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Evaluation Of High Altitude Orange Fleshed Sweetpotato (*Ipomoea Batatas*) Genotypes For Adaptability And Yield In Lowland Rainforest Ecology Of Umudike Southeastern Nigeria

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Abstract: *The orange fleshed sweetpotato (OFSP) which is so little known in Nigeria is extremely rich in bioavailable beta-carotene, which the body converts into vitamin A. As a result of the food benefit of OFSP, a full two year study was carried out at the experimental field of National Root Crops Research Institute-Umudike with the objectives to evaluate the yield and adaptability of the OFSP genotypes in Umudike rainfed forest agro-ecology of Southeastern Nigeria, to investigate the response of the foliage to sweetpotato virus disease and the response of the roots to sweetpotato weevils and nematode diseases and pests prevalent in the rainfed forest agro-ecology of Nigeria. The experimental design was randomized complete block design replicated 3 times. Seven OFSP genotypes introduced from the highland areas of Uganda by the Sweetpotato breeding unit of National Root Crops Research Institute- Umudike plus one national check variety were used in the study. Data collected on total root number, large root number, percentage small root number, total root yield, large root yield, response of root to sweetpotato virus disease, root weevil and nematodes were statistically analyzed and means separated using standard error of difference means. Results obtained indicated that none of the OFSP varieties yielded more than the standard check variety. The consistent high percent small roots indicated that the OFSP were not adaptable to the high virus pressure of Umudike, in the rainfed agro-ecology of Southeastern Nigeria. Based on the nutritive quality of higher beta- carotene fleshed colour of orange which was an improvement over the standard check variety 87/0087 (which has cream fleshed colour), the following varieties: Centinnial, 440293 and Shaba were selected for multilocational evaluation across the agro-ecologies to select areas their performance is location specific before final release to farmers.*

Key word*: OFSP, highland, lowland rainforest, evaluation, adaptability*

I. Introduction

Nigeria is the second largest Sweetpotato producing country in the sub-Saharan Africa behind Uganda. Sweetpotato is a vegetatively propagated crop grown in a 4-6 month cropping cycle, starting each cropping cycle by planting cuttings. The root fresh colour varied from white, yellow, and pink to orange. The orange fleshed colour is so little known in Nigeria. The orange fleshed sweetpotato is extremely rich in bioavailable beta-carotene, which the body converts into vitamin A (retinol) at a ratio of 12 to 1. According to Sweetpotato knowledge (2012), one small root (100- 125 grams) of most Orange Fleshed Sweetpotato (OFSP) varieties can supply the recommended daily allowance of vitamin A for children under five years of age. In addition, OFSP contributes significant amount of vitamins C, E, K and several B vitamins. The leaves also have good micronutrient contents and adequate protein (4%) for use as food and animal feed. Sweetpotato is also a good source of dietary fiber (2.5 - 3.3g/100gm), and is classified as a low glycemic index food (Sweetpotato knowledge, 2012). Generally, sweetpotato can be produced at relatively lower cost than yam and cassava (Kimber, 1970). The OFSP roots can be processed into different bakery products and the orange colour attracts consumers. Women in particular can make significant profit from selling sweetpotato products, and higher female income translates into better household nutrition and welfare. Population increase and high rate of urbanization have given rise to the need for inexpensive but healthy foods for the urban poor and created concurrent demand for fast food outlets and healthier foods by a growing middle class. The nutrition advantage of OFSP offers a unique opportunity to promote increased marketing and processing of sweetpotato, which will boost demand and ultimately produces incomes (Sorene, 1970).

OFSP can substitute for potato in making chips and crisps and serve as a partial substitute (20 - 50%) for wheat flour in bakery products. OFSP products have a golden colour that make it easy for marketing campaigns thus increasing demand. All classes of farmers can grow and invest in fresh root products and marketing of OFSP.

