PRELIMINARY EVALUATION OF SOME WHITE YAM (*Dioscorea rotundata* Poir) LINES FOR MORPHOLOGICAL CHARACTERS, YIELD AND RESISTANCE TO INSECT PESTS AND YAM LEAF MOSAIC VIRUS IN AKWA IBOM STATE, NIGERIA

Bassey[1], E. E., Nwankwo[2], I. I. M. and Eke-Okoro[2], O. N.

ABSTRACT

[1]Department of Crop Science, Faculty of Agriculture, University of Uyo, Nigeria. [2]National Root Crops Research Institute, Umudike, Nigeria. emmanuelessien@rocketmail.com; emmanuelbas_129@yahoo.com +2348024686153, +2349081333872

Field experiments were conducted in two locations, Itu and Uyo, Akwa Ibom State, Nigeria in 2016 cropping season to evaluate fourteen advanced guinea white yam (Dioscorea rotundata) lines vis-à-vis the national and local checks for morphological characters, yield and resistance to insect pests and yam leaf mosaic virus so as to identify superior ones for advancement to Uniform Yield Trial (UYT). The experiment was laid out in a randomized complete block design with three replications. Results indicated significant differences ($p<0.05$) in all the morphological characters and yield and yield components in both locations. Three advanced guinea white yam lines: 98/00933, 07/00168 and Obiauturugo were superior over the national (89/02665) and local (UL-A-1) checks in all characters studied as well as resistance to insect pests and yam leaf mosaic virus. The 98/00933 genotype was superior over others in eight characters, namely, tuber length (27.79 cm, 27.62 cm), number of ware yam per plot (4.36, 4.37), number of ware yam per hectare (2073.3, 2068.5), fresh weight of ware yam per plot (2.193 kg, 2.192 kg), fresh weight of ware yam (t ha^{-1}) (19.166, 19.158) and total fresh tuber yield (21.372 t ha^{-1}, 21.370 t ha^{-1}) and resistance to insect pests [(yam beetle (1) and leaf beetle (2)] and leaf mosaic virus (2), followed by 07/00168 in three characters, namely, circumference of tubers (20.72cm, 21.02cm), fresh weight of seed yam per plot (3.026kg, 3.025kg) and fresh weight of seed yam (6.052 t ha^{-1}, 6.050 t ha^{-1}), while Obiauturugo was superior in two, namely, fresh weight of seed yam per plot (2.666 kg, 2.664 kg) and fresh weight of seed yam (5.480 t ha^{-1},5.332 t ha^{-1}). The three yam lines could be advanced to the Uniform Yield Trial in the area.

Keywords*: Guinea white yam, morphological characters, yield, insect pests, leaf mosaic virus, resistance.*

INTRODUCTION

The guinea white yam (*Dioscorea rotundata*) belongs to the family, *Dioscoreaceae*, (Aighewi *et al*., 2001). It is considered to be indigenous to West Africa (Degras, 2000) and the Niger-Benue trough is pin pointed as the probable Centre of domestication (Hahn *et. al*., 1987). Yam is a major staple food in many tropical countries particularly West Africa, the Caribbean, South America, India, South East Asia and South Pacific (IITA, 2014). Yam is produced in 5 million hectares in about 47 countries in tropical and sub-tropical regions of the world (Nweke *et al*., 1991). It is also a cash as well as a socio-cultural crop in Nigeria. It is the only crop which is usually celebrated during and after harvest, called yam festivals (Ugwu, 1996). Yam is also highly regarded in Jamaican ceremonies and many West African countries. In many yam producing areas in Nigeria, "yam is food and food is yam''. Nigeria is the largest world producer of yam with more than 45.004 million tonnes annually and the largest consumer of yam (Ezulike *et al*., 2006), with Ghana (7.119 mmt), Cote d' Voire (5.808 mmt), Benin (3.220 mmt) and Ethiopia (1.448 mmt) (FAO, 2014) following that order. Yam may be barbecued, roasted, fried in oil, grilled, boiled, baked,smoked,pounded into paste (fofoo) or grated and produced into a dessert recipe. It may be cooked with rice, beans, plantain, sweet potato, lamb, chicken and butter nut as squash soup (Umar *et al*., 2006). It can also be boiled, roasted and eaten with oil, vegetable (Ubo) or sauce (IITA, 2004; Timothy and Bassey, 2009). The tubers may be peeled and sliced into tiny pieces and dried to very low moisture content and ground into flour and flakes (Udoh *et. al*., 2005). The tubers may be peeled and prepared into porridge with traditional spices and served to the sick and aged as appetizer (Nwankwo and Bassey, 2013).

