GROWTH AND TUBER YIELD PERFOMANCE OF TARO LANDRACES IN THE FACE OF TARO LEAF BLIGHT (*Phytophthora colocasiae* Rachib) OUTBREAK IN NIGERIA

Eze[1]*, C. E., Nwofia[1], G. E., Onyeka[2], J. and Nwaogu[3], A. G.

ABSTRACT

*[1]Department of Agronomy, Michael Okpara University of Agriculture, Umudike, Nigeria. [2]National Root Crops Research Institute, Umudike, Nigeria. [3]Department of Plant Health Management, Michael Okpara University of Agriculture, Umudike, Nigeria. *Corresponding author: chineduemmanuel2000@gmail.com*

The study was carried out to assess the growth, taro leaf blight (TLB) severity and yield of some taro (Colocasia esculenta (L.) Schott) genotypes commonly grown by farmers in Nigeria across four environments (two locations in two years). The experiment was laid out as a split-split plot in a randomized complete block design with year as main plot, location as subplot and genotype as the sub-subplot in three replications. The eight genotypes used were: NCe 001, NCe 002, NCe 003, NCe 005, NCe 010, NCe 011, NCe 012, and "Ede Orba". Data were collected on the growth, TLB severity and yield attributes. There was no significant year effect for most of the yield attributes measured. However, significant year effect was observed for cormel weight and taro yield. Location had significant effect on taro yield with Umudike giving the best performance for yield and most of the measured traits. TLB severity measured overtime showed significant location effect at some stages of the disease. The genotypes varied significantly (p<0.001) in their performance for all the traits studied with NCe 010 having the best performance for taro yield and few of other characters. This did not differ significantly from NCe 003 which was the second-best performer for taro yield and best performer for leaf area, number of leaves/plant and corm weight. TLB severity was highest on NCe 001 and NCe 005 at almost all the stages of disease assessment. The study showed that TLB is at its highest severity at 4 weeks after symptom appearance in taro and this incidentally may be a period where it could cause maximum damage to the taro plants. However, genotypes NCe 010 and NCe 003 have shown to give relatively better yield under the widespread severity of TLB ravaging taro fields in Nigeria.

Keywords: *Growth, taro leaf blight, yield performance, Nigeria.*

INTRODUCTION

Edible aroids (family Araceae) comprise many underground food crops grown in several tropical and sub-tropical countries. Taro (*Colocasia esculenta* L. Schott; also called cocoyam) and tannia (*Xanthosoma sagittifolium*; also referred to as new cocoyam) are the most important species (Green and Oguzor, 2009). Taro is probably one of the oldest crops on earth and its domestication occurred more than 10,000 years ago. Although Matthews (1990) consider that taro (*Colocasia esculenta*) originated in the Indo-Malayan region, between Myanmar and Bangladesh, there is insufficient evidence to confirm this supposition. Furthermore, there have not been comprehensive and detailed genetic studies including cultivars and wild materials from the entire area of cocoyam distribution (i.e., India, Southeast Asia, South China, Melanesia, and Australia).

Taro is an important traditional staple crop in many sub-Saharan African countries, but its potential contribution to food security is poorly harnessed by lack of research and development on its agronomy and commercialization (Mare, 2009). It is a starchy tuber crop that has been widely cultivated and consumed in the southeastern agricultural zone of Nigeria for decades (Ndon *et al*., 2003). Nigeria is the world's largest producer of cocoyam (taro and tannia), where these species ranked third among the nation's root and tuber crops after yam and cassava (FAO, 2007). From 1990 to 2000, cocoyam production in Nigeria rose from 0.73 to 3.89 million metric tonnes per annum (Ojiako *et al*., 2007), and further increased to 5.068 million metric tons in 2007 (FAO, 2007). In recent years (2008 – 2012), the production of taro has declined drastically due to the incidence of taro leaf blight (TLB) in the country and it has continued (FAO, 2013). TLB is caused by *Phytophthora colocasiae*, and it takes less than 14 days to completely attack an entire cocoyam field, leading to massive defoliation and plant die-back (Onyeka, 2014). It is believed to have been present in the Pacific region since the early 1920s but was first recorded in Nigeria in 2009 (Bandyopadhyay *et al*., 2011). The epidemic of taro leaf blight (TLB) may occur throughout the year during continuous rainy season, for example, in the tropics (July – Sept.) over cast weather where night temperatures are 20-22ºC and daily temperatures of 25-28ºC usually with little seasonal variations (Mbong, *et al*., 2013) hence, resulting in rapid taro defoliation, death as well as heavy total yield losses under favourable weather conditions. Similarly, survival of the sporangia can be directly or indirectly within 2 weeks by continuous recycling, and often as a single plant within the crop, between seasons as vegetative mycelium in infected corms, later the spores are unto the soil under favourable condition (Chiejina, 2013).

Taro is used mostly as food, and prepared the same way as potatoes. Its flour is considered good for formulation of baby food because its starch is easily digestible, helps with digestive problems and acts as iron supplements (Onwueme, 1999; Shange, 2004; Van Wyk, 2005). Taro is regarded as potential and important crop because of its nutritional status and the role it plays in food security, especially in the rural areas where it provides meaningful source of income and plays an important part in the cultural practices and as a vehicle for rural development (Onwueme, 1999). It is an excellent multipurpose food crop for subsistence agriculture and home gardens. Its ability to tolerate salinity makes it suitable for localities where few other crops grow. As such, it merits more attention in research focusing on yield (Grubben and Denton, 2004). However, taro is a difficult crop to grow because of its high requirements for soil nutrients, moisture and labour. It is also affected by numerous pests and diseases, which can have a drastic impact on yield. These factors have, cumulatively, caused farmers to lose interest in its farming (Okpul *et al*., 2002). Thus, the objective of this study was to investigate the growth, TLB severity and yield of some taro genotypes in the South-Eastern zone of Nigeria.

MATERIALS AND METHODS

The experiments were conducted on the National Root Crops Research Institute's farm at Igbariam (Latitude 06° 15' N; Longitude 06° 52' E; Alt. 81 m) and Michael Okpara University of Agriculture teaching and research farm, Umudike (Latitude 05º 29' N; Longitude 07º 33' E; Alt. 122 m) in 2013 and 2014 cropping seasons. Umudike is in the humid tropics and has a total rainfall of about 2177 mm per annum, and annual average temperature of about 26 °C. The predominant vegetative type is rain forest (NEST, 1991), while the soil has been classified as sandy loam ultisol. The rainfall pattern is bimodal. A stretched wet season from April to July is interrupted by a short "August break" followed by another short rainy season from September to October/early November. Dry season stretches from early November to March. Igbariam has no distinct temperature seasons; the temperature is relatively constant during the year. The vegetation is classified as a derived savanna, with a tropical moist forest biozone. The soil in the area is high in acrisols, alisols, plinthosols (ac), acid soil with clay-enriched lower horizon and low base saturation. Pre-planting composite soil samples were collected at the various locations using soil auger at a depth of 20cm and analyzed for their physicochemical properties. Eight (8) genotypes of taro (*Colocasia esculenta* L. Schott) obtained from National Root Crops Research Institute, Umudike were used. The genotypes and their symbolic representation are shown below: NCe 001 – "Cocoindia"; NCe 002 – "Ede ofe green"; NCe 003 – "Ede ofe purple"; NCe 005 – "Ukpong"; NCe 010 – "Akiri"; NCe 011 – "Akpahiri"; NCe 012 – "Akiri mgbawa"; "Ede orba (Reserve)"