According to WHO (2011), every year an estimated 861,000 Nigerian children die before the age of 5. Over a third of these deaths are attributed to under nutrition. Forty - one percent of children under five years are stunted. Infant and young child feeding is characterized by low rates of exclusive breastfeeding, poorly timed introduction of complementary foods and a high prevalence of deficiency of essential micronutrients (vitamin A Zinc and Iron). Almost 30% of pre-school aged children in Nigeria are deficient in vitamin A a micronutrient

that helps young children grow and develop normally and stay healthy. Women of childbearing age, food insecure and HIV/AIDS affected households are also at high risk of vitamin A deficiency (VAD) (Walter *et al*, 1992).

Vitamin A deficiency (VAD) contributes to significant rates of blindness, diseases and premature deaths in Sub-Saharan Africa (SSA). Young children and pregnant or lactating women are particularly at risk of VAD (IFPRI, 2009). As a result of the food benefit of OFSP, the challenge is to introduce the beta-carotene rich varieties and promote their production, uptake and consumption. Based on this, Seven OFSP genotypes were introduced from the highland areas of Uganda by the Sweetpotato breeding unit of National Root Crops Research Institute- Umudike with the objective to evaluate the yield and adaptability of the OFSP genotypes in Umudike rainfed forest agro-ecology of Southeastern Nigeria. Other related objectives include investigating the response of the foliage to sweetpotato virus disease and the response of the roots to sweetpotato weevils and nematodes diseases and pests prevalent in the rainfed forest agro-ecology of Nigeria.

II. Materials and methods

The study was conducted at the western experimental farm of National Root Crops Research Institute Umudike, Nigeria during the 2009 and 2010 cropping season. Umudike lies in the humid tropical rainforest zone of Nigeria between longitude 7^0 32'E and latitude $5^0$22'N of the equator with elevation of 122 meters above sea level and annual rainfall that ranges from 1800mm to 2200mm.

The soil is described as acid sandy loam in the ultisol group. The Orange fleshed varieties for this experiment were obtained from highland areas of Uganda through the sweetpotato breeding unit of National Root Crops Research Institute, Umudike. The varieties used were 199004-1, Ex-Onyunga, 440293, 199004.2, SPK004, Centinnial, Shaba, and one check variety TIS87/0087.

The site for the experiment was slashed, manually stumped, disc ploughed, harrowed twice and ridged 1.0m apart. The experiment was then laid out in a randomized complete block design and replicated three times. Each block consisted of 8 plots. Each plot had 30 plants in the three rows with between row spacing of 1.0m while within row spacing was 0.3m. Symptomless vine tip cuttings and middle vine cuttings of 30cm long were used as planting materials. Vine cuttings were stored for two days before planting. This induces sprouting and better establishment. Planting was done in two seasons 2009 and 2010 and in the month of May when there was adequate moisture in the soil. About 5cm length of the vine was buried into the crest of the ridge to leave only the tip exposed. One vine cutting per planting point on the ridge.

The plots were kept weed-free by manual hoeing and hand-pulling of over grown weeds towards harvesting period. Application of NPK 15:15:15 fertilizer at 400kg/ha by side placement was carried out at 4 weeks after planting.

The trial was harvested at 4 months after planting and data were recorded on: total root weight, Large root weight, and small root weight, total number of roots, Large number of roots, and small number of roots. Percent Dry matter content was computed using the following formula:

$$\frac{\text{Dry matter} \times 100}{\text{Fresh weight} \quad 1}$$

Incidences and severity response of the foliage to sweetpotato virus diseases (SPVD), and root response to sweetpotato weevils and nematodes were recorded using severity rate scale of 1 to 5. 1= no apparent damage, 2= very little damage, 3=moderate damage, 4= considerable damage, 5 = severe damage (Wilson *et al*, 1989).

Data collected were subjected to analysis of variance for each of the years and then combined. Mean separation was done using standard error of means.

III. Result and Discussion

Total Root Number.