Yam prices have been increasing in recent years because of a strong demand for the crop in Africa, and even in Europe and the United States of America where rapidly growing West African migrant communities still have a big appetite for their traditionally preferred staple. Nigeria exported US $27.7 million worth of yam to the United State of America in 2011. Average yam consumption per capital per day is highest in Benin (364 kcal) followed by Cote d'Ivoire (342 kcal), Ghana (296 kcal) and Nigeria (258 kcal) (IITA, 2009). Yields are about 11tha^{-1} on average in major yam producing countries of West Africa and 11-14 tha^{-1} in West Indies (Anuebunwa, 2002). However, higher yields of more than 29.6 t / ha under good management have been reported (Adeniji *et al*., 2001). Yam production i1s labour intensive and pest/disease incidence increases production costs and may reduce yields (Ugwu, 1996). Collaborative evaluation of IITA derived breeding lines with the National Root Crops Research Institute, Umudike, Nigeria and the Crop Research Institute, Ghana resulted in the release of ten varieties of *D. rotundata* between 2001 and 2009 in Nigeria and 1(one) in 2007 in Ghana. More lines have been released by research institutes in Nigeria, Ghana, Benin, Cote d'1voire, Sieria Leone, Togo and Liberia with

multiple pest and disease resistance, wide adaptability, higher yields and good organoleptic attributes (IITA, 2013). Therefore, the study was conducted to evaluate fourteen advanced guinea white yam lines vis-à-vis the national and local checks for morphological characters, yield performance and resistance to insect pests and yam leaf mosaic virus so as to identify superior ones for advancement to Uniform Yield Trial (UYT).

MATERIALS AND METHODS

This study was conducted in 2016 cropping seasons in two locations (Itu and Uyo) in Akwa Ibom State. The areas situate within latitude 15° 02′ north and longitude 07° 56′ east of the Greenwich meridian, and altitude 38m above sea level. It lies in the humid high rainfall area of southeastern Nigeria with average rainfall of over 2500mm per annum and mean daily sunshine of 3 hours, 31 minutes. The temperature is generally high, ranging from 23°C to 34^0C throughout the year. The average humidity is about 76 percent with the lowest and highest in January/December and July, respectively. The sites had fairly flat terrain. Soil samples were randomly collected using soil auger at depths 0-15cm and 15-30cm. The samples were air dried, crushed gently with wooden pestle in a porcelean mortar and sieved through a 2mm sieve. The samples were bulked and a representative sample of each site was analysed for physico-chemical properties as an aid to fertilizer application.

The treatments were sixteen guinea white yam genotypes. Fifteen (15) were advanced guinea white yam lines supplied by the National Root Crops Research Institute, Umudike, Nigeria for 2016 National Co-ordinated Trial, namely: 99AMO/XA, 89/02665 (National Check), 99/AMO/116, 98/00933, Nwakpoko, 07/00168, Obiauturugo, 99/AMO/109, Adaka, 99/AMO/095A, 99/AMO/114, 00606, 99/AMO/60, AME and 07/00033. A local genotype "Akpedu" UL-A-1obtained from Uyo yam farmers served as local check. The tubers of the yam genotypes were cut into minisetts of 40g; each genotype comprised 30 yam minisetts which were properly labeled and spread in a cool dry shed for two days before being taken to the field for planting (Timothy and Bassey, 2009; Ezulike *et al*., 2006). Each site required 480 minisetts and a total of 960 minisetts for the two experimental sites. Each experimental site measured 17 m x 16 m which was mechanically ploughed, harrowed and ridged 1 m apart and 0.5 m high.

The experiment was laid out in a randomized complete block design with three replications. Each ridge measured 5 m long and the blocks (replicates) were separated by 1 m paths. One yam minisett was planted per stand at 0.5 m by 1.0 m, giving 10 plants per ridge (plot) and 480 plants in one experimental site, equivalent to 20,000 plants per hectare. Staking was done 25 days after planting using the Indian bamboo which measured 2 m in height (Uguru, 2015). Weeding was done manually using the West African weeding hoe at 1, 3 and 5 months after planting. Fertilizer NPK (15:15:15) was applied 1 MAP at 400 kg ha^{-1}, 10cm away from the plant (NRCRI, 2016), using the ring method (Timothy and Bassey, 2009; Udealor and Ezulike, 2009). Four plants were tagged at the centre of each plot for data collection. Growth characters studied were stand count at harvest, vine length, number of leaves per plant, number of branches per plant and leaf area (cm^2). Leaf area was calculated as L x W x 0.43 (Rabi and Roy, 1989), where L = mean length of yam leaves, W = mean of widest portion of yam leaves, and 0.43 = the correction factor. Yield and yield components studied were tuber length (cm), circumference of tubers (cm), number of seed yam per plot, number of seed yam per hectare, fresh weight of seed yam per plot (kg), fresh weight of seed yam (t ha^{-1}), number of ware yam (above 1 kg) per plot, number of ware yam per hectare, fresh weight of ware yam (t ha^{-1}) and fresh tuber yield (t ha^{-1}).

Insect pest incidence and severity in-ground and above ground at 8 weeks after planting (WAP) were estimated using the scale:

1 = clean tubers;
2 = < 20% of each genotype (tubers) damaged per plot
3 = 21-50% of each genotype (tubers) damaged per plot
4 = 51-80% of each genotype (tubers) per plot damaged
5 = > 80% each genotype damaged per plot (NRCRI, 2016).

Similarly, disease severity of yam leaf mosaic virus (YLMV) was determined at 8 WAP, using the scale:

1 = No visible YLMV symptoms on all plants in the plots
2 = Very mild symptoms on susceptible/infected plants
3 = Moderate symptoms on infected plants
4 = Severe symptoms on infected plant, and
5 = Very severe symptoms on infected plants (NRCRI, 2016).

