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Original Research

Soil Characteristics, Microbial Compostion of Plot, Leaf Count and Sprout Studies of Cocoyam (*Colocasia* [Schott] and *Xanthosoma* [Schott], Araceae) Collected in Edo State, Southern Nigeria

Ogwu, M.C*and Osawaru, M.E

Department of Plant Biology and Biotechnology, Faculty of Life Sciences, University of Benin, Benin City, Nigeria

Abstract

Cocoyam (*Colocasia* [Schott] and *Xanthosoma* [Schott]) belongs to the family Araceae and Alismatales order. The aim of this study is to collect cocoyam from the eighteen Local Government Areas (LGA) in Edo state and describe them based on leaf count and sprout percentage. Using random stratified sampling methods, cocoyam were collected. Field trials were conducted in the Experimental Garden, Department of Plant Biology and Biotechnology. The soil was subjected to analysis at the Soil Science Department, University of Benin to determine its characteristics and suitability for the growth of these arable crops.. The soil microbial count was 6.25 X 10^5 and 1.34 X 10^5 cfu/g for bacterial and fungi respectively. Phosphorus, potassium, manganese and copper were low, zinc and iron were moderate whereas soluble salts were high in the soil. Results of percentage sprout indicate accessions from Esan south east had highest percentage sprout of 92.0 % while accessions from Owan East had the lowest percentage sprout value of 33.3 %. Visible sprouting was observed beginning from seventh day after planting. Leaf count reveals varied levels of significance at P ≥ 0.5 from March to July. Highest mean count of 1.35±0.85 was obtained from Egor in March. In April, highest mean count of 5.42±2.00 was obtained from Esan North East and 8.58 ± 1.69 as highest mean count in May was obtained from Ovia North East. Owan West had the highest mean count in June and July with 14.50±2.84 and 15.50±1.76 respectively. This study suggests great amount of cocoyam diversity. Their leaves is an important vegetable which may be available all year round. The cocoyam accessions can sprout with minimum requirements. More investigation is required to elucidate their constituents of these uncommon vegetable.

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***Corresponding Author:**

Ogwu, M.C

E-mail:

matthew.ogwu@uniben.edu

INTRODUCTION

Colocasia [Schott] and *Xanthosoma* [Schott] most often called Cocoyam are important tropical crops because of their cormels and leaves. These genera belong to the monocotyledonous family Araceae. According to Olson (2013), the Araceae also called Arum or Aroid family is made up of 104 genera and 3300 species. APG (2009) include the family in the order Alismatales. The origination of these genera from various tropical regions and the characteristics of naturalized species indicate an inherent plasticity for adaptation to different climatic conditions and habitat types (Serviss *et al.,* 2000). The family is represented by 18 genera and 60 species in West Africa (Gill, 1988). *Alocasia, Colocasia*, *Dieffenbachia*, *Lemna*, *Pistia* and *Xanthosoma* are some of the important genera with economic and aesthetic roles. Others examples are *Anthurium*, *Asterostigma*, *Caladium*, *Dracontioides*, *Dracontium*, *Heteropsis*, *Monstera*, *Montrichardia*, *Philodendron*, *Rhodospatha*, *Scaphispatha*, *Spathicarpa*, *Spathiphyllum*, *Syngonium*, *Taccarum*, *Typhonium*, *Urospatha* and *Zomicarpa* (Boyce *et al.,* 2012). Members of the family are either terrestrial or aquatic herbs or shrubby, with erect climbing or prostrate orientation, vines and epiphytes; floating aquatics which can be monoecious and dioceous (Boyce *et al.,* 2012; Olson, 2013). Many species are also epiphytes (Ekanem and Osuji, 2006). They may be described as cosmopolitan with greatest diversity in the tropics and subtropics.

Cocoyam is naturally a perennial crop, but for practical purposes may be harvested after 5 - 12 months of growth (Onwueme, 1978). Its growth and developmental cycle goes through three main periods. Immediately after planting, there is a rapid increase in shoot growth until about six months after planting. There after growth of the shoot (mostly leaves) as well as the total dry weight of the shoot declines. This pattern of growth holds true for both the *C. esculenta* and *X. sagittifolium* (Onwueme, 1978). Propagation of cocoyam is generally through vegetative means using tubers or the apical portions of large tubers harvested at maturity. Segmentation of the setts is possible as in yams. In regions where the growing season

is interrupted by dry periods, *Xanthosoma* species are usually first multiplied by means of shoots and later transplanted (Janseens, 2001). In cases where shoots are used for multiplication instead of corms, yields are usually higher compared to using lateral buds. However, shoots have to be pruned to encourage growth of the corms (Williams *et al.,* 1982; Janseens, 2001). The shoot of the cocoyam plant consists mainly of the leaves which arise in a whorl from the apex of the corm. The terminal bud remains close to this apex. The sagittate or peltate leaves are the most prominent aerial organ of the plant. Each leaf consists of a long erect petiole and large lamina (Onwueme, 1978; Williams *et al.,* 1982). The leaf lamina is large, thick, entire and globrous. It is more or less rounded, except for a slight indentation at the base and pointedness at the top. The petiole may be one metre long and is thick along its entire length, but thicker at the base than near the attachment to the lamina. The petiole is solid throughout its length, but replete with large air spaces, which functions as conduits for aeration of the subterranean organs when the plant is grown under swampy or flooded conditions (Onwueme, 1978; Williams *et al*., 1982; Janseens, 2001).

Unisexual flowers may appear shortly after planting, sometimes before any of the leaves have expanded from the leaf axils or the centre of the cluster of unexpanded leaves with two or more inflorescences (Mwenye, 2009). Male flowers are at the top with the female underneath. Sterile flowers are located in between the pistillate and staminate flowers Purseglove, 1972). The inflorescence of cocoyam is protogamous and pistillate flowers are normally receptive 2 - 4 days before pollen is shed. The spadices are seldom fertile and produce few viable seed (Castro, 2006). Yields are generally higher under flooded conditions, due to the greater ability of the plant to produce suckers, the larger leaf area and the slow rate of leaf senescence (Mwenye, 2009). Cocoyam prefer alluvial soil in hot humid areas or in damp shaded places of tropical rain forests (Green and Oguzor, 2009). The time from planting to harvest varies with genotype and method of cultivation. Its corms are frequently eaten as vegetable and represent an important source of vitamins, especially folic acid more so the blades and petioles of leaves can be preserved or dried, and used as an important food in times of scarcity, petioles and stolons are also eaten fried or pickled while the inflorescence (a flowering stalk) is a delicacy in some food cultures of Asia and the Pacific (Rao *et al.,* 2010).