The experiment was laid out as a Split-split plot in a Randomized Complete Block Design with the year as the main plot, location as the sub-plot and genotype as the sub-sub plot in three replications at both locations. Each plot measured 4m by 4m, consisting of 4 rows. Planting was carried out in Umudike and Igbariam on 11th and 16th May in 2013 and on 15th and 21st May in 2014 respectively. Cormels were sown on ridges at a spacing of 100 cm x 50 cm within and between rows respectively (20,000 plants/ha). Weed control was carried out manually.

Data on taro growth were taken on the twelve (12) plants from the two middle rows for assessment at 10 and 12 weeks after planting (WAP) and that of yield obtained at harvest.

The severity of TLB was examined at 1, 2, 3, 4, 5, 6, and 7 week (s) after first symptom (WAS) and scored using Jenkins-Wehner Method on a scale of 0 – 90 based on percentage plant area infected as shown below (Jenkins and Wehner, 1983):

0 = (0%) no disease
10 = (0 - 3%) few small leaf lesions
20 = (3 - 6%) few lesions on few leaves with no stem lesions
30 = (6 - 12%) few lesions on few leaves or with superficial stem lesions
40 = (12 - 25%) few well-formed leaf lesions or superficial stem lesions
50 = (25 - 50%) few well-formed leaf lesions or enlarging stem lesions
60 = (50 - 75%) many large leaf lesions or deep stem lesions with abundant sporulation, or plant more than 50% defoliated
70 = (75 - 87%) many large coalescing leaf or stem lesions, over 75% of plant area affected or defoliated
80 = (87 - 100%) plants largely defoliated, leaves or stems with abundant sporulating lesions
90 = (100%) plants dead.

The data collected were subjected to Analysis of Variance using the GenStat Discovery 12th edition (GenStat, 2009).

RESULTS

Soil physicochemical properties and meteorological data of experimental sites

The soil physicochemical properties of the experimental sites are presented in Table 1. The result showed that the soil texture of both locations was sandy loam. The pH ranged from 4.65 – 5.10 with the soil of Umudike being more acidic than that of Igbariam in both years. Available Phosphorus (mg/kg) was higher at Umudike in 2013 but in 2014, Igbariam had higher available phosphorus. Total Nitrogen was higher at Igbariam in 2013 while in 2014, it was higher in Umudike. Umudike soil had higher organic Carbon and organic matter contents in both years. In both years, Igbariam soil had higher proportion of Calcium, Magnesium, Potassium and Sodium. Exchange acidity was higher at Umudike in both years while the Effective Cation Exchange Capacity was higher at Igbariam also in both years. The analysis also indicated that the percentage Base Saturation of Igbariam soil was higher than that of Umudike in both years. The average monthly rainfall at Umudike and Igbariam over 2013 and 2014 is presented in Table 2. The total rainfall at Umudike was 2210.0 mm in 2013 and 2068.5 mm in 2014 while the total rainfall at Igbariam was 1912.8mm in 2013 and 1823.4mm in 2014. At Umudike in 2013, the highest rainfall was recorded in May while in 2014, it was recorded in August. At Igbariam in 2013, the rainfall pattern was bimodal with peaks in June and September. In 2014, the highest rainfall at Igbariam was recorded in the month of September.

Variability in growth attributes of taro

Number of leaves/plant: Tables 3 and 4 show the number of leaves/plant at 10 and 12WAP respectively, in both years at both locations. Number of leaves/plant was significantly influenced by genotype throughout the assessment period, while year x genotype interaction was significant at 12WAP. Location x genotype interaction was significant at 10WAP ($p<0.001$). Location, year x location interaction, year x genotype interaction and location x genotype interaction were significant at 10WAP ($P<0.01$). The year effect was significant ($P<0.05$) at 12WAP.

Table 1: Soil physicochemical properties of experimental sites in 2013 and 2014

	2013		2014	
Soil properties	Umudike	Igbariam	Umudike	Igbariam
Texture	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
Sand (%)	71.80	75.80	76.40	72.40
Silt (%)	11.40	11.40	7.40	11.40
Clay (%)	16.40	12.40	14.20	16.20
pH (H_20)	4.70	4.80	4.65	5.10
Available phosphorus (mg kg^{-1})	33.40	25.40	35.20	38.40
Total nitrogen (%)	0.028	0.042	0.146	0.077
Organic carbon (%)	0.54	0.24	1.69	0.89
Organic matter (%)	0.93	0.41	2.91	1.53
Calcium (cmol kg^{-1})	3.20	4.80	2.00	2.40
Magnesium (cmol kg^{-1})	1.20	1.60	1.20	1.60
Potassium (cmol kg^{-1})	0.137	0.219	0.065	0.438
Sodium (cmol kg^{-1})	0.278	0.287	0.243	0.348
Exchange Acidity (cmol kg^{-1})	1.52	0.64	1.28	0.88
ECEC (cmol kg^{-1})	6.34	7.55	4.79	5.67
Base Saturation (%)	75.95	91.47	73.24	84.41

Table 2: Average monthly rainfall (mm) at the experimental sites in 2013 and 2014

	Umudike		Igbariam	
Months	2013	2014	2013	2014
January	75.4	0.0	74.8	18.2
February	84.8	43.7	0.0	0.0
March	40.8	138.8	13.0	88.3
April	92.8	78.7	89.7	169.9
May	446.1	249.2	310.9	202.8
June	239.4	281.8	361.2	164.2
July	280.5	114.9	302.7	232.1
August	237.1	436.5	176.3	282.5
September	318.0	412.4	361.6	304.0
October	184.8	165.1	206.1	205.8
November	99.5	147.4	0.6	150.2
December	90.8	0.0	15.9	5.4
Total	2210.0	2068.5	1912.8	1823.4

At 10WAP, number of leaves/plant ranged from 3 - 10 in 2013 and 4 - 11 in 2014. Umudike differed significantly from Igbariam with Umudike producing more leaves/plant than Igbariam. In Umudike, the highest number of leaves/plant was produced by NCe 001 while the lowest number of leaves/plant was produced by NCe 005. The Same trend was observed in Igbariam. From Table 4, number of leaves/plant at 12WAP ranged from 3 - 11 in 2013 and from 5 - 20 in 2014. Igbariam had more number of leaves/plant than Umudike but the number of leaves did not differ significantly. Though number of leaves/plant was not significant at both locations, in Umudike, the genotype NCe 012 had the highest leaf number while NCe 005 had the lowest. Similar trend was observed in Igbariam among the genotypes.

