the event of drought, political turmoil, or other food supply-threatening events.

Sweet potato has been cultivated in Ethiopia for the last several years and over 95 percent of the crop is produced in the South west, eastern and southern parts, where it has remained for centuries as one of the major subsistence crops especially in the periods of drought (Adhanom*et al.*, 1985 and Endale*et al.*, 1992). In Ethiopia, sweet potato is widely grown on about 50,000 ha with an average yield of only 7 t/ha (Geleta, 1996). According to Geleta (1996), the reason for its low productivity in Ethiopia is low soil fertility, lack of agronomic packages especially plant nutrient management. In addition, poor seedbed preparation, the diverse and complex biotic, abiotic and human factors have contributed to the existing low productivity of sweet potato in Ethiopia. Some of the production constraints include lack of good quality planting materials, poor soil management practices, lack of suitable seedbed preparation, disease, insect pests, weeds and improper time of planting and harvesting (Enyi, 1977; Onwueme and Sinha, 1991).

Objective (1) to review sweet potato breeding methods for quality traits,(2)

METHODS OF SWEET POTATO BREEDING

General steps of sweet potato breeding

1st Collecting, evaluating, and selecting from the local germplasm.

2nd Importing cultivars that have been bred in other parts of the world and evaluating them under your conditions.

3rd Breeding cultivars in your own Programme

Print ISSN: 2399-1151, Online ISSN: 2399-116X

Breeding and multiplication of sweet potato

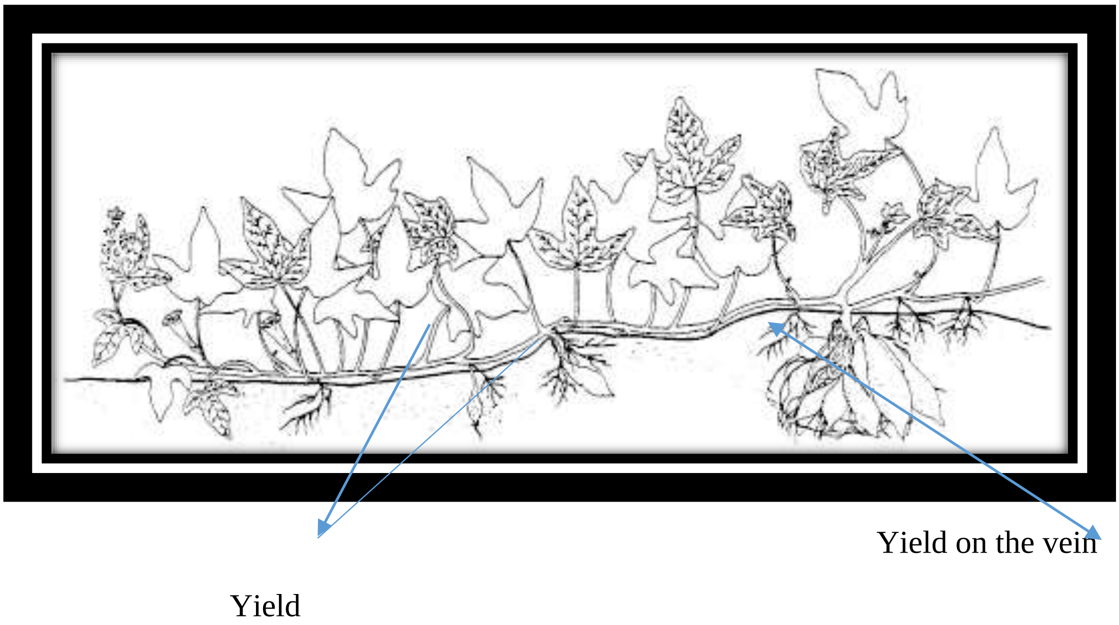
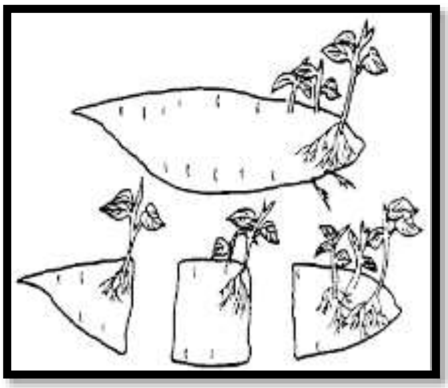
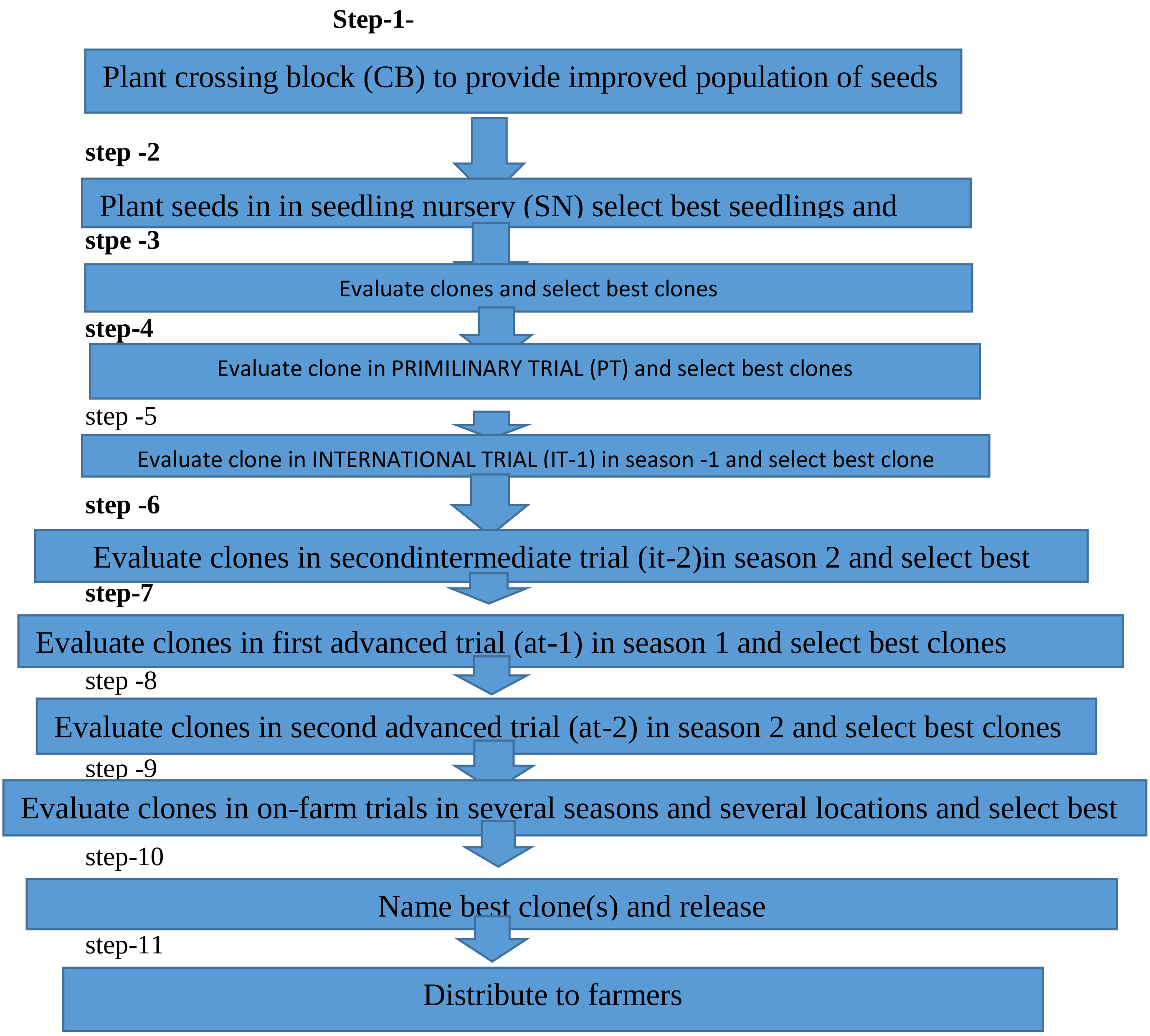


Figure:2-Sweet potato Multiplication



Steps in sweet potato breeding



Sources:- AGRO FACTS crops , IRETA Publications No__/89

Mutation breeding for quality trait

Mutation breeding can be used as a major approach in improving sweet potato varieties, since it is a clonally propagated crop. Irradiation-induced mutation breeding is effective in improving sweet potato characters such as yield, starch and soluble sugar content, carotenoids content of storage roots and disease resistance (Kukimura, 1986; Wang et al., 2007). Irradiation has also been successfully used for mutation breeding in various crops and ornamental plants (Song and Kang, 2003) and has proven an adept means of encouraging the expression of recessive genes and producing new genetic variations

(Schum, 2003; Song and Kang, 2003; Yoon et al., 1990). Sweet potato is a typical starch crop that is used as a foodstuff and, importantly, for industrial applications. In the present study, gamma irradiation mediated mutation breeding was applied to sweet potato to produce useful varieties having a high yield and high starch content. Irradiation-induced mutants were grown in the field and assessed for their starch and sugar characteristics.