In many countries, cocoyam leaves, petiole, and flowers can be eaten as vegetables (Seetohul *et al.,* 2008). *Colocasia* leaves are about 30 - 60 cm long and 45 cm wide) and velvety soft to touch. The sagittate-ovate or peltate leaves of cocoyam arise alternatively from the main corm in a spiral kind of arrangement. The leaves grow out of the leave stalk of existing leaves just after the death of older, most matured and outermost leaves. This ensures that approximately the same amount/number of leaves are found on a Cocoyam plant at different times/period. The leaves are pigmented with marginal veins and central lobes. Harvested cocoyams are stored by different methods to extend their shelf life for the next planting season and for subsequent use as food (Ugwuoke *et al.,* 2008). Although cocoyam has good nutritional qualities, it is not a nutritionally complete food and cooking of some sort is almost always required to detoxify the corms and leaf parts, and to make them softer and physically palatable (Matthews, 2010). Taro leaf blades contain more protein than corms and are a good source of minerals and vitamins. Cocoyam leaf stems (petioles) are eaten but there is relatively little information on their nutritional qualities and use likewise the stolons and flower heads (inflorescences) especially in Southern China, Southeast Asia and the Pacific Islands (Matthews, 2010). It is a staple food for many people in developing countries in Africa, Asia and the Pacific. Essential amino acid contents are fairly good except for the sulphur containing amino acids such as tryptophan and histidine (Huang *et al.,* 2007).

Cocoyam research and conservation efforts are gaining ground although limited information abounds about the amount and nature of diversity. Their major constraint is due to their recalcitrant status which hampers long term storage. The traditional knowledge base of these crops amongst tribes in Edo state have been documented by Osawaru and Ogwu (2014). Their report suggest Cocoyam ranks high among root and tuber crops and are more popular among poor families. The dearth of data about the crop in most countries has ensured they are more popular among the elderly. The aim of this study is to collect cocoyam from the eighteen Local Government Areas (LGA) in Edo state, cultivate the collections and describe them based on leaf count and sprout percentage. Sprout studies will enable the determination of early and late germinating corms. The study will also fill the vacuum occasioned by paucity of information regarding cocoyam leaves and emergence as well as availability as a vegetable.

MATERIALS AND METHODS

Study Area and Collection of Cocoyam Germplasm

Detailed description of the study area and collection of Cocoyam germplasm have been reported by Osawaru and Ogwu (2014). Eighteen accessions with three replicates were used for this study. For each accession collected, a detailed passport data was recorded (Table 1).

Planting Sites and Agronomic Practices

Planting was done in the Experimental Garden of Department of Plant Biology and Biotechnology, University of Benin. Planting materials was 0.25 Kg of replicated corms (cut setts) at 1m X 1m apart. Randomize block design (RBD) by Remison (2005) was used to establish replicated planting materials at each home garden site. The most important agronomic practice during cultivation was daily wetting with 2 litres of tap water prior to sprouting and leaf production as well as weeding, which was done once every three weeks.

Soil Analysis of the Experimental Plot

About 3.0 Kg of dry surface and subsurface soil was sampled using a hand auger to collect at a depth of 5.0 cm. Composite sampling method was adopted, which involves pooling several smaller subsamples randomly throughout the field, which were then mixed together for one large representative sample that was sent to Laboratory of Soil Science Department, University of Benin in a transparent plastic bag for analysis.

Isolation, Enumeration and Characterization of Soil Bacteria and Fungi

Isolation and enumeration of bacteria were performed by soil dilution plate technique using nutrient agar for total

Table 1: Passport information of Cocoyam accessions

No	Accession Code	LGA	Exact Location/Site	Genera	Status	Long. and lat.
1	ED/NA/ONE001	Ovia North East	Ofunmwengbe	*Colocasia*	Cultivar	6.02 N and 5.08 E
2	ED/OA/OSW001	Ovia South West	Ikoha village	*Xanthosoma*	Weedy	6.23 N and 5.20 E
3	ED/BB/EGR003	Egor	Owode Siluko	*Xanthosoma*	Cultivar	6.35 N and 5.64 E
4	ED/LA/ORD001	Oredo	Ogbe road	*Xanthosoma*	Cultivar	6.36 N and 5.71 E
5	ED/KB/IKB003	Ikpoba Okha	Idogbo	*Colocasia*	Cultivar	6.26 N and 5.67 E
6	ED/RA/UHW001	Uhunmwode	Eyaen village	*Xanthosoma*	Wild	6.45 N and 5.82 E
7	ED/MA/ORH001	Orhionmwon	Abudu	*Xanthosoma*	Wild	6.30 N and 5.80 E
8	ED/EA/ESE001	Esan South East	Ubiaja-Ariah	*Colocasia*	Cultivar	6.64 N and 6.35
9	ED/DA/ENE001	Esan North East	Uromi-Ogbidi	*Colocasia*	Cultivar	6.71 N and 6.31 E
10	ED/CA/ECT001	Esan Central	Irrua	*Colocasia*	Cultivar	6.69 N and 6.24 E
11	ED/FB/EWE003	Esan West	Ekpoma	*Colocasia*	Weedy	6.47 N and 5.92 E
12	ED/JA/IGB001	Igueben	Iduomon	*Colocasia*	Cultivar	6.49 N and 6.18 E
13	ED/AA/AKD001	Akoko edo	Igarra-Itua	*Xanthosoma*	Weedy	7.25 N and 6.13 E
14	ED/IC/ETW005	Etsako West	Aviele-Ubiane	*Xanthosoma*	Wild	7.00 N and 6.29 E
15	ED/GA/ETC001	Etsako Central	Fugar-Ogbona	*Xanthosoma*	Weedy	7.15 N and 6.19 E
16	ED/HA/ETE001	Etsako East	Upland Agenebode	*Colocasia*	Cultivar	7.17 N and 6.51 E
17	ED/PB/OWE003	Owan East	Afuze-Locust road	*Colocasia*	Weedy	7.14 N and 6.12 E
18	ED/QC/OWW005	Owan West	Ovbiokhumrin	*Xanthosoma*	Cultivar	6.93 N and 6.10 E