In sweetpotato root number contributes to yield. The large root number plus the small root number make up the total root number. There was high significant {P<0.01) variation in the number of roots produced by the Orange fleshed Sweetpotato varieties in the two years and combined over the years. In 2009, the mean number of root ranged from 15.0 (Centinnial) to 49.0 (Ex-Onyunga) with mean of 25.89. In 2010, the least mean total number of roots was10.50 (440293), while the highest was 33.0 (SPK004) with mean of 15.62. The least mean total root number across the season was 14.25 (440293), while the highest root number was 39.50 (Ex-Oyunga) with mean of 23.99 (Table 1).

Large Root Number

The significant (P<0.05) variation in the number of Large roots produced by the Orange fleshed Sweetpotato varieties in 2009 ranged from 9.00 (Centinnial) to 22.60 (Ex-Oyunga) with a general mean of 15.06 number of roots. Also, in 2010 the least number of Large roots was 6.87 (87/0087) while the highest was 20.73

roots, with general mean of 10.48 roots. The least root yield across season was 7.00 (Centinnial) while the highest was 22.25(SPK004) with mean of 13.38 roots (Table 2).

Number of storage roots is one of the indices for selecting or rejecting a variety. Nwankwo (2008), in his work on yam reported that higher the number of Large tubers ('ware' tubers) per plant, the higher the yield per plant and that justifies the selection of this character for tuber yield in yam plants. This implied that number of roots per plant is a function of yield, and number of large roots in sweetpotatoes is an index for selection of the variety. Sweetpotato varieties with high percentage of small number of roots should be rejected (Table 4). According to Kimber (1970), cultivation treatment such as closer spacing and environmental factors results in a reduction in size of roots. However, consistent increase in the number of small roots over the years and to no real change in the proportion in root size in the total root number may lead to rejection of the variety. Based on this study, the high percentage of small number of roots in both seasons is an indication that the Orange fleshed varieties are not adaptable to the lowland rain forest agro-ecology of Southeastern Nigeria.

Total fresh root yield:

The result of the analysis of variance for each year and combined over the years indicated high significant ($P < 0.01$) genotype variation in total fresh root yield of the sweetpotato genotypes. The total mean root yield of the orange fleshed varieties in 2009 was 7.84t/ha. The highest yielded variety in 2009 was 15.40t/ha obtained from the check variety (870087) while the least yielded variety was 3.30t/ha (440293). Also in 2010, the mean total root yield was 7.77t/ha. The yields varied from 3.08t/ha (Ex-oyunga) to as high as 13.25t/ha (870087) a check variety. The mean total root yield for the two seasons indicated that the least yield was Ex-oyunga with the yield of 3.84t/ha. The check variety (87/0087) gave the highest yield of 14.33t/ha and was given the performance rank 1, followed by Centinnial with yield of 9.40t/ha and was given performance rank 2 while 199004.2 with yield of 9.26t/ha and was given performance rank 3 (Table 2). The mean total root yield of the introduced orange fleshed varieties (Centinnial with yield of 9.40t/ha, SPK 004 with yield of 8.98t/ha and 1990034.1 with yield of 5.85t/ha) were lower than that of the check variety (87/0087) (Table 2). However, their yields were found to be higher than the yield of Sweetpotato varieties in farmers' field in Nigeria. The yield in farmers fields ranges from 5.0 to 8.6t/ha (Agbo and Ene, 1994).

Large Root Yield

Large roots in Sweetpotato are those roots weighing above 100g or roots with diameter 4cm and above. They are consumable tuberous roots which can be sold in the market. The mean yield analysis indicated strong significant ($P<0.01$) variation in the mean large root yield of the orange fleshed sweetpotato varieties which indicated variations in yield among the genotypes. Yield variation ranges from 2.10 t/ha (199034.1) to as high as 10.10 t/ha (87/0087, a check variety), and with a general mean of 4.75t/ha in 2009. In 2010, yields varied from 2.43t/ha (1990034.1) to 8.05t/ha (87/0087, a check variety) with a general mean of 4.32t/ha (Table 3).