Table 3: Number of leaves/plant of some taro genotypes at 10WAP in two locations over 2 years

	Location					
	Umudike			Igbariam		
Genotype	2013	2014	Mean	2013	2014	Mean
NCe 001	9.88	10.64	10.17	8.20	5.36	6.78
NCe 002	4.58	6.42	5.50	4.23	4.56	4.39
NCe 005	3.30	4.64	3.97	4.57	4.05	4.31
NCe 010	8.14	10.22	9.18	8.23	4.86	6.55
NCe 011	4.52	8.56	6.54	4.53	4.83	4.68
NCe 012	6.22	10.90	8.56	4.90	5.25	5.07
NCe 003	5.80	13.19	9.50	4.80	5.08	4.94
Ede Orba	3.69	5.42	4.55	5.23	4.17	4.70
Mean	5.77	8.72	7.25	5.59	4.77	5.18

LSD0.05 Year = ns
Location = 0.801**
Genotype = 1.231***
Year x Location = 1.228**
Year x Genotype = 1.799**
Location x Genotype = 1.727***
Year x Location x Genotype = ns

Table 4: Number of leaves/plant of some taro genotypes at 12WAP in two locations over 2 years

		Location					
		Umudike			Igbariam		
Genotype		2013	2014	Mean	2013	2014	Mean
NCe 001		10.66	13.94	12.30	9.37	16.97	13.17
NCe 002		8.61	9.03	8.82	9.30	9.44	9.37
NCe 005		2.70	5.95	4.32	4.60	4.97	4.78
NCe 010		12.72	13.53	13.13	11.37	18.53	14.95
NCe 011		6.50	10.39	8.44	7.27	9.22	8.24
NCe 012		10.55	16.64	13.59	10.20	19.94	15.07
NCe 003		10.81	18.03	14.42	9.63	19.14	14.38
Ede Orba		6.14	6.36	6.25	8.50	6.00	7.25
	Mean	8.59	11.73	10.16	8.78	13.03	10.90
LSD0.05	Year = 3.328*						
	Location = ns						
	Genotype = 1.878***						
	Year x Location = ns						
	Year x Genotype = 3.043***						
	Location x Genotype = ns						
	Year x Location x Genotype = ns						

Number of secondary shoots/plant

Tables 5 and 6 show the number of secondary shoots/plant at 10 and 12WAP respectively. Significant variation ($P<0.001$) was observed among the genotypes at both period of assessment while year x genotype interaction was also significant at 10WAP. Significant year x location interaction at 12WAP was also observed ($P<0.01$). Year x location x genotype interaction at 12WAP had significant effect ($P<0.05$). The number of secondary shoots/plant at 10WAP ranged from 0 - 5 in 2013 and in 2014; it ranged from 1 - 5. At 10WAP, the taro plants in the two locations had similar number of secondary shoots/plant. NCe 003 had the highest number of secondary shoots/plant in Umudike while NCe 005 had the lowest. In Igbariam, the highest number of secondary shoots/plant was produced by NCe 010 while NCe 005 produced the lowest number. At 12WAP, the range is from 1 - 7 in 2013 and 2 - 7 in 2014. In Umudike, NCe 010 produced the highest number of secondary shoots while NCe 005 produced the lowest number of secondary shoots. Similar trend was observed for this trait in Igbariam.

Leaf area (cm^2)

Tables 7 and 8 show the leaf area (cm^2) at 10 and 12WAP respectively across the two locations over the years. Genotype at all the stages was significant ($P<0.001$). Year x location interaction at both stages were significant at $P<0.05$. The leaf area (cm^2) at 10WAP ranged from 425.0 - 1221.0 cm^2 in 2013 and from 401.0 - 1315.0 cm^2 in 2014. Though not significant, Umudike produced taro plants that had larger leaf area than that of Igbariam. In both Umudike and Igbariam, NCe 011 had the highest leaf area while NCe 001 had the lowest leaf area (Table 7).

At 12WAP, it ranged from 592.0 - 1361.0 cm^2 in 2103 and from 411.0 - 1348.0 cm^2 in 2014. At 12WAP, taro plants planted in Umudike had larger taro leaf area than those planted at Igbariam. The highest taro leaf area in Umudike was produced by NCe 002 while the lowest was produced by NCe 001. In Igbariam, the highest taro leaf area was observed in NCe 003 while the lowest leaf area was observed in NCe 001.

Table 5: Number of secondary shoots/plant of some taro genotypes at 10WAP in two locations over 2 years

		Location					
		Umudike			Igbariam		
Genotype		2013	2014	Mean	2013	2014	Mean
NCe 001		3.330	2.280	2.805	3.407	2.890	3.148
NCe 002		2.413	2.307	2.360	1.910	1.777	1.843
NCe 005		0.137	1.197	0.667	0.153	1.140	0.647
NCe 010		4.000	2.913	3.457	4.720	4.193	4.457
NCe 011		1.857	3.777	2.817	3.247	3.473	3.360
NCe 012		2.997	3.667	3.332	2.693	3.667	3.180
NCe 003		2.360	5.140	3.750	2.733	4.750	3.742
Ede Orba		0.830	1.697	1.263	1.307	1.330	1.318
	Mean	2.240	2.872	2.556	2.521	2.903	2.712
$LSD_{0.05}$	Year = ns						
	Location = ns						
	Genotype = 0.6500***						
	Year x Location = ns						
	Year x Genotype = 1.0162***						
	Location x Genotype = ns						
	Year x Location x Genotype = ns						

Table 6: Number of secondary shoots/plant of some taro genotypes at 12WAP in two locations over 2 years

		Location					
		Umudike			Igbariam		
Genotype		2013	2014	Mean	2013	2014	Mean
NCe 001		5.05	5.42	5.23	5.51	3.52	4.52
NCe 002		5.00	3.83	4.41	3.93	5.05	4.49
NCe 005		0.83	2.67	1.75	1.33	2.39	1.86
NCe 010		6.63	6.70	6.66	7.35	6.25	6.80
NCe 011		2.78	7.14	4.96	5.39	5.05	5.22
NCe 012		4.69	6.81	5.75	5.32	5.36	5.34
NCe 003		5.39	6.28	5.83	5.59	6.16	5.87
Ede Orba		2.80	3.36	3.08	3.43	4.47	3.95
	Mean	4.15	5.28	4.71	4.73	4.78	4.76
$LSD_{0.05}$	Year = ns						
	Location = ns						
	Genotype = 0.941***						
	Year x Location = 1.006**						
	Year x Genotype = ns						
	Location x Genotype = ns						
	Year x Location x Genotype = 1.847*						

Effect of year, location and genotype on the severity of taro leaf blight

Table 9 shows the severity of taro leaf blight (TLB) at 1 week after first symptom (WAS) across two locations over the years scored on a scale of 0 – 90. Year, location and year x location interaction significantly affected the severity of the TLB among genotypes ($P<0.001$). The TLB scores ranged from 0.28 - 8.06 in 2013 and from 0.00 to 16.04 in 2014. The severity was higher in 2014 than 2013. It was observed that TLB was higher in Igbariam in the first week of scoring than Umudike. The result also showed that across the two years, Igbariam had significantly higher level of TLB disease severity at 1WAS. Table 10 shows TLB severity at 4WAS. The result showed significant year and genotype effect ($P<0.001$). Location was significant at $P<0.05$. The severity range is from 21.67 - 40.55 in 2013 and from 13.54 - 31.67 in 2014. It was higher in 2013 than in 2014. It was observed that TLB severity was higher in Umudike. At both locations in 2013 and at Umudike in 2014, NCe 001 significantly recorded the highest severity while at Igbariam in 2014, the highest severity was observed in NCe 005.