heterotrophic bacteria counts. Enumeration of different isolates was carried out. Selected colonies of bacteria were transferred from the mixed culture of the plates onto respective agar plates and incubated at 37 ^{0}C for 24 hours. Plates containing pure cultures were stored at 4 ^{0}C until examination. Fungi isolation was done using 1mm of the diluents from 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4} and 10^{-5} dilutions pour plated on sterilized potato dextrose agar for fungi and allowed to solidify before incubating at 28 ± 2 ^{0}C for 72 hours. Colonies that developed were counted and recorded as spore forming unit per of soil (cfu/g) for fungi. The isolates were sub cultured to obtain pure isolates. Isolated fungi were characterized by macroscopic (physical appearance on agar plates) and microscopic techniques (under light microscope) including colour of aerial and substrate mycelia. Thus, comparing them with those of known taxa as described by (Domsch and Gams, 1970). Each isolates was as described by Cowan (1974), Holt *et al*. (1994). The basic identification keys used including Domsh *et al*. (1993) and Barnett and Hunter (1998) using morphological and microscopic characteristics.

Physico-Chemical Properties of Soil

The soil physico-chemical parameters were analysed to determine its characteristics and suitability for cultivation including particle size (Buoyocos, 1951), cation exchange capacity, pH, temperature, electrical conductivity, total nitrogen, potassium and calcium content (Sankaram, 1996), organic carbon content, available phosphorus (Olsen, 1954), moisture content and magnesium content.

Data Analysis

Sprout percentage was recorded by counting accessions within the experimental plot that have emerged. More so, leaves were counted monthly during the study period. The data accrued were subjected to analysis using SPSS version 16. This was done to determine their mean, standard error, standard deviation, single factor ANOVA and Duncan Multiple Range.

RESULTS

Results are presented in Tables 2, 3, 4, 5, 6, 7 and figures 1, 2, 3, 4, 5

Result of the physico chemical properties of the soil are presented in Table 2. The result shows the soil is suitable for cocoyam cultivation.

Table 2: Physico-chemical properties of the soil

Parameters	Value
pH	6.1
Moisture content (%)	0.78
Conductivity (mhos/cm)	20.3
Carbon (%)	0.94
Nitrogen (%)	0.08
Phosphorus (%)	10.83
Sand (%)	92.70
Silt (%)	1.60
Clay (%)	5.70
Sodium (mg/l)	0.23
Potassium (mg/l)	0.16
Calcium (mg/l)	8.52
Magnesium (mg/l)	3.78
Zinc (mg/l)	0.63
Iron (mg/l)	4.03
Manganese (mg/l)	0.03
Copper (mg/l)	≤ 0.1
Soil texture	Sandy or silty (fine textured)

Bacterial and fungal counts of the soil sample are presented in Table 3. Bacterial and fungal counts decreased serially from 10^{-1} to 10^{-5}. Mean bacterial count was higher than those of fungi suggesting higher presence of bacteria.

Table 3: Bacterial and fungal counts

Dilution	Bacterial count	Fungal counts
10^{-1}	182	61
10^{-2}	139	48
10^{-3}	77	29
10^{-4}	43	14
10^{-5}	26	5
Mean counts (cfu/g)	6.25 X 10^5	1.34 X 10^5

Result of cultural, morphology and biochemical characteristics of the bacterial isolates from the soil sample is presented in Table 4. The result shows that convex and low convex were the most common elevation while most margins were entire. Colour varied from cream, yellow, white and green. Most of the isolates were circular. Five of the isolates were gram positive and rod celled while two were gram negative and cocci celled. The

isolates mostly responded negatively to spore staining. Isolates were mostly positive to catalase, Citrate, glucose and urease and negative to lactose, indole, coagulase and oxidase.

Table 4: Cultural, morphology and biochemical characteristics of the bacterial isolates from the soil sample

Characteristics	Isolate 1	Isolate 2	Isolate 3	Isolate 4	Isolate 5	Isolate 6	Isolate 7
Cultural							
Elevation	Convex	Flat	Convex	Low convex	Convex	Convex	Low convex
Margin	Entire	Entire	Entire	Entire	Smooth	Entire	Entire
Colour	Cream	Cream	Yellow	Cream	White	Cream	Green
Shape	Circular	Circular	Circular	Circular	Circular	Circular	Circular
Morphological							
Gram staining	+	+	+	-	+	+	-
Cell type	Rod	Rod	Cocci	Rod	Cocci	Rod	Rod
Cell arrangement	Single	Chains	Single	Single	Chains	Single	Single
Spore staining	-	+	-	-	-	-	-
Biochemical							
Catalase	+	+	+	+	-	+	+
Oxidase	-	-	-	-	-	-	+
Coagulase	-	-	-	-	-	-	-
Urease	+	+	+	-	+	+	+
Indole	-	-	-	-	-	-	-
Citrate	+	+	+	+	+	+	+
Glucose	+	+	+	+	+	-	+
Lactose	-	-	-	+	-	-	-
Suspected Organism	*Corynebacterium* species	*Bacillus* species	*Micrococcus* species	*Enterobacter* species	*Streptococcus* species	*Arthrobacter* species	*Pseudomonas* species

The result from the cultural and morphological characteristics of fungal isolates are presented in Table 5. Results suggest fungal isolates were mostly colony forming. Colours observed include yellow, grey, creamy, white and dark green. Septate and no septate hypha were also recorded amongst the isolates. The isolates also possessed varied shape and cell structures.