The mean large root yield in the two seasons showed that 199034.1 gave the least yield of 2.07t/ha. The highest yield was obtained from the check variety 87/0087 which was 9.08t/ha with performance rank 1, followed by Centinnial with yield of 4.97t/ha with performance rank 2, while 199004.2 gave the yield of 4.78t/ha with performance rank 3 (Table3). The large root yield of some of the introduced orange fleshed varieties fall within range of what is obtained in farmers' field (Agbo and Ene, 1994) (Table 3). Indicating that the introduced varieties do not have yield advantage over the locally cultivated varieties.

Dry Matter Content

In sweetpotato the dry matter content is most preferred by both farmers and consumers and this determines the marketability and adoption of any variety (Gad and George, 2009). The percentage dry matter content ranged from 13.30% (199044.2) to 31.19% (Shaba) with mean of 24.70% for all the varieties. The variety Shaba had the highest dry matter content (31.19%) of all the varieties evaluated. This was followed by the check variety 87/0087 with 30.47% dry matter. Dry matter content of above 27% has been found to be acceptable to most consumers of Sweetpotatoes (Carey *et al* 1997). High dry matter content is an indication of high starch content for that particular variety.

Pests and diseases: The response of the Orange fleshed Sweetpotato varieties to the attack of pests and diseases showed that the severity scores for the two varieties (449293 and Centinnial) had a considerable heavy infestation of virus diseases (severity score 4) using rating scale for severity (Table 4). This was followed by Ex-Onyunga (severity score 4). Sweetpotato weevil at the time of harvest was mild in most varieties to moderately severe in Shaba (severity score 3) (Table 4). The attack of these pests and diseases might contribute to the low yield of these varieties. Loebenstein *et a*l (2009) reported that in China, on average, losses of over 20% due to Sweetpotato virus diseases were observed mainly due to Sweetpotato feathery mottle virus (SPFMV) and Sweetpotato latent virus (SPLV) and that the infection rate reaches 5 - 41%. The author further added that were

care is taken to provide virus tested planting material, yield increase markedly go up to seven times and more is obtained. Virus diseases are a major constraint for Sweetpotato production (Loebenstein *et al* 2009). Sorensen (2009) also in his work on Sweetpotato indicated that annual losses due to Sweetpotato weevil worth billions of dollars worldwide and damage range from 1-100%. As mentioned above, this might had contributed to the low yield of the introduced orange fleshed sweetpotato varieties. No symptom/attack of nematodes was observed in the roots of all the varieties. This indicated that the varieties are either resistant to the nematodes or not in the soil of the experimental sites.

IV. Conclusion

None of the Orange fleshed Sweetpotato varieties yielded more than the standard Check variety TIS 87/0087. The high percentage small number of roots of the introduced orange fleshed varieties is an indication that the Orange fleshed Sweetpotato varieties are not adaptable to the local environmental conditions of Umudike in the rainforest agro-ecology of Southeastern Nigeria. The high percentage of small roots in both seasons of the Orange fleshed sweetpotato varieties is an indication that the introduced OFSP from abroad found it difficult to adapt to the rainforest climatic conditions of Southeastern Nigeria. Local germplasm should be collected and hybridized with the exotic genotypes to obtain hybrids that can withstand the local climatic conditions.

Based on the nutritive quality of higher beta-carotene content, which is an improvement over the standard Check variety (87/0087), the following OFSP varieties: Centinnial, 440293 and Shaba have been selected for multilocational evaluation of their performance across various agro-ecological zones of the Country to select areas of low virus pressure before final release to farmers in the specific agro-ecologies.