Table 11 shows the severity of TLB at 6WAS. Genotype, year x genotype interaction and year x location interaction had significant effects ($P<0.01$). Year was also significnt ($P<0.05$). TLB severity ranged from 13.06 - 20.25 in 2013 while in 2014, it ranged from 12.71 - 30.44. Severity was more in 2014 than in 2013. In 2013, at both locations, NCe 003 recorded the highest severity while in 2014; NCe 005 recorded the highest TLB severity. Across the years, severity was higher in Umudike. Highest severity was observed in NCe 003 in 2013 while it was observed in NCe 005 in 2014. The TLB disease severity progress curves for the two years at both locations are shown in Figure 1a and 1b. The progressive curve at both locations peaked at 4WAS in 2013 and then dropped (Figure 1a). In 2014, the TLB disease severity progress curve also peaked around 4WAS and then remained steady (Figure 1b). This result showed that TLB is at its highest severity at 4 weeks after symptom appearance in taro and this incidentally may be a period where it can cause its maximum damage to the taro plants.

Table 7: Leaf area (cm^2) of some taro genotypes at 10WAP in two locations over 2 years

		Location					
		Umudike			Igbariam		
Genotype		2013	2014	Mean	2013	2014	Mean
NCe 001		578.0	401.0	490.0	561.0	413.0	487.0
NCe 002		1066.0	1067.0	1067.0	592.0	924.0	758.0
NCe 005		425.0	647.0	536.0	452.0	917.0	685.0
NCe 010		1221.0	947.0	1084.0	626.0	1315.0	971.0
NCe 011		1081.0	1213.0	1147.0	948.0	1151.0	1049.0
NCe 012		932.0	840.0	886.0	695.0	1039.0	867.0
NCe 003		819.0	1024.0	922.0	972.0	1109.0	1040.0
Ede Orba		754.0	968.0	861.0	775.0	1005.0	890.0
	Mean	860.0	889.0	874.0	703.0	984.0	843.0
$LSD_{0.05}$	Year = ns						
	Location = ns						
	Genotype = 167.8***						
	Year x Location = 264.6*						
	Year x Genotype = ns						
	Location x Genotype = ns						
	Year x Location x Genotype = ns						

Table 8: Leaf area (cm^2) of some taro genotypes at 12WAP in two locations over 2 years

		Location					
		Umudike			Igbariam		
Genotype		2013	2014	Mean	2013	2014	Mean
NCe 001		658.0	411.0	535.0	650.0	444.0	547.0
NCe 002		1295.0	1273.0	1284.0	829.0	970.0	900.0
NCe 005		592.0	806.0	699.0	690.0	911.0	800.0
NCe 010		1361.0	1078.0	1219.0	837.0	1348.0	1092.0
NCe 011		1242.0	1292.0	1267.0	1115.0	1191.0	1153.0
NCe 012		1021.0	910.0	966.0	876.0	1115.0	995.0
NCe 003		1211.0	1156.0	1184.0	1273.0	1207.0	1240.0
Ede Orba		955.0	1186.0	1071.0	981.0	1061.0	1021.0
	Mean	1042.0	1014.0	1028.0	906.0	1031.0	969.0
$LSD_{0.05}$	Year = ns						
	Location = ns						
	Genotype = 163.2***						
	Year x Location = 370.8*						
	Year x Genotype = ns						
	Location x Genotype = ns						
	Year x Location x Genotype = ns						

Effect of year, location and genotype on the yield and yield attributes of taro
Number of cormels/plant

There was a significant genotypic variation in number of cormels/plant (P<0.001) while year, location and all the interactions were not significant. The number of cormels/plant ranged from 4 - 17 in 2013 and 7 – 23 in 2014. NCe 010 had the highest number of cormels/plant while NCe 005 had the lowest number of cormels/plant in Umudike. Similar observation was made in Igbariam (Table 12).

Table 9: TLB severity of test genotypes at 1WAS in two locations over 2 years

		Location					
		Umudike			Igbariam		
Genotype		2013	2014	Mean	2013	2014	Mean
NCe 001		0.28	0.00	0.14	2.09	14.58	8.34
NCe 002		2.78	3.06	2.92	2.71	10.21	6.46
NCe 005		1.39	0.00	0.70	3.54	22.71	13.13
NCe 010		7.22	0.00	3.61	4.79	16.04	10.42
NCe 011		2.50	3.33	2.92	4.79	14.58	9.69
NCe 012		8.06	1.67	4.87	6.56	12.50	9.53
NCe 003		3.61	0.00	1.81	3.13	14.17	8.65
Ede Orba		3.89	0.83	2.36	5.83	13.34	9.59
	Mean	3.72	1.11	2.42	4.18	14.77	9.48
$LSD_{0.05}$	Year = 2.836***						
	Location = 2.166***						
	Genotype = ns						
	Year x Location = 6.153***						
	Year x Genotype = ns						
	Location x Genotype = ns						
	Year x Location x Genotype = ns						

Table 10: TLB severity of test genotypes at 4WAS in two locations over 2 years

		Location					
		Umudike			Igbariam		
Genotype		2013	2014	Mean	2013	2014	Mean
NCe 001		40.55	31.67	36.11	33.96	22.29	28.13
NCe 002		25.97	19.44	22.71	21.67	13.54	17.61
NCe 005		27.08	25.00	26.04	23.34	23.33	23.34
NCe 010		30.00	16.11	23.06	24.65	17.50	21.08
NCe 011		23.33	17.50	20.42	22.09	14.79	18.44
NCe 012		28.19	20.55	24.37	25.00	14.58	19.79
NCe 003		24.45	21.11	22.78	22.65	13.54	18.10
Ede Orba		23.75	15.00	19.38	21.75	14.58	18.17
	Mean	27.92	20.80	24.36	24.39	16.77	20.58
$LSD_{0.05}$	Year = 3.679***						
	Location = 2.433*						
	Genotype = 4.078***						
	Year x Location = ns						
	Year x Genotype = ns						
	Location x Genotype = ns						
	Year x Location x Genotype = ns						