RESULTS AND DISCUSSION

Significant differences ($p<0.05$) were observed among the sixteen guinea white yam genotypes for all the characters studied. The highest number of leaves per plant for all the months and locations was produced by Obiauturugu, followed by Adaka, 89/02665 (national check), 07/00168 and 99/AMO/114, in that order while the lowest was from 99/AMO/109 (Table 1). Obiauturugo produced the longest vines followed by Adaka, 98/00933, 89/02665 and AME while the shortest vines were observed in 99/AMO/109 in all the months and locations. However, no significant difference in vine length was observed between 99/AMO/95A and 07/0033 (Table 2).

Similarly, significant differences were observed for number of branches per plant ($p<0.05$) among the yam genotypes. The highest number of branches was produced by 00604, followed by 99/AMO/109, 99/AMO/60, 07/00168, Obiauturugo, Nwakpoko, Adaka and 98/00933. However, 99/AMO/114, 99/AMO/116 and 89/02665 were not significantly different ($p<0.05$) in number of branches (Table 3).

Table 1: Number of Functional Leaves of Advanced Guinea White Yam Lines in Itu and Uyo, Akwa Ibom State, Nigeria

Yam genotype	Number of functional leaves per plant months after planting									
	1		2		3		4		5	
	A	B	A	B	A	B	A	B	A	B
UCL-A-1	0h	0h	55.13k	56.02k	86.88k	87.09k	102.73j	103.20j	102.94i	103.42i
99/AMO/XA	10.70d	11.02d	78.23i	78.56i	106.29i	106.84i	131.74h	131.89h	132.75h	132.74h
89/02665	20.73b	20.96b	208.33b	208.91b	246.95c	247.28c	266.69c	266.84c	269.47c	271.06c
99/AMO/116	8.30e	9.01e	48.46i	48.72i	69.00i	70.10i	97.73j	98.20j	97.38j	98.22j
98/00933	13.53c	13.68c	131.83g	132.40g	169.65g	169.86g	187.01f	187.96f	187.75f	187.98f
Nwakpoko	8.43e	8.69e	64.33j	64.80j	97.12ij	98.05ij	122.13i	122.68i	122.42i	122.72i
07/00168	45.50a	46.20a	191.53c	191.75c	229.08d	230.20d	248.33d	248.76d	248.98d	248.99d
Obiauturugo	21.33b	22.16b	216.76a	217.19a	267.88a	268.11a	297.42a	298.21a	297.98a	299.16a
99/AMO/109	11.40d	11.85d	32.50m	32.76m	55.52m	56.02m	76.55k	77.66k	76.71k	77.92k
Adaka	7.73e	8.17e	216.80a	217.10a	256.65b	256.76b	281.07b	282.40b	281.95b	282.72b
99/AMO/95A	5.26f	6.22f	159.86e	159.87e	170.96g	171.05g	190.91f	191.10f	191.22f	191.74f
99/AMO/114	11.20d	11.28d	144.86f	145.12f	198.76e	198.92e	208.10e	209.16e	208.71e	209.70e
00604	11.26d	12.11d	102.86h	103.16h	142.69h	143.28h	166.07g	167.11g	166.00g	167.45g
99/AMO/60	2.16g	3.04g	160.90e	161.03e	182.39f	184.22f	202.20e	203.28e	202.29e	203.82e
AME	2.73g	3.50g	62.80j	63.0j	93.45j	94.76j	120.02i	120.76i	120.66i	120.94i
07/00033	13.53c	13.65c	77.73i	78.05i	100.64i	101.22i	125.74h	125.98h	126.62h	126.76h

* A =Itu, B = Uyo; Means with the same letter(s) within a column are not significantly different ($p < 0.05$)

Table 2: Vine length of advanced guinea white yam lines in Itu and Uyo, Akwa Ibom State, Nigeria

Yam genotype	Vine Length (cm) Month After Planting									
	1		2		3		4		5	
	A	B	A	B	A	B	A	B	A	B
UL-A-1	4.70i	4.79i	36.24i	36.74i	86.14i	86.76j	117.46k	118.03k	118.59j	119.01j
99/AMO/XA	72.69b	73.18b	94.19e	94.85e	105.73i	106.20i	139.19j	139.72j	146.26h	146.68h
89/02665	65.76c	66.12c	107.94c	108.42c	148.09d	149.24d	206.86d	207.11d	210.40d	210.78d
99/AMO/116	46.58e	46.78e	68.02g	69.24g	108.03i	108.76i	186.92f	187.06f	189.60f	189.86f
98/00933	69.95b	70.36b	117.48b	118.06b	165.55c	166.10c	222.16c	222.75c	224.90c	224.98c
Nwakpoko	40.64f	41.22f	52.14h	52.94h	66.11i	66.82i	79.90m	80.22m	83.13i	83.62i
07/00168	57.52d	57.86d	74.94fg	75.42fg	112.32h	112.74h	136.97j	137.16j	141.96i	142.36i
Obiauturugo	78.29a	78.74a	164.29a	164.85a	232.41a	233.20a	296.36a	296.84a	298.82a	298.95a
99/AMO/109	25.27h	25.96h	39.01i	40.18i	45.18m	46.70m	69.06n	69.75n	70.12m	70.76m
Adaka	40.68f	41.40f	101.93d	102.24d	207.90b	208.10b	265.56b	266.20b	268.68b	268.98b
99/AMO/95A	22.06h	22.68h	81.81f	82.08f	141.49e	142.18e	176.23g	176.86g	178.68g	178.84g
99/AMO/114	46.31e	47.10e	90.58e	91.24e	125.35g	125.92g	165.40h	166.24h	167.00h	167.65h
00604	52.37d	52.84d	67.02g	67.86g	76.34k	77.08k	110.05i	110.86i	111.81k	111.92k
99/AMO/60	18.32hi	18.89hi	69.66g	69.84g	107.10i	107.80i	146.14i	146.73i	162.85h	162.86h
AME	31.53g	32.16g	78.76f	79.32f	149.72d	150.21d	194.57e	195.32e	194.82e	195.18e
07/00033	78.41a	78.69a	92.09e	92.65e	136.56f	137.03f	171.20g	171.90g	172.98g	172.99g