Characteristics of good Quality of sweet potato and major sweet potato producing countries

Good quality sweet potatoes should be smooth and firm, with uniform shape and size, be free from mechanical damage, and have a uniform peel color typical of the variety. There are four U.S. Grades for sweet potato (U.S. Extra No. 1, U.S. No.1, U.S. commercial and U.S. No. 2), and grades are based on degree of freedom from defects(dirt, roots, cuts, bruises, growth cracks, decay, insects, and diseases), but also size and weight categories. It is essentially a warm weather crop. However, its production occurs on a wide range of agro-ecologies. In Ethiopia, sweet potato was first established in lowland and mid elevation areas (Doku, 1989). It is planted in altitudes between 800 and 1900 m.a.s.l. and also grows below and above the minimum and maximum altitude mentioned. Cooler temperatures, however, prolong the plant's vegetative cycle and tend to diminish yields. Optimal average growing temperature is about 25^{o}C, with well-distributed rainfall between 750-1250 mm (FAO, 1988).

Table 1 quality parameters of nine genotypes

Genotype	Crude fiber %	Ash content %	Fat content %	Crude protein %	Moisture content %	Carbohydrate
NRSP/05/3D	1.07	0.94	1.1	5.57	60.45	31.94
CIP440293	1.99	1.2	1.72	5.55	71.25	20.28
CIP440163	1.63	1.3	1.62	5.18	63.26	28.64
NRSP/05/022	1.47	1.3	1.2	3.94	60.73	32.83
CIP199004-2	1.04	1.5	1.32	5.39	64.82	26.97
NRSP/05/3B	1.29	1.3	1.36	5.18	64.12	28.04
Centennial	1.06	0.94	1.07	3.77	59.1	35.12
199034-1	0.67	0.5	1.61	6.94	60.74	30.21

Sources: **Omodamiro *et al.*, 2013**

Table -2: major sweet potato producing countries in the world

S/N	Country	Total production (ton)	Productivity(Tonnes /ha)
1	China	81175660 22.037	81175660 22.037
2	Uganda	2838000 4.577	2838000 4.577
3	Nigeria	2703500 2.896	2703500 2.896
4	Indonesia	2051050 11.327	2051050 11.327
5	United Republic of Tanzania	1400000 2.917	1400000 2.917
6	Viet Nam	1317060 8.716	1317060 8.716
7	India	1094700 9.207	1094700 9.207

Print ISSN: 2399-1151, Online ISSN: 2399-116X

8	USA	1081590 22.863	1081590 22.863
9	Angola	986563 5.796	986563 5.796
10	Burundi	966343 6.903	966343 6.903
11	Mozambique	920000 7.077	920000 7.077
12	Madagascar	919127 7.125	919127 7.125
13	Japan	863600 21.753	863600 21.753
14	Rwanda	840072 7.488	840072 7.488
15	Ethiopia	736349 9.013	736349 9.013

Source: (FAOSTAT, 2010).

BIOFORTIFICATION OF SWEET POTATO

More than half the world's population suffers from micronutrient malnutrition. Biofortification of staple food crops is a new public health approach to control vitamin A, iron, and zinc deficiencies in poor countries. Biofortification is the development of micronutrient-dense staple crops using traditional breeding practices and modern biotechnology. It has multiple advantages: it capitalizes on the regular daily intake of a consistent and large amount of the food staples that predominate in the diets of the poor, recurrent costs are low (germplasm can be shared internationally), it is sustainable, and it can reach undernourished populations in remote areas.

Increasing micro nutrient through breeding

There is potential to increase the micronutrient density of staple foods by breeding, and micronutrient density traits are stable across environments. In all crops studied, it is possible to combine the high micronutrient density trait with high yield, economically. For example, orange-fleshed sweet potato lines with high levels of β-carotene have been identified, and beans with improved agronomic traits and grain type and 50–70% more iron have been bred through conventional means. Transgenic approaches are in some cases necessary, or potentially advantageous, as for example, in the case of Golden Rice.