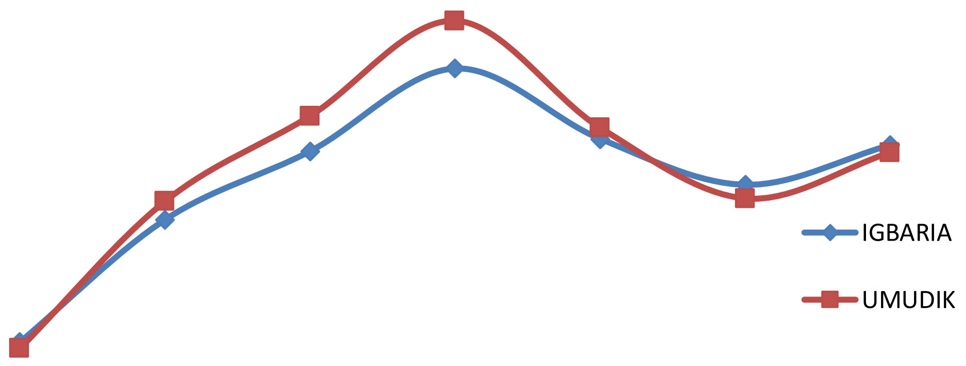

Figure 1a: Trend showing mean TLB severity at different scoring weeks in year 2013

Table 11: TLB severity of test genotypes at 6WAS in two locations over 2 years

		Location					
		Umudike			Igbariam		
Genotype		2013	2014	Mean	2013	2014	Mean
NCe 001		16.67	25.89	21.28	17.02	17.92	17.47
NCe 002		15.55	14.17	14.86	14.90	14.17	14.54
NCe 005		13.06	30.44	21.75	13.99	19.80	16.90
NCe 010		15.83	15.28	15.56	15.25	12.71	13.98
NCe 011		13.06	15.00	14.03	15.13	17.29	16.21
NCe 012		13.06	15.83	14.45	14.65	15.00	14.83
NCe 003		17.50	19.56	18.53	20.25	13.96	17.11
Ede Orba		13.61	16.50	15.06	15.21	13.33	14.27
	Mean	14.79	19.08	16.94	15.80	15.52	15.66
$LSD_{0.05}$	Year = 0.948*						
	Location = ns						
	Genotype = 2.920**						
	Year x Location = 6.308**						
	Year x Genotype = 5.553**						
	Location x Genotype = ns						
	Year x Location x Genotype = ns						

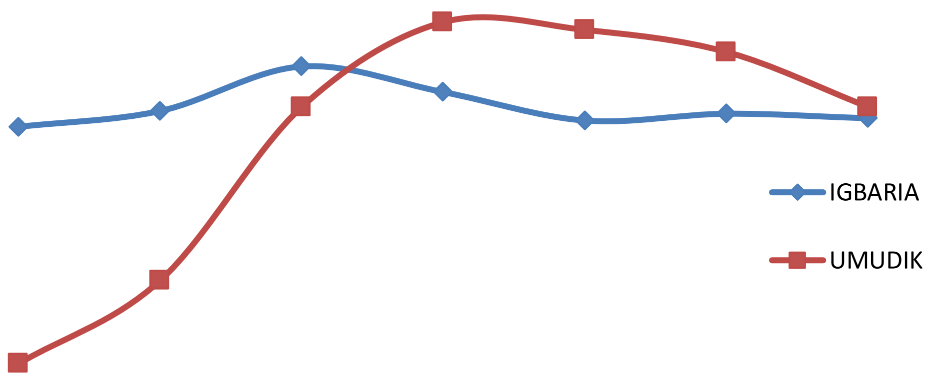

Fig. 1b: Trend showing mean TLB severity at different scoring weeks in year 2014

Cormel weight (g)
Table 13 shows the cormel weight (g) across two locations over two years. Genotype was highly significant (P<0.001). Year, location, year x genotype interaction and year x location x genotype had significant effect on cormel weight. Cormel weight ranged from 19.12 - 36.15 g in 2013 and from 21.89 - 46.48 g in 2014. The taro genotypes planted in Umudike differed significantly from those planted in Igbariam. In both years at Umudike, the heaviest cormels were produced by NCe 005 (41.31 g) while “Ede Orba” (29.98 g) produced cormels with the lowest weight. In Igbariam, the heaviest cormels were observed in the genotype NCe 011 (32.61 g) while NCe 001 (22.12 g) produced cormels with the lowest weight.
Corm weight (g)
Genotype and location x genotype interaction had high significant effect on the taro corm weight (P<0.001). Year x genotype interaction was also significant while the rest of the sources of variation were not significant (P>0.05). The corm weight (g) of the taro genotypes ranged from 55.3 - 194.1 g in 2013 and from 74.6 - 170.0 g in 2014 as shown in Table 14. The taro genotypes planted at Umudike had higher corm weight than those planted in Igbariam but did not differ significantly. The highest mean corm weight (179.2 g) in Umudike was observed in NCe 002 while the lowest corm weight was observed in NCe 001 (65.0 g). At Igbariam, biggest corm weight (125.9 g) was observed in NCe 005 while the lowest corm weight (73.8 g) was observed in NCe 001.
Cormel length (cm)
Table 15 shows the cormel length (cm) of the taro genotypes. Significant genotypic effect was observed for this trait (P<0.001) while the other sources of variation were not significant. Cormel length ranged from 4.4 - 11.3 cm in 2013 and from 4.3 - 10.1 cm in 2014. Though not significant, longer cormels were produced in Umudike than Igbariam. The longest cormels were observed in NCe 005 while NCe 012 produced the shortest cormels.

Table 12: Number of cormels/plant of some taro genotypes in two locations over 2 years

		Location					
		Umudike			Igbariam		
Genotype		2013	2014	Mean	2013	2014	Mean
NCe 001		9.08	14.50	11.79	11.72	14.67	13.20
NCe 002		12.97	20.83	16.90	12.78	14.64	13.71
NCe 005		4.14	7.55	5.85	5.47	6.97	6.22
NCe 010		15.00	22.75	18.88	17.42	19.36	18.39
NCe 011		6.64	16.59	11.61	7.56	11.25	9.40
NCe 012		10.75	20.50	15.63	11.39	13.50	12.45
NCe 003		11.00	18.60	14.80	14.06	13.91	13.98
Ede Orba		12.72	17.34	15.03	14.94	14.11	14.53
	Mean	10.29	17.33	13.81	11.92	13.55	12.73
$LSD_{0.05}$	Year = ns						
	Location = ns						
	Genotype = 2.240***						
	Year x Location = ns						
	Year x Genotype = ns						
	Location x Genotype = ns						
	Year x Location x Genotype = ns						