* A =Itu, B = Uyo; Means with the same letter(s) within a column are not significantly different ($p < 0.05$)

The sixteen guinea white yam genotypes showed significant differences ($p < 0.05$) for leaf area per plant throughout the months and locations. The largest leaf area per plant was produced by Adaka, followed by 99/AMO/109, 07/0033, 07/00168 and 98/00933 while the smallest leaf area per plant was found in UCL-A-1. However, no significant difference ($p < 0.05$) was observed between 07/00168 and 98/00933 for the character. Also, 99/AMO/116 and 89/02665 were not significantly different ($p < 0.05$) in leaf area per plant (Table 4).

The guinea white yam genotypes were significantly different ($p < 0.05$) for all the yield and yield components studied. The longest tubers were produced by 98/00933, followed by Adaka, 07/00168, Obiauturugo, 89/02665, 99/AMO/95^{A}, 00604 and 07/0033, while the shortest tubers were found in 99/AMO/109 and Nwakpoko. However, no significant difference ($p < 0.05$) was observed between 07/00168 and Obiauturugo for the character. Similarly, AME, 99/AMO/60, 99/AMO/XA and 99/AMO/116 were not significantly different ($p < 0.05$) in tuber length. Also, 99/AMO/114 and UL-A-1 were not significantly different in tuber length ($p < 0.05$). The guinea white yam genotypes were significantly different ($p < 0.05$) in circumference of tubers in both locations. The largest tuber circumference was produced by 07/00168, followed by Obiauturugo, 98/00933, 00604, 89/02665, Adaka and 99/AMO/95^{A}, while the smallest tuber circumference was produced by UL-A-1. However,

Obiauturugo and 98/00933 were not significantly different ($p < 0.05$). Similarly, significant differences ($p < 0.05$) were not observed among the yam genotypes 99/AMO/114, 99/AMO/109, 99/AMO/60, Nwakpoko, AME and 99/AMO/XA for circumference of tubers. Also, 99/AMO/116, and UL-A-1 were not significantly different ($p < 0.05$) in tuber circumference (Table 5).

Table 3: Number of Branches Per Plant of Advanced Guinea White Yam Lines in Itu and Uyo, Akwa Ibom State, Nigeria

Yam genotype	Number of branches per plant month after planting									
	1		2		3		4		5	
	A	B	A	B	A	B	A	B	A	B
UCL-A-1	0.0e	0.0e	1.93f	1.92f	7.70h	7.72h	16.25h	16.27h	16.25h	16.27h
99/AMO/XA	0.0e	0.0e	7.19e	7.20e	10.90g	10.84g	19.20g	19.22g	19.20g	19.22g
89/02665	5.93b	5.89b	8.0e	8.06e	19.16e	19.20e	27.48e	27.50e	27.48e	27.50e
99/AMO/116	4.06c	4.10c	16.70c	16.63c	17.23e	17.22e	26.25e	26.27e	26.25e	26.27e
98/00933	5.20b	5.16b	24.03ab	24.05ab	24.68c	24.70c	31.62c	31.65c	31.62c	31.65c
Nwakpoko	1.23d	1.40d	8.60e	8.56e	25.46c	25.44c	32.98c	32.96c	32.98c	32.96c
07/00168	3.73c	3.80c	27.13a	27.16a	28.00b	27.98b	35.20bc	35.30bc	35.20bc	35.30bc
Obiauturugo	7.53a	7.52a	25.28a	25.63c	25.64c	23.22c	33.20c	33.20c	33.22c	33.20c
99/AMO/109	3.30c	3.36c	8.70e	8.78e	30.63b	30.65b	37.46b	37.48b	37.46b	37.48b
Adaka	2.63cd	2.60cd	22.73b	22.70b	22.46c	25.48c	32.24c	32.25c	32.24c	32.25c
99/AMO/95A	0.0e	0.0e	14.76c	14.74c	16.26f	16.28f	25.91ef	25.90ef	25.91ef	25.90ef
99/AMO/114	4.40c	4.42c	15.32c	15.22c	19.53e	19.52e	27.96e	27.95e	27.96e	27.95e
00604	3.60c	3.64c	23.56ab	23.58ab	36.50a	36.48a	40.96a	40.94a	40.96a	40.94a
99/AMO/60	1.06d	1.17d	27.83a	27.85a	28.16b	28.16b	35.74b	35.72b	35.74b	35.72b
AME	2.20d	2.20d	6.76e	6.78e	15.50f	15.49f	24.92f	24.95f	24.92f	24.95f
07/00033	4.54b	4.55b	13.06d	13.02d	22.80d	22.78d	30.68d	30.66d	30.68d	30.66d