Adaptation of biofortification by farmers

The biofortification strategy requires widespread adoption by farmers. The visibility of the trait and infrastructural development are critical to adoption. Biofortified crops with visible traits willrequire that producers and consumers accept this change in addition to equivalent productivity and end-use features. Crops with invisible traits do not require behavior change, and thus productivity and improved end-use features will be important. Market networks and information flow will affect uptake once a new improved variety is released. Where infrastructure is strong, such as in Asia, uptake should be rapid; but where infrastructure is poor, such as in Africa, constraints to farmer adoption must be overcome.

Set of breeding target level

Retention of the nutrient following processing and cooking, bioavailability and nutrient requirements of target populations is needed to set breeding targets. For example, true retention ofB-carotene in a variety of orange fleshed sweet potato averages 80% after processing and cooking. The target level set will vary depending on whether people rely

Print ISSN: 2399-1151, Online ISSN: 2399-116X

upon the sweet potato as their sole source of β-carotene or if they eat a mixed diet. If children and women can consume up to 200 g and 400 g sweet potato each day, respectively, and if these daily intake levels supply 100% of EAR, the target breeding level would be 75 μg/g β-carotene (to provide 50% of the EAR would require a target of 37 μg/g β-carotene).

Studyingbiofortification cost effective or not

The largest cost in biofortification is the research to develop biofortified varieties at the outset. However, because an international agricultural research system is in place to develop modern varieties of staple foodstuffs, research costs are essentially the incremental costs of enhancing micronutrient density. Once biofortified varieties have been developed, implementation costs for in-country trials and local adaptation research are incurred, after which routine maintenance breeding will ensure the trait remains stable. Where there are no systems for disseminating modern varieties in place.

Addressing to end used

Biofortified crops must be incorporated into existing markets or new markets must be developed. One strategy is to facilitate dissemination of, and create demand for, biofortified crops by linking producers and consumers through product and market development. Diagnostic research can identify tools to encourage consumption of biofortified crops and develop strategies to achieve desired behavior changes in the production-marketing-consumption chain. Parameters will differ by crop and target area, and will be affected by the extent of trait visibility.

Figure 1. Sweet potato field (A), Fresh sliced sweet potato (B), Sample preparation (C), Frying of OFSP (D), OFSP fried chips (E) and fried white fleshed sweet potato chips (F).

Print ISSN: 2399-1151, Online ISSN: 2399-116X

Tuber of sweet potato breeding at field

SUMMARY

Sweet potato (*Ipomoea batatas*L.) is among the important food crops in the world, after wheat, rice, maize, Irish potato, and barley and it ranks second following Irish potato in the world's root and tuber crops production and third after Irish potato and cassava in consumption in several parts of tropical Africa. Sweet potato is both a staple and a vegetable crop, containing a significant amount of proteins, provitamin A, B, and C and minerals such as Ca, Fe and Na.Both tuber and shoot can serve for human consumption, livestock feed and for the prevention of skin cancer, indicating the importance of this crop. The tuber is also used for the industrial production of starch, sugar and alcohol.

Mutation breeding can be used as a major approach in improving sweet potato varieties, since it is a clonally propagated crop. Irradiation-induced mutation breeding is effective in improving sweet potato characters such as yield, starch and soluble sugar content, carotenoids content of storage roots and disease resistance. Irradiation has also been successfully used for mutation breeding in various crops and ornamental plants and has proven an adept means of encouraging the expression of recessive genes and producing new genetic. Sweet potato is a typical starch crop that is used as a foodstuff and, importantly, for industrial applications. In the present study, gamma irradiation mediated mutation breeding was applied to sweet potato to produce useful varieties having a high yield and high starch content. Irradiation-induced mutants were grown in the field and assessed for their starch and sugar characteristics. Three breeding of method 1st Collecting, evaluating, and selecting from the local germplasm. 2nd Importing cultivars that

Print ISSN: 2399-1151, Online ISSN: 2399-116X

have been bred in other parts of the world and evaluating them under your conditions.3rd breeding cultivars in your own programme.

Good quality sweet potatoes should be smooth and firm, with uniform shape and size, be free from mechanical damage, and have a uniform peel color typical of the variety. There are four U.S. Grades for sweet potato (U.S. Extra No. 1, U.S. No.1, U.S. commercial and U.S. No. 2), and grades are based on degree of freedom from defects (dirt, roots, cuts, bruises, growth cracks, decay, insects, and diseases), but also size and weight categories.