Table 13: Cormel weight (g) of some taro genotypes in two locations over 2 years

		Location					
		Umudike			Igbariam		
Genotype		2013	2014	Mean	2013	2014	Mean
NCe 001		26.45	40.59	33.52	22.35	21.89	22.12
NCe 002		34.64	31.91	33.27	23.88	28.23	26.06
NCe 005		36.15	46.48	41.31	19.12	31.69	25.40
NCe 010		35.92	35.97	35.95	22.00	30.37	26.19
NCe 011		29.39	45.74	37.56	30.07	35.15	32.61
NCe 012		30.61	35.90	33.26	24.09	28.16	26.12
NCe 003		33.03	46.18	39.61	26.47	34.50	30.49
Ede Orba		30.92	29.05	29.98	23.16	25.49	24.32
	Mean	32.14	38.98	35.56	23.89	29.44	26.66
$LSD_{0.05}$	Year = 5.704*						
	Location = 7.012*						
	Genotype = 4.029***						
	Year x Location = ns						
	Year x Genotype = 6.055*						
	Location x Genotype = ns						
	Year x Location x Genotype = 9.612*						

Corm length (cm)

Significant genotypic effect was also observed in the corm length of the taro genotypes ($P<0.001$). Location x genotype interaction was significant at $P<0.05$ while year, location and the interactions were not significant. Table 16 shows the corm length (cm) of the taro genotypes which ranged from 4.9 - 7.6 cm in 2013 and from 4.7 - 7.5 cm in 2014. Longer corms were observed among the taro genotypes grown at Umudike (6.3 cm) than those planted at Igbariam (6.0 cm) but the difference was not significant. In both locations, NCe 005 produced the longest corms while NCe 001 produced the shortest corms.

Tuber yield (t/ha)

Table 17 shows the yield (t/ha) of the taro genotypes across two locations over two years. Location and genotype had highly significant effect ($P<0.001$) on the yield of the taro genotypes. Year x location interaction, location x genotype interaction and year x location x genotype interaction were also significant ($P<0.01$). Year and year x genotype interaction had significant effect at $P<0.05$. The yield ranged from 2.17 - 9.12 t/ha in 2013 and from 3.29 - 15.01 t/ha in 2014. Better yield was observed in 2014 than in 2013. At Umudike, 2014 yield was almost double the yield in 2013 while at Igbariam, the yield in 2014 was about 1.2t/ha higher than that of 2013. The first year produced an average taro yield of 6.47 t/ha at Umudike with NCe 002 having the highest yield and NCe 005 having the lowest while the avearge yield at Igbariam was 5.05 t/ha with NCe 010 producing the highest yield. The average taro yield in the second year was 11.52 t/ha at Umudike and 6.26 t/ha at Igbariam. The highest yield at Umudike was observed in NCe 003 while the highest yield at Igbariam was observed in NCe 010. NCe 005 also had the lowest yield at both locations that same year. The taro genotypes planted at Umudike had higher yield than those planted at Igbariam. Across the years, NCe 010 had the highest yield in 2013 while in 2014, the highest yield was observed in NCe 003. NCe 005 had the lowest yield in both years. Across the locations, NCe 010 had the highest yield while NCe 005 had the lowest yield. Across both years and locations, NCe 003 had the highest yield which was about seven times higher than the yield observed in NCe 005.

Table 14: Corm weight (g) of some taro genotypes in two locations over 2 years

		Location					
		Umudike			Igbariam		
Genotype		2013	2014	Mean	2013	2014	Mean
NCe 001		55.3	74.6	65.0	66.1	81.5	73.8
NCe 002		194.1	164.3	179.2	102.6	99.6	101.1
NCe 005		110.7	151.1	130.9	102.7	149.2	125.9
NCe 010		146.8	145.9	146.3	113.2	130.6	121.9
NCe 011		155.7	144.3	150.0	111.4	135.1	123.2
NCe 012		126.1	119.4	122.7	106.4	112.7	109.5
NCe 003		150.6	170.0	160.3	128.1	151.8	139.9
Ede Orba		162.8	119.9	141.3	131.5	139.6	135.5
	Mean	137.8	136.2	137.0	107.7	125.0	116.4
$LSD_{0.05}$	Year = ns						
	Location = ns						
	Genotype = 17.69***						
	Year x Location = ns						
	Year x Genotype = 41.34*						
	Location x Genotype = 35.50***						
	Year x Location x Genotype = ns						

Table 15: Cormel length (cm) of some taro genotypes in two locations over 2 years

		Location					
		Umudike			Igbariam		
Genotype		2013	2014	Mean	2013	2014	Mean
NCe 001		4.940	6.070	5.505	4.400	4.317	4.358
NCe 002		5.710	6.160	5.935	5.280	6.197	5.738
NCe 005		10.460	9.917	10.188	11.267	10.073	10.670
NCe 010		5.563	5.737	5.650	4.883	6.087	5.485
NCe 011		5.833	7.293	6.563	6.560	7.070	6.815
NCe 012		5.227	5.503	5.365	5.020	5.823	5.422
NCe 003		5.360	6.350	5.855	5.570	6.400	5.985
Ede Orba		5.653	5.600	5.627	5.657	6.350	6.003
	Mean	6.093	6.579	6.336	6.080	6.540	6.310
$LSD_{0.05}$	Year = ns						
	Location = ns						
	Genotype = 0.6410***						
	Year x Location = ns						
	Year x Genotype = ns						
	Location x Genotype = ns						
	Year x Location x Genotype = ns						

DISCUSSION

This study assessed the growth, (Taro Leaf Blight) TLB severity and yield of taro across two locations over two years. The result of the combined Analysis of Variance showed that there was no significant year effect for most of the growth traits studied except in number of leaves/plant. Though there was no significant year effect in most of the traits, 2014 was consistently better for all the growth traits studied. The superiority of 2014 over 2013 could be attributed to the soil chemical properties of the sites used in both years. The composition of N, P, K and organic matter in 2014 at both locations was more than that of 2013. The better performance of 2014 than 2013 could also be attributed to taro leaf blight severity which was more in 2013 than in 2014. At 12 weeks after planting (WAP), all the growth traits were not significantly influenced by location. Umudike expressed better performance for leaf area while Igbariam was better in terms of number of leaves/plant and number of secondary shoots/plant. Genotypic effect was highly significant for all the measured traits. This is a good indication of the existence of considerable genetic variation among the genotypes used in this study and suggests the possibility of improving these traits through selection (Nwofia and Ojimelukwe, 2012). NCe 005 and NCe 001 consistently had the lowest values of most of the growth traits measured indicating poor growth development of these genotypes. NCe 003 had the broadest leaves but did not differ from NCe 011 and NCe 010. NCe 001 had taro plants with the smallest leaves. This result disagrees with Mare (2009) who found that there was no significant cultivar effect on leaf area per taro plant.