Table 5: Cultural and morphological characteristics of fungal isolates

Cultural	Macroscopic examination	Isolates
White, thick and abundant cottony mycelium	Non-septate sporangiophores, rhizoid, spongiosphore and black sporangium containing hemispherical collumela	*Rhizopus* species
Blackfluffy colonies with reverse side yellow	Septate and branched hyphae and conidia in chains	*Aspergillus niger*
Grey colonies that were large with white border	Long conidiophore consisting of broom like conidia in chains	*Penicillium* species
Medium creamy colonies, convex elevation and entire margin	Spherical cells in clusters with buds	*Saccharomyces* species
Cottony white colony with reverse side colourless	Multi-segmented canoe like spores with branched and segmented conidiophores	*Fusarium* species
White flat colony with reverse side colourless	Non-septate hypae with straight sporangiophore with many spherical spores	*Mucor* species
Dark green, dense wooly colony	Smooth green conidia subglobose to ovoidal	*Trichoderma* species

Figure 1 show percentage sprout of cocoyam accession collected from eighteen Local Government Areas (LGA) of Edo state. Result indicate accessions from Esan south east had highest percentage sprout of 92.0 % while accessions from Owan East had the lowest percentage sprout value of 33.3 %. Most of the accessions recorded more than 50 % sprout.

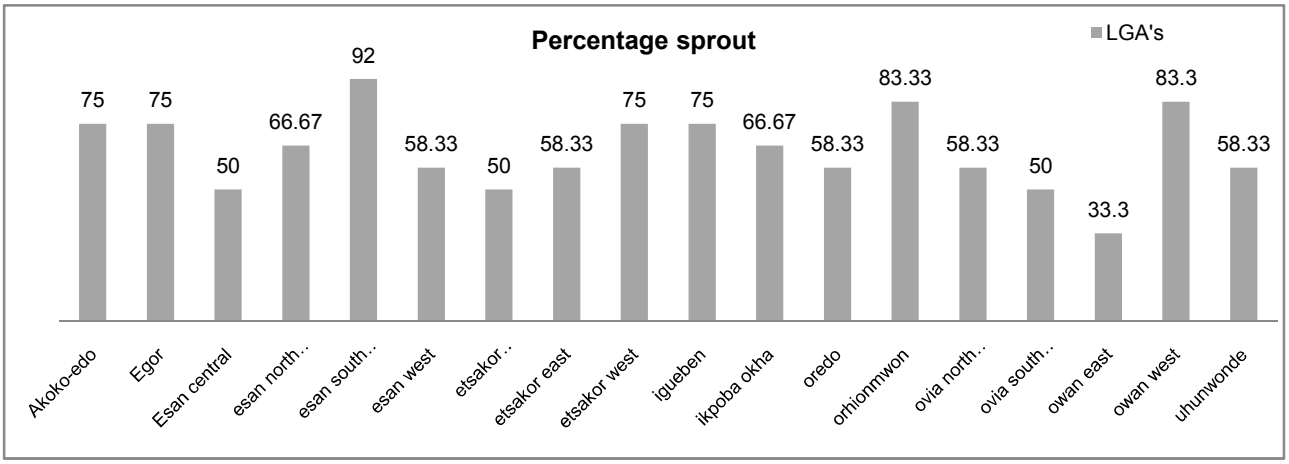

Figure 1: Percentage sprout of cocoyam accessions collected from 18 Local Government Areas (LGA) of Edo state

Leaf count (from March to July) of cocoyam accession collected from Edo state is presented in Table 6. Mean leave count increased monthly with highest values obtained in July and lowest in March. Values also formed more homogenous subsets in July.

The analysis of variance for leaf count during the study is presented in Table 7. The result show the different significant levels obtained.

Table 6: Leaf count of Cocoyam (*Colocasia* and *Xanthosoma*) accessions collected from Edo state

No	LGA	March	April	May	June	July
1.	Akoko Edo	0.92 ± 0.33^{a}	4.25 ± 1.13^{abc}	7.00 ± 0.25^{abc}	9.33 ± 0.68^{ab}	13.57 ± 1.73^{cd}
2.	Egor	1.33 ± 0.85^{a}	4.25 ± 1.42^{abc}	6.92 ± 1.21^{abc}	8.08 ± 1.71^{a}	9.17 ± 1.41^{abc}
3.	Esan Central	0.83 ± 0.44^{a}	2.67 ± 0.30^{abc}	7.67 ± 1.67^{abc}	6.75 ± 0.87^{a}	11.17 ± 1.45^{bcd}
4.	Esan North East	0.58 ± 0.22^{a}	5.42 ± 2.00^{c}	6.00 ± 0.14^{abc}	7.83 ± 1.20^{a}	8.28 ± 0.98^{ab}
5.	Esan South West	1.00 ± 0.50^{a}	4.50 ± 0.50^{abc}	7.75 ± 1.50^{abc}	8.67 ± 2.00^{a}	10.89 ± 0.95^{bcd}
6.	Esan West	1.33 ± 0.33^{a}	3.69 ± 1.55^{abc}	3.83 ± 1.10^{a}	5.25 ± 0.66^{a}	9.13 ± 1.11^{abc}
7.	Etsako Central	0.00 ± 0.00^{a}	1.92 ± 0.08^{a}	6.17 ± 2.05^{abc}	7.92 ± 2.57^{a}	13.83 ± 0.93^{cd}
8.	Etsako East	0.75 ± 0.50^{a}	3.00 ± 0.87^{abc}	4.50 ± 0.63^{ab}	5.17 ± 0.46^{a}	5.67 ± 0.33^{a}
9.	Etsako West	0.17 ± 0.08^{a}	2.17 ± 0.30^{ab}	5.00 ± 1.00^{abc}	7.08 ± 1.24^{a}	10.33 ± 0.88^{abc}
10.	Igueben	0.42 ± 0.22^{a}	3.58 ± 0.17^{abc}	4.33 ± 0.74^{ab}	6.42 ± 0.68^{a}	11.33 ± 0.44^{bcd}
11.	Ikpoba Okha	0.58 ± 0.17^{a}	4.50 ± 0.63^{abc}	7.17 ± 1.21^{abc}	7.75 ± 1.28^{a}	12.00 ± 1.00^{bcd}
12.	Oredo	0.92 ± 0.58^{a}	5.58 ± 0.46^{c}	4.75 ± 1.01^{abc}	7.90 ± 1.43^{a}	9.67 ± 1.76^{abc}
13.	Orhionmwon	0.25 ± 0.25^{a}	3.42 ± 0.68^{abc}	5.75 ± 0.50^{abc}	8.33 ± 2.42^{a}	10.33 ± 1.76^{abc}
14.	Ovia North East	0.25 ± 0.25^{a}	2.38 ± 0.32^{abc}	8.58 ± 1.69^{cd}	10.50 ± 2.93^{ab}	9.33 ± 1.45^{abc}
15.	Ovia South West	0.25 ± 0.25^{a}	1.92 ± 0.44^{a}	6.17 ± 1.67^{abc}	9.85 ± 0.35^{ab}	15.33 ± 1.01^{d}
16.	Owan East	1.17 ± 0.42^{a}	5.25 ± 1.47^{bc}	11.75 ± 1.61^{d}	10.23 ± 2.51^{ab}	12.83 ± 2.92^{bcd}
17.	Owan West	1.17 ± 0.42^{a}	2.58 ± 0.30^{abc}	5.67 ± 0.83^{abc}	14.50 ± 2.84^{b}	15.50 ± 1.76^{d}
18.	Uhunmwode	1.00 ± 0.52^{a}	4.83 ± 1.08^{abc}	8.17 ± 0.60^{bc}	10.83 ± 1.20^{ab}	11.50 ± 1.61^{bcd}