* A =Itu, B = Uyo; Means with the same letter(s) within a column are not significantly different ($p<0.05$)

Table 4: Leaf area (cm^2) of advanced guinea white yam lines in Itu and Uyo, Akwa Ibom State, Nigeria

Yam genotype	Leaf Area (cm^2) Month After Planting									
	1		2		3		4		5	
	A	B	A	B	A	B	A	B	A	B
UL-A-1	0	0	16.51g	16.50g	17.73i	17.72i	17.42i	17.41i	17.39i	17.38i
99/AMO/XA	16.56f	16.58f	34.20e	34.19e	30.35e	30.36e	28.35e	28.34e	28.32e	28.32e
89/02665	29.03e	29.36e	22.16f	22.18f	23.49b	24.48h	24.10f	24.08f	24.01f	24.03f
99/AMO/116	15.88f	15.90f	24.29f	24.28f	26.77g	26.79g	25.36f	25.37f	25.12f	25.14f
98/00933	12.30g	12.46g	36.37e	36.39e	42.95d	42.84d	40.17d	40.19d	40.03d	40.0d
Nwakpoko	3.11d	35.26d	32.60ef	32.62ef	24.80g	24.82g	22.46g	22.48g	21.96g	21.94g
07/00168	28.69e	28.71e	54.22b	54.21b	41.49d	41,48d	40.28d	40.26d	40.06d	40.02d
Obiauturugo	51.84b	51.87b	35.55e	35.57e	28.64f	28.62f	26.50ef	26.49ef	26.24ef	26.21ef
99/AMO/109	6.57h	6.59h	20.46f	20.45f	50.19b	50.20b	48.66b	48.58b	48.20b	48.21b
Adaka	16.98f	16.96f	50.92c	50.89c	54.50a	54.51a	52.25a	52.27a	50.18a	50.16a
99/AMO/95A	15.71f	15.76f	32.20ef	32.21ef	23.63gh	23.65gh	21.61g	21.68g	20.74g	20.69g
99/AMO/114	30.99e	30.84e	36.37e	36.38e	21.07h	21.05h	19.80h	19.78h	19.65h	19.64h
00604	47.11c	47.16c	47.32d	47.30d	28.17f	28.19f	27.06e	27.03e	27.0e	27.01e
99/AMO/60	2.49i	2.50i	22.08f	22.10f	31.51e	31.56e	29.18e	29.20e	29.12e	29.12e
AME	3.91i	3.92i	16.60g	16.56g	21.83h	21.76h	20.10gh	20.08gh	20.01gh	20.02gh
07/00033	59.26a	59.22a	59.89a	59.69a	46.91c	46.93c	43.75c	43.69c	43.46c	43.44c

* A =Itu, B = Uyo; Means with the same letter(s) within a column are not significantly different ($p < 0.05$)

Significant differences were observed among the guinea white yam genotypes for number of seed yam per plot, number of seed yam per hectare and fresh weight of seed yam per plot. The highest number of seed yam per plot was produced by 99/AMO/60, followed by AME, 99/AMO/XA,99/AMO/109, 07/00168, Adaka, Obiauturugo, 99/AMO/116, 89/02665 and 00604. Significant differences ($p < 0.05$) were not observed among the following yam genotypes: 99/AMO/60, AME and 99/AMO/XA. Similarly, 07/00168, Adaka, Obiauturugo, 89/02665 and 00604 were not significantly different in number of seed yam per plot. The number of seed yam per hectare produced by the yam genotypes followed a similar trend with number of seed yam per plot. The highest number of seed yam per hectare was produced by 99/AMO/60, followed by AME, 99/AMO/XA, 99/AMO/109, 07/00168, Obiaututrugo, 89/02665 and 00604, while the lowest seed yam was produced by UL-A-1 (Table 5). However, no significant difference ($p < 0.05$) was observed between 89/02665 and 00604 for number of seed yam per hectare.

The highest fresh weight of seed yam per plot (kg) was produced by 07/00168, followed by Obiauturugo, Adaka, 89/02665, 99/AMO/95A and 99/AMO/114 while the lowest fresh weight of seed yam per plot (kg) was found in 99/AMO/116. A similar trend was observed for fresh weight of seed yam (t/ha) with 07/00168 producing the

highest fresh weight of seed yam per hectare, followed by Obiauturugo, Adaka, 89/02665, 99/AMO/95[A], 99/AMO/114 while the lowest fresh weight of seed yam per plot was found in UL-A-1 (Table 5).