Table 16: Corm length (cm) of some taro genotypes in two locations over 2 years

		Location					
		Umudike			Igbariam		
Genotype		2013	2014	Mean	2013	2014	Mean
NCe 001		4.947	4.650	4.798	5.417	5.230	5.323
NCe 002		6.867	6.433	6.650	5.483	5.913	5.698
NCe 005		7.567	7.450	7.508	6.643	7.360	7.002
NCe 010		6.163	5.777	5.970	5.580	6.257	5.918
NCe 011		7.170	6.480	6.825	6.210	6.300	6.255
NCe 012		5.800	5.927	5.863	5.253	6.063	5.658
NCe 003		6.303	6.393	6.348	6.460	6.350	6.405
Ede Orba		6.160	6.050	6.105	5.710	6.460	6.085
	Mean	6.372	6.145	6.259	5.845	6.242	6.043
$LSD_{0.05}$	Year = ns						
	Location = ns						
	Genotype = 0.4087***						
	Year x Location = ns						
	Year x Genotype = ns						
	Location x Genotype = 0.7002*						
	Year x Location x Genotype = ns						

Table 17: Tuber Yield (t/ha) of some taro genotypes in two locations over 2 years

		Location					
		Umudike			Igbariam		
Genotype		2013	2014	Mean	2013	2014	Mean
NCe 001		4.81	12.73	8.77	3.60	3.92	3.76
NCe 002		9.12	10.81	9.97	4.96	5.80	5.38
NCe 005		3.54	7.96	5.75	2.17	3.29	2.73
NCe 010		9.06	13.53	11.30	6.91	9.19	8.05
NCe 011		5.46	10.48	7.97	5.43	6.21	5.82
NCe 012		6.58	13.36	9.97	5.43	6.97	6.20
NCe 003		7.45	15.01	11.23	6.59	7.75	7.17
Ede Orba		5.71	8.32	7.02	5.31	6.96	6.14
	Mean	6.47	11.52	9.00	5.05	6.26	5.66
$LSD_{0.05}$	Year = 1.697*						
	Location = 0.706***						
	Genotype = 0.992***						
	Year x Location = 1.348**						
	Year x Genotype = 1.585*						
	Location x Genotype = 1.407**						
	Year x Location x Genotype = 2.092**						

This difference in observation could be due to difference in sources of genotypes between the study of Mare (2009) and this present study. Higher significant leaf area accrues more area of photosynthetic process and thus, enhances tuber formation and root development (Mcfarland and Barko, 1990). NCe 003 had the highest number of leaves/plant but did not differ significantly from that of NCe 012 and NCe 010. Significant cultivar effect on number of leaves/plant was reported by Mare (2009). NCe 010 showed superiority in terms of number of secondary shoots/plant. Year significantly affected the severity of TLB at 1, 4, and 6 WAS. In almost all the stages, severity was more in 2013 than 2014. As a fungal disease, this may be due to the rainfall distribution in both years. More rainfall was experienced in 2013 than in 2014. Annual rainfall of above 2000 mm spread relatively evenly throughout the year has been reported by Rural Industries Research and Development Corporation (RIRDC) (2003) as a “common blight-enhancing condition”. This could have affected the overall yield performance of the taro genotypes in 2013. A report in Papua New Guinea has shown that TLB significantly affect yield (Deo *et al*., 2009). Location significantly influenced the severity of TLB at 1 and 4 WAS. The severity was higher in Igbariam at 1WAS while it was higher in Umudike at the remaining stages. This variation in severity could be explained by rainfall distribution across the two locations around the month of July. According to Bandyopadhyay *et al*., (2011), TLB is widespread during the rainy season (April to November) in all taro-growing areas of Nigeria. Genotypes also played a significant role in the severity of TLB in most stages of

assessment. NCe 001 consistently had the highest severity followed by NCe 005. "Ede Orba" had the least severity at 4WAS while NCe 012 had the least severity at 6WAS. Singh *et al*. (2006) reported that there were significant differences among eight taro lines examined for TLB resistance at different locations.
Significant year effect was observed in cormel weight and taro yield. ReyesCastro *et al.* (2005) reported similar result for yield. Even though there was no significant year effect in most of the traits, 2014 was consistently better for yield and all the associated traits studied. Similar to growth traits, the superiority of 2014 over 2013 may be attributed to the soil chemical properties of the sites used in both years. The composition of NPK and organic matter in 2014 at both locations was more than that of 2013. Most of the yield attributes of taro were not significantly affected by location except yield. The result corroborates the work of Onwueme and Charles (1994) who found that the yield of taro varies from place to place, depending on the cultivation methods and the environmental conditions. Umudike showed superiority for yield and the associated yield traits. These differences could be attributed to variations in the soil properties and rainfall distribution in both locations.
High significant genotypic effect was observed for yield and its associated traits. This is an indication of the existence of considerable genetic variation among the genotypes used in this study and suggests the possibility of improving these traits through genotypic selection (Nwofia and Ojimelukwe, 2012). NCe 005 and NCe 001 consistently had the lowest values of yield and almost all the associated traits measured except in corm and cormel length where NCe 005 was better. Among the yield attributes measured, NCe 003 had highest corm weight. NCe 011 had the heaviest cormels, which was followed by NCe 003. Genotype also affected number of cormels per plant and this is in accordance with the work of Mare (2009). NCe 010 had the highest number of cormels and differed significantly from NCe 002 that followed. NCe 010 had the best taro yield performance followed by NCe 003. This could be attributed by its exhibition of relatively high leaf area value, number of secondary shoots/plant and number of cormels/plant which are major indices of high yield. Ivancic and Lebot (2000) has reported yield as the most important goal in all taro programmes. Plant height and leaf area are important factors correlated with taro yield (Simin *et al*., 1995; Lebot *et al*., 2006). The variation in yield among the genotypes corroborates with the findings of Ogbonna *et al*. (2015).
Significant year x genotype, location x genotype and year x location x genotype interactions were not found for most of the yield attributes measured but were significant for yield. Year x genotype interaction was significant for cormel weight and corm weight while location x genotype interaction was significant for corm length and corm weight. Year x location x genotype interaction was significant cormel weight. Possible causes for the genotype x location interaction in yield as suggested by ReyesCastro *et al.* (2005) could be specific climatic factors at the different locations that make a ranking shift between genotypes from one location to the other. High significant year x location x genotype interaction observed for yield clearly demonstrates that genotype by environment interaction across the environments clearly plays a significant role in this crop. This is line with the work of Anley *et al.* (2013). Tripathi *et al.* (1987) also reported that the significant GxE interaction indicates that genotypes (G) responded differently to a change in the environment.

CONCLUSION
This study has shown that agro-ecological location influences taro yield and Umudike is recommended as the most appropriate location for taro cultivation in these zones. The significant Year x location x genotype interaction observed for yield showed that the genotypes exhibited differential response to different locations over both years. Genotypes had strong influence in all the characters considered in this study with NCe 010 consistently giving the best performance in yield and few of the studied traits followed by NCe 003 which was the second-best performer for yield and best performer for cormel circumference, leaf area, number of leaves/plant and corm weight. They also expressed relatively lower severity of TLB. This indicates that these two genotypes show relatively good adaptation to the soil and climatic conditions of these agroecosystems under TLB outbreak.