^{abcd} = Duncan Multiple Range (DMR) means for groups in homogenous subsets;
LGA = Local Government Areas where the Cocoyam accession are collected

Table 7: Analysis of variance for leaf count (ANOVA) from March to July of Cocoyam (*Colocasia* and *Xanthosomas*) germplasm in Edo state

Month		Sum of Squares	df	Mean Square	F	Sig.
	Between Groups	9.047	17	0.532		
Leaf count March	Within Groups	16.458	36	0.457	1.164	0.339
	Total	**25.506**	**53**			
	Between Groups	76.150	17	4.479		
Leaf count April	Within Groups	94.158	36	2.615	1.713	0.086
	Total	**170.308**	**53**			
	Between Groups	183.954	17	10.821		
Leaf count May	Within Groups	147.167	36	4.088	2.647	0.007
	Total	**331.120**	**53**			
	Between Groups	251.897	17	14.817		
Leaf count June	Within Groups	317.713	36	8.825	1.679	0.094
	Total	**569.610**	**53**			
	Between Groups	319.089	17	18.770		
Leaf count July	Within Groups	220.189	36	6.116	3.069	0.002
	Total	**539.277**	**53**			

The leaf count of cocoyam accessions in March is presented in Figure 2. Accessions from Esan West and Etsako Central had the highest and lowest leaf counts respectively. Accessions from Orhionmwon, Ovia North East and Ovia South West had same leaf count values.

Result leaf count of cocoyam accessions in April is presented in Figure 3. Accessions from Akoko Edo and Egor had similar leaf count values. Lowest count was recorded from Etsako Central and Ovia South West while Oredo accessions had highest count values.

Result of cocoyam leaf count in May is presented in Figure 4. Highest and lowest leaf count was obtained from Owan West and Esan West respectively. Most accessions had leaf count values around the median point.

Result of leaf count for June is presented in Figure 5. Highest count was recorded from Owan West accessions. Esan West and Etsako East had lowest leaf count values.

The result of leaf count from cocoyam accessions in July is presented in Figure 6. Etsako East had lowest count values. Highest count was recorded from Owan West and Ovia South West.

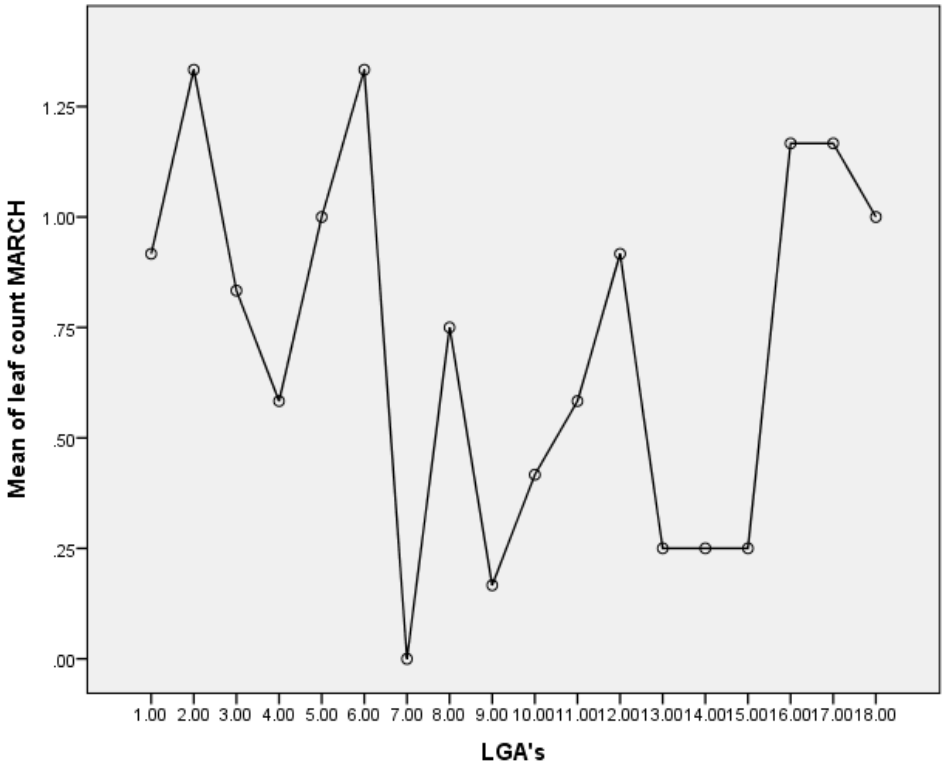

Figure 2: Leaf count of accession in March

Key: 1.00 = Akoko Edo, 2.00 = Egor, 3.00 = Esan Central, 4.00 = Esan North East, 5.00 = Esan South West, 6.00 = Esan West, 7.00 = Etsako Central, 8.00 = Etsako East, 9.00 = Etsako West, 10.0 = Igueben, 11.00 = Ikpoba Okha, 12.00 = Oredo, 13.00 = Orhionmwon, 14.00 = Ovia North East, 15.00 = Ovia South West, 16.00 = Owan East, 17.00 = Owan West, 18.00 = Uhunmwode