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Table 1: Total mean number of roots and mean number of large roots in 2009 and 2010 and across seasons

Varieties	Mean total root number 2009	Mean total root number 2010	Mean total root number In the two seasons	Mean salable root number 2009	Mean salable root number 2010	Mean salable root number In the two seasons
199034.1	18.10	24.22	21.16	15.35	10.34	12.84
Ex-Oyunga	49.00	30.00	39.50	22.60	20.73	21.67
440293	18.00	10.50	14.25	8.70	8.63	8.67
199044.2	20.83	19.00	19.92	20.10	6.40	13.25
SPK004	29.83	33.00	31.42	17.20	17.30	22.25
Centinnial	15.00	19.00	17.00	9.00	5.00	7.00
Shaba	25.12	21.21	23.17	11.73	8.60	10.00
87/0087	31.00	20.00	25.50	15.80	6.87	11.34
mean	**25.89**	**15.62**	**23.99**	**15.06**	**10.48**	**13.38**
Std Error	11.15	10.11	10.61	9.22	7.56	7.81
CV%	34.50	36.02	17.85	10.60	11,70	8.10
Sig. level	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05	P<0.05

Table 2: Total mean root yield of the Orange fleshed Sweetpotato varieties in 2009, 2010 and combined over the years

Varieties	Mean total root yield t/ha 2009	Mean total root yield t/ha 2010	Mean total root yield t/ha In the two seasons	Performance rank for two seasons	Percentage dry matter content
199034.1	4.85	6.84	5.85	6	28.91
Ex-Oyunga	4.60	3.08	3.84	8	17.21
440293	3.30	4.34	4.34	7	18.76
199004.2	10.32	8.20	9.26	**3**	13.30
SPK004	7.90	10.05	8.98	4	21.90
Centinnial	8.45	10.35	9.40	**2**	28.77
Shaba	7.90	6.03	6.97	**5**	**31.19**
87/0087	**15.40**	**13.25**	**14.33**	**1**	30.47
mean	**7.84**	**7.77**	**7.87**		**24.70**
Std Error	4.05	3.75	7.50		-
CV%	6.84	6.92	9.80		-
Sig. level	P<0.01	P<0.01	P<0.01		-

Table 3: Mean large root yield of Orange fleshed sweetpotato varieties in 2009 and 2010 and combined over the years

Varieties	Mean large root yield t/ha 2009	Mean large root yield t/ha 2010	Mean large root yield t/ha In the two seasons	Performance Rank across season
199034.1	2.10	4.11	2.07	8
Ex-Oyunga	2.25	2.43	2.34	7
440293	3.00	4.02	3.51	6
199004.2	6.48	3.08	4.78	3
SPK004	5.02	4.30	4.66	4
Centinnial	5.45	4.49	4.97	2
Shaba	3.60	4.10	3.85	5
87/0087	10.10	8.05	9.08	**1**
mean	**4.75**	**4.32**	**4.41**	
Std Error	2.98	3.23	3.16	
CV%	CV%	5.73	4.52	
Sig. level	Sig. level	P<0.01	P<0.01	

Table 4: Percentage small root number of the OFSP and roots response to Sweetpotato virus diseases, nematodes and Sweetpotato root weevil in two seasons combined

Varieties	% Number of unsalable roots	Percentage dry matter content	Nematodes	SPVD	SP root weevil
199034.1	39.34	28.91	1	2.0	2.3
Ex-Oyunga	45.20	17.21	1	3.0	2.0
440293	39.20	18.76	1	4.0	2.0
199004.2	33.50	13.30	1	2.0	2.3
SPK004	29.20	21.90	1	1.0	2.3
Centinnial	58.80	28.77	1	1.0	1.0
Shaba	56.10	**31.19**	1	4.0	2.0
TIS87/0087	55.10	30.47	1	2.0	3.3
Mean	**39.43**	**23.81**			

NOTE:

SPVD = Sweetpotato virus disease s

SP weevil = Sweetpotato root weevil

Rating scale for severity:

1 = no apparent damage/not present

2 = very little damage/very few present

3 = moderate damage/number present

4 = considerable damage/number present

5 = severe damage/very high number present