REFERENCES
Anley, W., Zeleke, H. and Dessalegn, Y. 2013. Genotype x environment interaction of maize (*Zea mays* L.) across North Western Ethiopia. *Journal of plant breeding and crop science,* 5(9):171-181.

Bandyopadhyay, R., Sharma, K., Onyeka, T.J., Aregbesola, A. and Lava Kumar, P. 2011. First report of Taro (*Colocasia esculeta*) leaf blight caused by *Phytophthora colocasiae* in Nigeria. *Plant Disease*, 95(5): 618.

Chiejina, N. N, Ugwuja, F. N. 2013. Incidence of *Phytophthora colocasiae* leaf blight disease of cocoyam in Nsukka area of South Eastern Nigeria. *Journal of Botanical Research,* 4(1): 21–24.

Deo, P. C., Tyagi, A. P., Taylor, M., Becker, D. K., and Harding, R. M. 2009. Improving taro *(Colocasia esculenta var. esculenta)* production using biotechnological approaches. *South Pacific Journal of Natural Science*, 27: 6-13.

Food and Agricultural Organization. 2007. FAOSTAT Statistics Division of the Food and Agriculture Organization, http://faostat.fao.org.

Food and Agricultural Organization. 2013. Food and Agricultural Organization (FAO) production statistics.

GenStat 2009. GenStat 12th Edition. VSN International bioscience software and consultancy. Hemel Hempstead, HP2 4TP UK.

Green, B. O. and Oguzor, C. 2009. Application of Biosystematic and Nutritional Parameters in the Delimitation of Family Areceae. *African Journal of Basic & Applied Sciences,* 1(1-2): 44-48.

Grubben, G. J. H. and Denton, O. A. 2004. *Vegetables. Plant Resources of Tropical Africa.* PROTA.

Ivancic, A. and Lebot, V. 2000. The genetics and breeding of taro. Séries Repères, CIRAD, Montpellier, 194p.

Lebot V, Ivancic A, Quero-García, J 2006 Comparative performance of local and introduce cultivars of taro (*Colocasia esculenta* (L.) Schott) in Vanuatu. In: Proceedings of the 14thSymposium of the International Society for Tropical Root Crops. Thiruvananthapuram, Kerala, India, 20–26 November, 2006 (ISTRC in press).

Mare, R. 2009. Taro (*Colocasia esculenta* (L). Schott) yield and quality response to planting date and organic fertilization. Unpublished *PhD Thesis*. School of Agricultural Sciences and Agribusiness University of KwaZulu-Natal Pietermaritzburg.

Matthews, P. J. 1990. The origins, dispersal and domestication of taro. Unpublished *PhD Thesis*, Australian National University, Canberra, Australia, 407p.

Mbong, G. A, Fokunang C. N, Lum A, Fonterm R, Bambot Mb, Tembe EA 2013 An overview of*Phytophthora colocasia* of cocoyams: A potential economic disease of food security in Cameroun. *Journal of Agriculture and Food Sciences*, 1(9):140 – 145.

Mcfarland D. G and Barko J. W. 1990. Temperature and Daylenght effects on Growth and Tuber formation in Hydrilla. *J. Aquat. Plant Manage,*. 28: 15–19.

Ndon, B. A., Ndulaka and Ndaeyo, N. U. 2003. Stabilization of Yield parameters andsome Nutrient Components in Cocoyam Cultivars with time in Uyo, S/E Nig. *Global Journal of Agric. Sc.,* 2(2): 74-78.

NEST (Nigeria Environmental Study Action /Team). 1991. *Nigeria's Threatened Environment: A National Profile. Nigeria*: NEST.

Nwofia, G. E. and Ojimelukwe, P. 2012. Variability in proximate, mineral and vitamin contents of *Carica papaya* (L.) leaves, fruit pulp and seeds. *Intl. J. Med. Arom. Plants,* 2(1): pp. 90-96.

Ogbonna, P. E., Orji, K. O., Nweze, N. J. and Opata, P. I. 2015. Effect of planting space on plant population at harvest and tuber yield in taro (*Colocasia esculenta* L). *African Journal of Agricultural Research,* 10(5): 308-316.

Ojiako, I. A, Asumugha, G. N, Ezedimma, C and Uzokwe N E. 2007 Analysis of Production Trends in the Major Root and Tuber Crops in Nigeria, 1961-2005. *Res in crops,* 8(2): 371-380.

Okpul, T., D. Singh, M. E. Wagih and D. Hunter. 2002. A review of Taro (*Colocasia esculenta*(L). Schott) genetic resources of Papua New Guinea. *Papua New Guinea Journal of Agriculture,Forestry and Fisheries.* 45 (1&2): 33-45.

Onwueme, I. C. 1999. Taro cultivation in Asia and the Pacific. FAO PAR publication 1996/16. Bangkok, Thailand.

Onwueme, I. C. and Charles, W. B. 1994. Tropical root and tuber crops. Production, perspectives and future prospects. FAO Plant Production and Protection Paper 126, pp. 139–161.

Onyeka, J. 2014. Status of Cocoyam (*Colocasia esculenta* and *Xanthosoma spp*) in West and Central Africa: Production, Household Importance and the Threat from Leaf Blight. Lima (Peru). CGIAR Research Program on Roots, Tubers and Bananas (RTB).

ReyesCastro, G., Nyman, M. and Rönnberg-Wästljung, A. C. 2005. Agronomic performance of three cocoyam (*Xanthosoma violaceum* Schott) genotypes grown in Nicaragua. *Euphytica*, 142: 265-272.

Rural Industries Research and Development Corporation (RIRDC). (2003). Select markets for taro, sweet potato and yam- a report for the rural industries research and development(RIRDC Publication No. 03/052).

Shange, L.P. 2004. Taro (*Colocasia esculenta* (L.) Schott) production by small-scale farmers in KwaZulu-Natal: Farmer practices and performance of propagule types under wetland and dry land conditions. Unpublished *MSc. Thesis*. University of KwaZulu-Natal, Pietermaritzburg.

Simin, A., Ivancic, A., Okpul, T., Ososo, E.K. and Maima, J. 1995. Relationship between yield componentsand other important plant characteristics of taro (*Colocasia esculenta*). Taro Seminar, PapuaNew Guinea University of Technology, Lae, 26–30 June, 1995.

Singh, D., Guaf, J., Okpul, T., Wiles, G. and D. Hunter, D. 2006. Taro (Colocasia esculenta) variety release recommendations for Papua New Guinea based on multi-location trials.*New ZealandJournal of Crop and Horticultural Science*, 34(2): 163-171.

Tripathi, B. K., Gill, S. S. and Misra, G .P. 1987. Genotype x environment interaci'ion and stability analysis in sugarcane *(Saccharum* spp. Hybrids). *Indian J. Genet* ,47(3): 271-274.

Van Wyk, B.E. 2005. Food plants of the world: Identification, culinary uses and nutritional value. Briza Publications, Pretoria, South Africa.