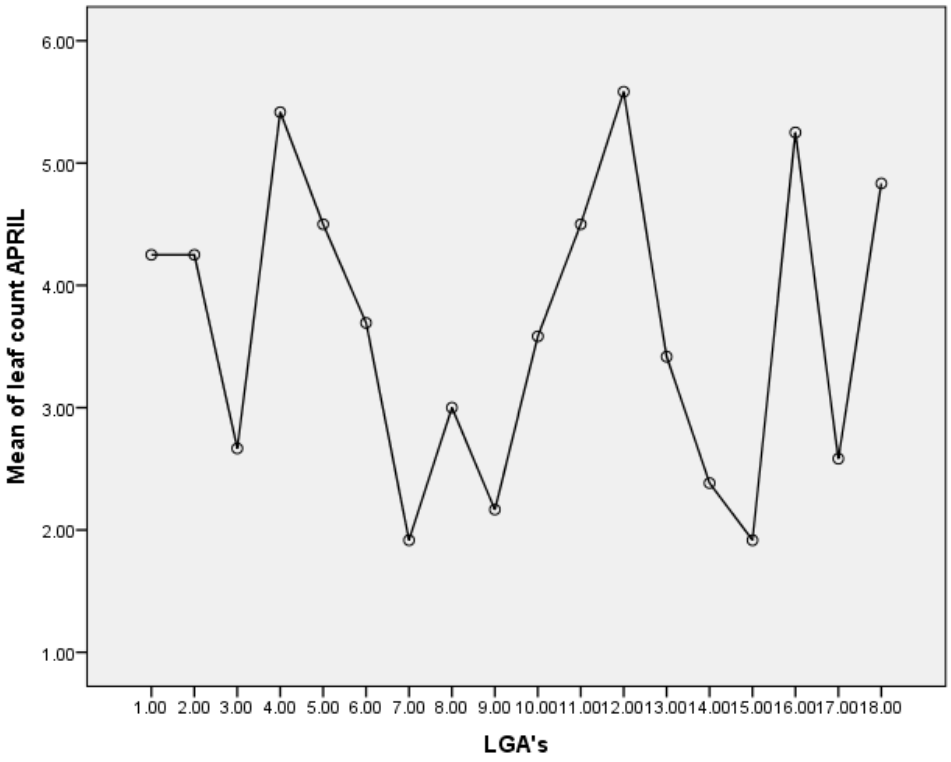

Figure 3: Leaf count of cocoyam accession in April

Key: 1.00 = Akoko Edo, 2.00 = Egor, 3.00 = Esan Central, 4.00 = Esan North East, 5.00 = Esan South West, 6.00 = Esan West, 7.00 = Etsako Central, 8.00 = Etsako East, 9.00 = Etsako West, 10.0 = Igueben, 11.00 = Ikpoba Okha, 12.00 = Oredo, 13.00 = Orhionmwon, 14.00 = Ovia North East, 15.00 = Ovia South West, 16.00 = Owan East, 17.00 = Owan West, 18.00 = Uhunmwode

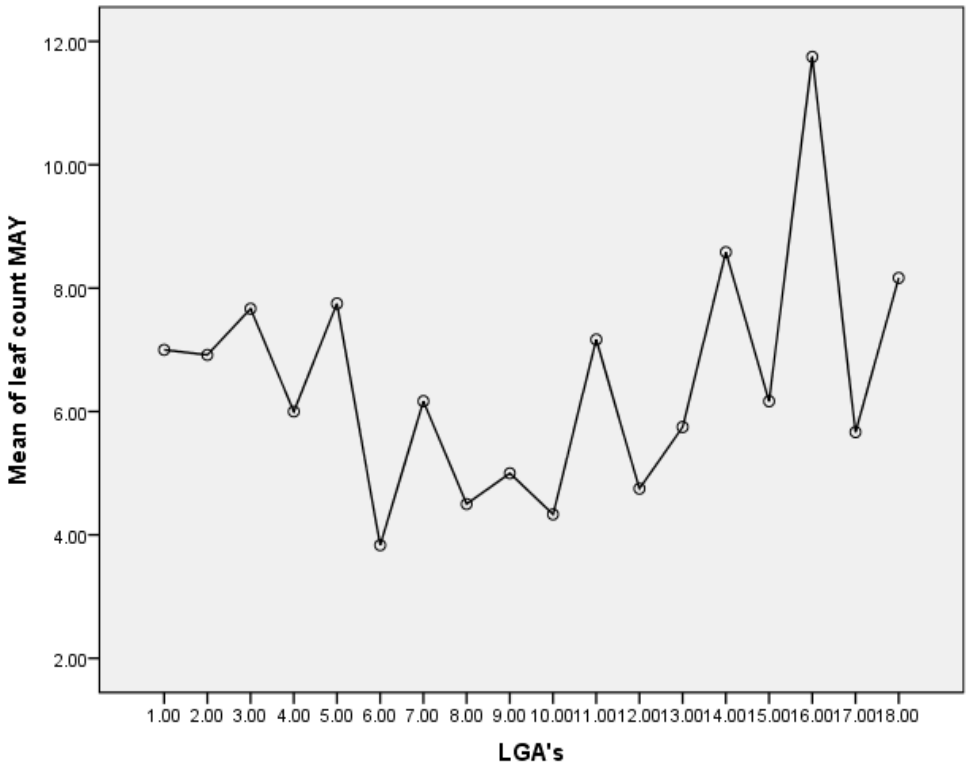

Figure 4: Leaf count of cocoyam accession in May

Key: 1.00 = Akoko Edo, 2.00 = Egor, 3.00 = Esan Central, 4.00 = Esan North East, 5.00 = Esan South West, 6.00 = Esan West, 7.00 = Etsako Central, 8.00 = Etsako East, 9.00 = Etsako West, 10.0 = Igueben, 11.00 = Ikpoba Okha, 12.00 = Oredo, 13.00 = Orhionmwon, 14.00 = Ovia North East, 15.00 = Ovia South West, 16.00 = Owan East, 17.00 = Owan West, 18.00 = Uhunmwode