Table 5: Tuber length, circumference of tubers and seed yam characteristics of advanced guinea white yam lines in Itu and Uyo, Akwa Ibom State, Nigeria

Yam Genotype	Tuber length (cm)		Circumference of Tubers (cm)		No. of Seed Yam/Plot		No. of Seed Yam/ha		Fresh Weight of Seed Yam/Plot (kg)		Fresh Weight of Seed Yam (ha)	
	A	B	A	B	A	B	A	B	A	B	A	B
UL-A-1	16.87de	17.14de	12.78e	12.82e	5.43d	5.45d	10.867m	10.900m	0.793m	0.793m	1.586g	1.582g
99/AMO/XA	14.93e	14.97e	14.32d	14.46d	10.63a	10.59a	21.267c	21.180c	1.313j	1.316j	2.626e	2.632e
89/02665	19.11cd	20.06cd	17.98c	17.92c	9.23b	9.42b	18.407f	18.840f	2.190d	2.192d	4.386c	4.380c
99/AMO/116	14.67e	14.64e	12.83e	12.78e	6.30d	6.34d	12.933k	12.680k	0.856i	0.854i	1.713g	1.708g
98/00933	27.79a	27.62a	18.63b	18.78b	5.70d	5.72d	11.400i	11.440i	1.103k	1.106k	2.206f	2.212f
Nwakpoko	12.95f	13.05f	14.42d	14.64d	8.36c	8.44c	16.733h	16.880h	1.086k	1.083k	2.173f	2.166f
07/00168	20.87c	20.85c	20.72a	21.02a	9.73b	9.72b	19.467e	19.440e	3.026a	3.025a	6.052a	6.050a
Obiauturugo	20.65c	20.46c	19.47b	19.52b	9.50b	9.48b	19.00oef	18.960ef	2.666b	2.664b	5.480b	5.332b
99/AMO/109	12.59f	12.66f	15.65d	15.69f	10.40ab	10.44ab	20.333d	20.350d	1.470i	1.471i	2.940de	2.942de
Adaka	22.09b	22.14b	17.04c	17.10c	9.63b	9.68b	19.267e	19.360e	2.380c	2.382c	4.760c	4.764c
99/AMO/95A	18.01d	18.26d	16.81c	16.76c	7.50c	7.54c	15.000i	15.008i	1.826e	1.825e	3.652d	3.650d
99/AMO/114	16.79de	16.71de	15.82d	15.94d	8.73bc	8.71bc	17.467g	17.450g	1.763f	1.762f	3.520d	3.524d
00604	18.49d	18.58d	18.11bc	18.08bc	9.20b	9.22b	18.400f	18.440f	1.663g	1.661g	3.326d	3.322d
99/AMO/60	15.04e	15.09e	14.85d	14.92d	11.46a	11.44a	22.933a	22.888a	1.693g	1.694g	3.386d	3.388d
AME	15.52e	15.68e	14.41d	14.36d	11.16a	11.14a	22.333b	22.288b	1.583h	1.584h	3.166de	3.168de
07/00033	17.68d	17.62d	16.57cd	16.51cd	6.80cd	6.76cd	13.600i	13.540i	1.350j	1.351j	2.700e	2.702e

* A =Itu, B = Uy; Means with the same letter(s) within a column are not significantly different ($p<0.05$)

Table 6: Yield and ware yam characteristics of advanced guinea white yam lines in Itu and Uyo, Akwa Ibom State, Nigeria

Yam Genotype	No. of Ware Yam/Plot		No. of Ware Yam/ha		Fresh Weight of Ware Yam/Plot (kg)		Fresh Weight of Ware Yam (tha^{-1})		Total Fresh Tuber Yield (tha^{-1})	
	A	B	A	B	A	B	A	B	A	B
UL-A-1	0f	0f	0f	0f	0.0f	0f	0f	0f	1.586k	1.582k
99/AMO/XA	0f	0f	0f	0f	0.0f	0f	0f	0f	2.626ij	2.632ij
89/02665	1.34e	1.36e	716.6e	719.5e	1.056e	1.058e	3.001e	3.049e	7.387e	7.429e
99/AMO/116	0f	0f	0f	0f	0.0f	0f	0f	0f	1.713k	1.708k
98/00933	4.36a	4.37a	2073.3a	3068.5a	2.193a	2.192a	19.166a	19.158a	21.372a	21.370a
Nwakpoko	0f	0f	0f	0f	0.0f	0f	0f	0f	2.173j	2.166j
07/00168	3.94b	3.92b	1073.3b	1067.8b	1.670b	1.668b	13.158b	13.077b	19.210b	19.127b
Obiauturugo	2.44c	2.45c	1066.6c	1082.5c	1.293c	1.291c	6.309c	6.325c	11.805c	11.648c
99/AMO/109	0f	0f	0f	0f	0.0f	0f	0f	0f	2.940i	2.942i
Adaka	2.06d	2.05d	1036.6d	1030.0d	1.120d	1.121d	4.350d	4.337d	9.110d	9.101d
99/AMO/95A	0f	0f	0f	0f	0.0f	0f	0f	0f	3.700f	3.650f
99/AMO/114	0f	0f	0f	0f	0.0f	0f	0f	0f	3.520g	3.524g
00604	0f	0f	0f	0f	0.0f	0f	0f	0f	3.326h	3.322h
99/AMO/60	0f	0f	0f	0f	0.0f	0f	0f	0f	3.386h	3.388h
AME	0f	0f	0f	0f	0.0f	0f	0f	0f	3.166h	3.168h
07/00033	0f	0f	0f	0f	0.0f	0f	0f	0f	2.700i	2.702i

* A =Itu, B = Uyo; Means with the same letter(s) within a column are not significantly different ($p<0.05$)