Biofortification is technically feasible and breeding for micronutrient concentrations that can have biological impact, without compromising agronomic traits, has been demonstrated. Predictive cost-benefit analyses show biofortification to be important for controlling micronutrient deficiencies.

REFERENCES

Collins, M. (1989).*Economic Analysis of Wholesale Demand for Sweet potatoes in Lima*, Peru, M.Sc.Thesis, Department of Agricultural and Resource Economics, University of Florida, Gainesville, USA.pp.1-164.

Doku, E.V., 1989. Root Crops in Ethiopia, In: M.N. Alvarez and S.K. Hahn (ed). Root Crops and Low Input Agriculture: Helping to meet food self-sufficiency goals in eastern and Southern Africa.

El-sahy, K.M. and Siliha, H. (1988). Use of sulphite treated sweet potato flour in manufacturing of wheat bread. *GetreideMehl and Brot.* 42 (7): 215-217.

Endale, Taboge, Geleta, L, Mulugeta, D. And Terefe, B. 1992. Improvement Studies on Ensete and Sweet Potato. Pp. 63-74. In: Horticultural Research and Development in Ethiopia. Proc second. Natl. Hort. Workshop of Ethiopia, 13 Dec., 1992. Addis Ababa, Ethiopia.

Enyi, B.A.C., 1977. Growth, Development and Yield of Some Tropical Root Crops. Dec., 2-29th. 1973. pp 87-97. Ibadan, Nigeria.

FAOSTAT (2010). Statistics division. FAO. http://faostat.fao.org/site/612/default.aspx#ancor (accessed 10 June 2016).

Food and Agricultural Organization of the United Nations (FAO), 1988. Root and Tuber Corps, Plantains, and Bananas in Developing Countries Challenges and Opportunities. Plant Production and Protection Paper No. 87. FAO, Rome, Italy.

Gass, T. and J. Lekunze, 1990. Cameroon National Potato and Sweet potato Survey Preliminary Report No.1 Phase1, North West Provinces. International Potato Center(CIP)/Institute of Agronomic Research (IAR). Bamenda, Cameroon.

GeletaLegese, 1996. Improved Technologies for Sweet Potato Production in Ethiopia. Research Achievements and Technology Transfer Attempts in Southern Ethiopia. pp 9-18. In:Proc. of the Second Tehcnol. Gener. Trans. And Gap Analysis Workshop,9-11July,Nazareth, Ethiopia.

Horton, D. and Fano, H. (1985). Potato Atlas, International Potato Center (CIP), *Lima, Peru.* p. 136.

Kukimura H (1986). Mutation breeding in sweet potato and tuber crops. Gamma Field Symp., 25: 109-130.

Print ISSN: 2399-1151, Online ISSN: 2399-116X

Lenne', J.M., 1991. Diseases and Pests of Sweet Potato: South east Asia, the pacific and east Africa. Natural Resources Institutes. Bulletin No. 46 Vii + 116pp.

Omodamiro et al.,2013. Acceptability and proximate composition of somesweet potato genotypes: Implication of breeding forfood security and industrial quality. International Journal of Biotechnology and Food ScienceVol. 1(5), pp. 97-101, December 2013ISSN: 2384-7344Research Paper.

Onweme, I.C. and T.D. Sinha, 1991. Field Crop Production in Tropical Africa: Principles and Practice, CTA. The Netherlands.

Schum A (2003). Mutation breeding in ornamentals and efficient breeding method. Acta Hort., 612: 47-60.

Song HS, Kang SY (2003). Application of Natural Variation and Induced Mutation in Breeding and Functional Genomics: Papers for International Symposium; Current Status and Future of Plant Mutation Breeding. Korean J. Breed. Sci., 35(1): 24-34.

Sorensen, K. A., 1987. Cultural, regulational and educational programs on the sweet potato weevil in the United States. *Insect Sci. Applic*. Vol.8: 825-830.

Talekar, N.S., 1987. Resistance in sweet potato weevil. Insect Sci. Applic. Vol. 8:819-823.

Wang Y, Wang F, Zhai H, Liu Q (2007). Production of a useful mutant by chronic irradiation in sweet potato. Sci. Hortic., 111(2): 173-178.

Woolfe JA (1992). Sweet potato: an untapped food resource. Cambridge University Press, Cambridge,UK.

Yoon KE, Park YH, Im BG (1990). Effect of gamma radiation on seed germination and androgenesis in *Nicotiana tabacum*L. Korean J. Breed. Sci., 21: 256-262.