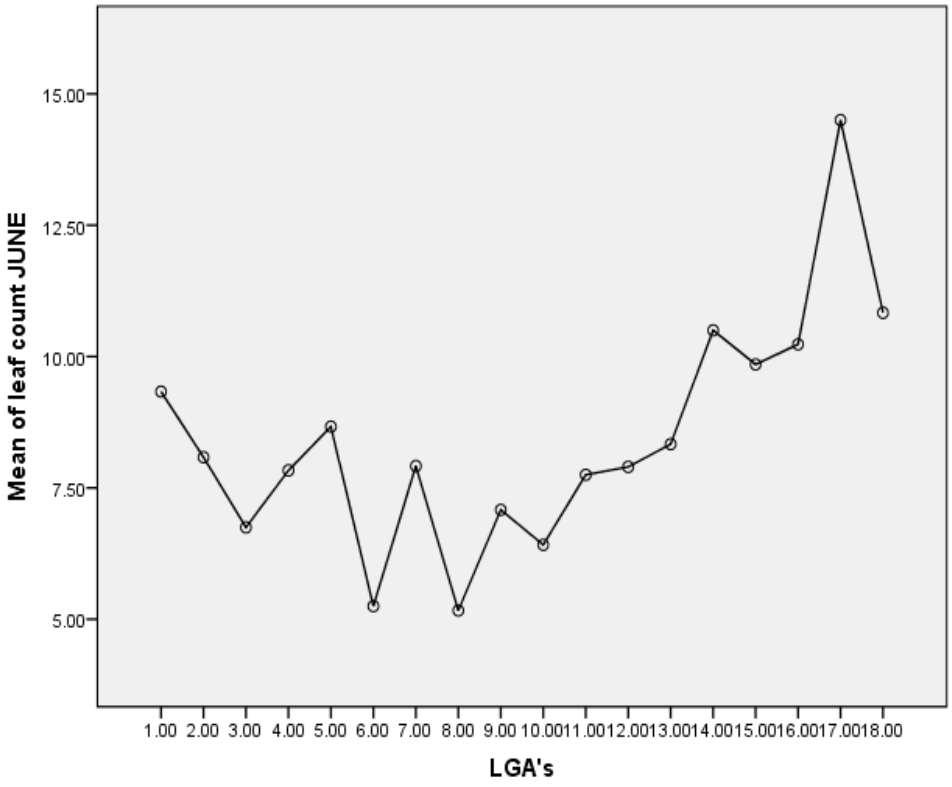

Figure 5: Leaf count of cocoyam accession in June

Key: 1.00 = Akoko Edo, 2.00 = Egor, 3.00 = Esan Central, 4.00 = Esan North East, 5.00 = Esan South West, 6.00 = Esan West, 7.00 = Etsako Central, 8.00 = Etsako East, 9.00 = Etsako West, 10.0 = Igueben, 11.00 = Ikpoba Okha, 12.00 = Oredo, 13.00 = Orhionmwon, 14.00 = Ovia North East, 15.00 = Ovia South West, 16.00 = Owan East, 17.00 = Owan West, 18.00 = Uhunmwode

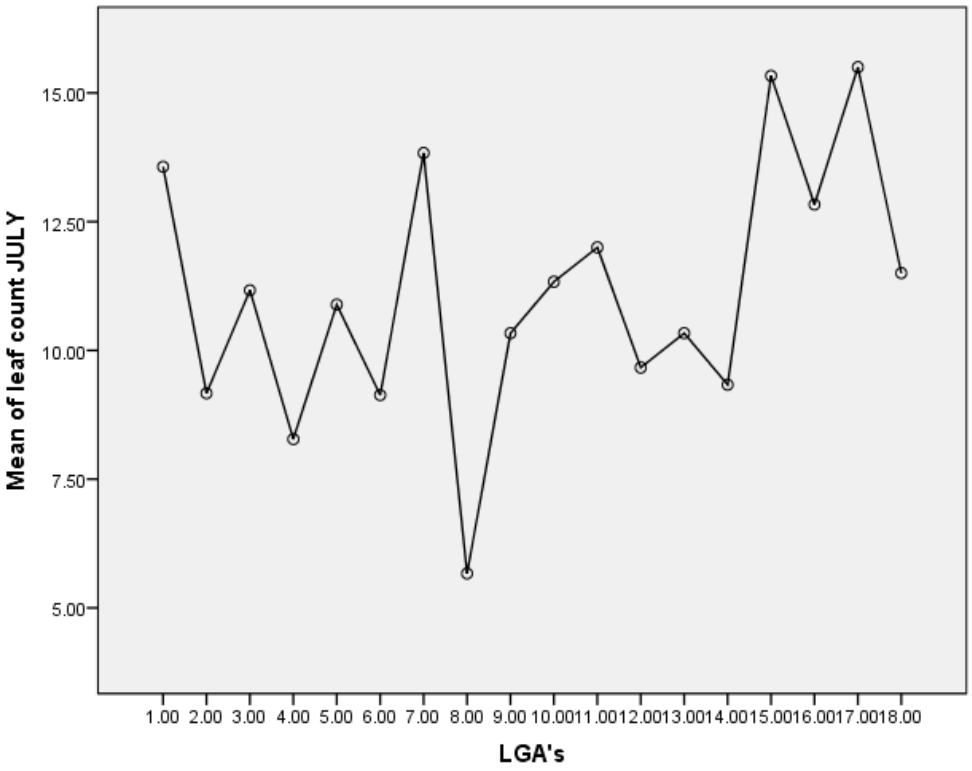

Figure 6: Leaf count of cocoyam accession in July

Key: 1.00 = Akoko Edo, 2.00 = Egor, 3.00 = Esan Central, 4.00 = Esan North East, 5.00 = Esan South West, 6.00 = Esan West, 7.00 = Etsako Central, 8.00 = Etsako East, 9.00 = Etsako West, 10.0 = Igueben, 11.00 = Ikpoba Okha, 12.00 = Oredo, 13.00 = Orhionmwon, 14.00 = Ovia North East, 15.00 = Ovia South West, 16.00 = Owan East, 17.00 = Owan West, 18.00 = Uhunmwode