The highest number of ware yam per plot, number of ware yam per hectare, fresh weight of ware yam per plot and fresh weight of ware per hectare were produced by 98/00933, followed by 07/00168, Obiauturugo, Adaka and 89/02665. The other genotypes ULC-1, 99/AMO/XA, 99/AMO/116, Nwakpoko 99/AMO/109, 99/AMO/95A, 99/AMO/114, 00604, 99/AMO/60, AME and 07/00033 did not produce ware yam at all. Similarly, the highest total fresh tuber yield (tha^{-1}) was produced by 98/00933, followed by 07/00168, Obiauturugo, Adaka, 89/02665, 99/AMO/95A and 99/AMO/114 while the lowest was found in UL-A-1 (Table 6). It was observed that besides being high yielding, the genotypes 98/00933, Adaka, 98/02665 and 99/AMO/95 also showed high resistance to pests notably yam beetle (*Heteroligus meles*), leaf beetle as well as yam leaf mosaic virus which are desirable characteristics of a good yam. For example, 98/00933 was ranked first (high resistance) to insect pests and second to yam leaf mosaic virus. Adaka came second while Obiauturugo was rank 3rd (moderately resistant) to yam beetles and 2nd in resistance to leaf beetles and yam leaf mosaic virus. Genotype 07/00168 which was ranked second in tuber yield (tha^{-1}) was relatively susceptible to yam beetles and yam leaf mosaic virus (Table 7). However, the low resistance of this genotype could be improved through breeding.

Variability in one or several characters observed among the advanced guinea white yam lines is a desirable characteristic which fosters selection of suitable genotypes for the environment (Nwankwo*et al*., 2011) and also provides guide post for further breeding in yam. In spite of the fact that the yam lines were planted in June, some of them displayed unique characteristics for selection. For example, 98/00933 showed superior performance in six characters which include tuber length, number of ware yam per plot, number of ware yam per hectare, fresh tuber

yield (tha^{-1}), fresh weight of ware yam per plot, fresh weight of ware yam per hectare as well as high resistance to pests and leaf mosaic virus. This was followed by 07/00168 in three characters, namely circumference of tubers, fresh weight of seed yam per plot and fresh weight of seed yam per hectare while 99/AMO/60 showed outstanding performance in two characters, namely, number seed yam per plot and number of seed yam per hectare. The result also showed 07/00168 as the second best yielding line, followed by Obiauturugo, Adaka and 89/02665. In terms of total fresh tuber yield, 98/00933 was ranked first, in the two locations, followed by 07/00168, Obiauturugo, Adaka and 89/02665. The three yam lines (98/00933, 07/00168 and Obiauturugo) which out yielded the national check (89/02665) and the local check (UL-A-1) could be selected and advanced to the uniform yield trial. Yield is an important factor which determines choice of a genotype for cultivation (Nwachukwu *et a*l., 2009). The result showed that yield was significantly influenced by genotypic variations among the yam lines (Gooding, 1987).The three advanced guinea white yam lines namely, (98/00933, 07/00168 and Obiauturugo) besides out yielding the national and local check also produced tuber yields within 5 months higher than 11 t ha^{-1} which is considered average in major yam producing countries of West Africa (Anuebunwa, 2002).

CONCLUSION

Three advanced guinea white yam lines 98/00933, 07/00168 and Obiauturugo out yielded both the national (89/02665) and local (UL-A-1) checks, also produced tuber yield higher than 11.0 (t ha^{-1}) average for West Africa. For example, 98/00933 produced 21.371 t ha^{-1}, 07/00168 had 19.168 t ha^{-1} while Obiauturugo produced 11.776 t ha^{-1} (averages of two locations). Also, 98/00933 was superior in eight characters namely, tuber length, number of ware yam per plot, number of ware yam per hectare, fresh weight of ware yam per plot, fresh weight of ware yam (t ha^{-1}), total fresh tuber yield (t ha^{-1}) and also possessed high resistance to insect pests and yam leaf mosaic virus. The genotype 07/00168 was superior in three characters namely, circumference of tubers, fresh weight of seed yam per plot (g) and fresh weight of seed yam (t ha^{-1}), while Obiauturugo came third in two characters namely, number of seed yam per plot and number of seed yam per hectare. The three yam lines could be recommended for advancement to Uniform Yield Trial (UYT) in the area.

Table 7: Number of stands planted, number of stands at harvest and pest and disease severity in advanced guinea white yam lines in Itu and Uyo, Akwa Ibom State, Nigeria

Yam Genotype	No. of stands planted per plot	Stands at harvest per plot	Severity of Yam Beetle	Severity of Leaf Beetle	Disease Severity (YLMV)
UCL-A-1	30	15	5	5	4
99/AMO/XA	30	30	1	1	1
89/02665	30	30	1	2	2
99/AMO/116	30	18	2	2	2
98/00933	30	21	1	2	2
Nwakpoko	30	24	3	3	2
07/00168	30	30	5	3	4
Obiauturugo	30	30	3	2	3
99/AMO/109	30	30	4	3	3
Adaka	30	30	2	2	1
99/AMO/95A	30	21	3	2	2
99/AMO/114	30	24	4	3	4
00604	30	24	1	2	2
99/AMO/60	30	24	3	2	4
AME	30	30	2	2	2
07/00033	30	18	3	2	3
	480	399	NA	NA	NA

* Scaling for pest or disease severity in advanced guinea white yam lines in Itu and Uyo. NA = Not applicable

REFERENCES

Adeniji, M. O. Obigbesan, G. O, Asiedu, R. and Bokanga, M. 2001. Influence of fertilizers on yield, storage and food qualities of yam, Proceedings of the 7th Triennial Symposium of the International Society for Tropical Root Crops-African Branch (Akoroda, M. O. &Ngeve, J. M. eds) held at the Centre International des Conferences, Cotonou, Benin, 11-17 October, 1998.

Aighewi, B. A., Asiedu, R and Akoroda, M. O. 2001. Producing seed yams (*Dioiorea rotundata*) from sprouts. Root crop in the 21st Century. Proceedings of the 7th Triennial symposium of the international society for tropical root crops- African Branch, held, Centre International des Conference, Cotonou, Benin, 11-17 October, 1998, PP. 297-299.

Aniebunwa, F. O. 2002. A structural analysis of yam flow into Abia state of Nigeria.*Nigerian Agricultural Journal*, 33:17-22.

Degras, L. 2000. *The yam: A tropical root crop.*The Technical centre for Agricultural and Rural cooperation (CTA). The Macmillan press, London, P. 408.

Ezulike, T. O., Udealor, A., Nwosu, K. I. and Asumugha, G. N. 2006. Rapid multiplication of seed yam by minisett technique, Extension Guide, No.15, Extension Service Programme, National Root Crop Research Institute, Umudike, Nigeria, PP.1-10.

FAO (Food and Agriculture Organization) 2014. FAOSTAT: Top 10 Yam Producing Countries in the World. FAO, Rome. FAOSTAT, Available at http://www.fao.org/faostat/en#data.

Gooding, E. G. B. 1987. Reports on crops. TDRI Crop and Product Digest No. 2. Second Edition, pp. 200-214.

Hahn, S. K., Osiru, D. S. O., Akoroda, M. O. and Otoo, J. A. 1987. Yam production and its future aspects. *Outlook on Agriculture*, 16:109-118.

IITA (International Institute of Tropical Agriculture) 2004. Annual Report, International Institute of Tropical Agriculture, Ibadan, Nigeria, PP.8-10.

IITA 2009. IITA Annual Report, International Institute of Tropical Agriculture, Ibadan, Nigeria.

IITA (International Institute of Tropical Agriculture) 2013. Report, Achievements, Challenges and Prospects of yam production in Nigeria, IITA, Ibadan, Nigeria.

IITA (International Institute of Tropical Agriculture) 2014. IITA Annual Report.International Institute of Tropical Agriculture, Ibadan, Nigeria.

NRCRI (National Root Crops Research Institute) 2016. Yam Research Guide National Root Crops Research Institute, Umudike, Abia State, pp1-2.

Nwachukwu, E. C. 2009. Field evaluation of 24 top white hybrid yam in Umudike and Otobi. Proceedings of the 45th Annual Conference of the Agricultural Society of Nigeria held at Abuja, Nigeria, pp. 88-90.

Nwankwo, I. I. M. and Bassey, E. E. (2013). A study of variability and heritability for yield and yield related traits in guinea white yam (*Dioscorea rotundata*, Poir) genotypes in Umudike, South-eastern Nigeria. *Wudpecker Journal of Agricultural Research*, 2(4): 122-127.

Nwankwo, I. M., Eka, M. J., Bassey, E. E. and Nwachukwu, E. C. 2011. Floweing behavior and physiological characteristics of interspecific hybrids of *Dioscorea rotundata* Poir in humid environment of Southeastern Nigeria. *Nigerian Journal of Agriculture, Food and Environment*, 7(1): 16-21.

Nweke, F. I., Ugwu, B. O., Asedu, C. L. A. and Ay, P. 1991. Production cost of yam based cropping in southeastern Nigeria, RCMD Research Monogragh No.6., IITA, Ibadan, Nigeria.

Ravi, B. and Roy, C. S. 1989. A method of leaf area determination in *Dioscorea*. *Journal of Root Crops*, 15: 54-48.

Timothy, G. E and Bassey, E. E. 2009. Preliminary study on the effect of tuber sett weight derived from regions of seed yam on growth and yield of yam in south eastern Nigeria. *Nigerian Journal of Agricultural Technology*, 2:32-40.

Udealor, A. and Ezelike, T. O. 2009. On-farm evaluation of the performance of new yam minisett sizes for increased adoption. *The Nigerian Agricultural Journal*, 40(1): 100-103.

Udoh, D. J., Ndaeyo, N. U., Asuquo, P. E. and Ndon, B. A. 2005. *Crop production Techniques for the tropics*. Concept Publication, Lagos, PP 182-187.

Uguru, M. I. 2011. Crop Production: Tools, Techniques and Practice. Fulladu Publishing Co., Nsukka, Nigeria, pp. 40-48.

Ugwu, B. O. 1996. Yam and cassava production as income generating activities for households. African evaluation of the performance of new yam minisett sizes for increased adoption. *The Nigerian Agricultural Journal*, 40(10): 100-103.

Umar, A. G., Nwator, M. S., Likita, S. and Adoko, S. 2006. The indeginous yam storage technology and post-harvest loses in Nigeria: The Benue State perspective. *International Journal of Food and Agricultural Research*, 5(2): 113-139