DISCUSSION

Leaf count and sprout percentage of two genera of Cocoyam in Edo state was investigated. The report of Osawaru and Ogwu (2014) suggest cocoyam leaves are consumed as vegetables in Edo state. In addition to providing a place for crops to grow, soil is the source for most of the essential nutrients required by the crop (Baker, 2013). Hence, it is essential to chemically extracts and measure most of the elements essential to plant nutrition as well as pH (Hardy *et al.,* 2013). Baker (2013) opined that high yields of top-quality crops require an abundant supply of sixteen essential nutrient elements. Based on Olsen *et al.* (1953), it can be inferred that the levels of phosphorus and potassium in the soil is in the low and very low range respectively. Both are considered important nutrient although phosphorus has been implicated as a water pollutant. Crops vary in their response to soluble salt concentration in the soil. The value obtained for electrical conductivity suggest it is very high for Cocoyam and most other crops. Using the standards of Self (2010) the values obtained for Manganese (Mn) and Copper (Cu) can be considered low while Zinc (Zn) and Iron (Fe) are in the marginal range for dryland crop production. The pH value obtained from the soil analysis suggest the soil is slightly acidic. According to Herrera (2013) most crops will grow satisfactorily on soils with a pH ranging from 6.2 to 8.3 although crops susceptible to iron and zinc deficiencies may be affected at pH levels above 7.5. The electrical conductivity of the soil is high crops but no visible sign of its effects including signs of reduced growth, foliage burn or chlorosis were observed. Hence, it can be suggested that Cocoyam can tolerate moderate to high saline contents in soil. Leaching can decrease the salinity hazard if soil permeability is adequate (Herrera, 2000). High levels of leaching was observed in certain portion of the experimental plot. The amount of sodium in the soil can be considered low.

According to Herrera (2000) fine textured soil often have structural and infiltration problems. It was observed during the study that some portion of the experimental plot were often flooded after heavy rains especially during the rainy season. This is capable of leaching available soil nutrient rendering them unavailable for the Cocoyam root. The soil nitrogen is in the low range as well. Mineral soils require a higher pH to neutralize exchangeable aluminium so that plant growth is not affected. Since mineral-organic and organic soils contain less exchangeable aluminium due to their lower mineral content, a lower pH can be maintained without any detrimental effects to crop production (Hardy *et al.,* 2013).

A variety of soil-related microbial pathogens cause serious human disease and their growth are typically favoured by specific soil characteristics and may involve complex life cycles. Soil fungi are a diverse group of microorganism with tens of thousands of species identified so far (Juo and Franzlueba, 2003). Microbes are the unseen majority in soil and comprise a large portion of life genetic diversity (van der Heijden *et al.,* 2008). There are more microbes in a teaspoon of soil than there are people on the earth (Hoorman and Islam, 2010). The study suggests that there are more fungi than bacteria population in the soil of the experimental plot. Their roles are evident in plant productivity, organic matter decomposition, nutrient recycling as well as regulation of plant diversity and community composition and overall soil quality (van der Heijden *et al.,* 2008; Hoorman and Islam, 2010; Hill *et al.,* 2000). Soil microorganism is affected by

climate and temperature as their populations double with every 10 degree Fahrenheit change in temperature (Hoorman and Islam, 2010). The development of effective methods for studying the diversity, distribution, and behaviour of microorganisms in soil habitats is essential for a broader understanding of soil health (Hill *et al.,* 2000). *Rhizopus* species which are isolated are known to inhibit the growth of other fungus and are fast growing and along with *Mucor* are frequent infectious agents. More so, *Fusarium* is opportunistic pathogen causing cutaneous and subcutaneous infections. *Pennicillium* and *Aspergillus* are common environmental fungi, which are also capable causing disease. They are also essential in biotechnology and food microbiology (Gupta *et al.,* 2012). *Trichoderma* have also found application as biocontrol agents due to their high reproductive capacity, ability to survive under very unfavorable conditions, efficiency in the utilization of nutrients, capacity to modify the rhizosphere, aggressiveness against phytopathogenic fungi, and efficiency in promoting plant growth and defense mechanisms (Giniger, 2007). They also have remarkable abilities to mobilize and take up soil nutrients. Saccharomyces species recorded from the soil has also been reported to support the growth of other soil microrganisms especially bacteria due to their organic acids and vitamin. The following bacteria isolates Enterobacter, Streptococcus and Pseudomonas are opportunistic pathogens. Streptococcus might have gotten to the soil through contamination. *Corynebacterium*, *Bacillus*, *Anthrobacter* and *Micrococcus* are usually associated with the soil flora but their high amount suggests favourable condition for their growth in the experimental plot. They are mostly associated with saline soil (Chen *et al.,* 2004).

Various descriptions of tuber-head exist based on its position and shape with its increasing recognition as an organ/bud that produce the vine, roots and tuber(s) during visible vegetative growth (Hamadina, 2012). This role was exploited in this study to cultivate the collected accession. Some of the accessions were planted as tuber head while others were as portions of the corm (tuber). Sprouting was visible in some of the accessions on the experimental plot as early as 1 week after planting. Although prior to their cultivation the tuber head of some of the collected cormels and corms were already showing visible signs of emergence and growth. To distinguish tuber-head from corms, Hamadina (2012) referred to it as headless tubers while those with intact Tuber-head are called intact tubers and defined it as the corm-like structure attached to the proximal region of the tuber. The ethnobotanical survey and collection mission reveal no special preference is accorded the tuber-head of cocoyam corms and cormels during the planting season by the farmers. This is because the tuber-head cannot be sufficient to generate enough plant materials. Hence, along with portions of the mother corms and selected cormels are used for Cocoyam cultivation in Edo state. Little is known concerning the changes in carbohydrate accumulation during dormancy and sprouting in major tuber crops (Panneerselvam and Jaleel, 2008). Although study by Ravi *et al.* (2009) on *Amorphophallus* (Araceae) suggest that the portion used for planting affect sprouting by extending or reducing the number of days to emergence. A tuber cut into seed pieces will sprout earlier than one which is uncut. The use of phytohormones to enhance the process is also practicable. Management and crop improvement techniques could also be devised to manipulate cocoyam canopy architecture, leaf production, planting distance, planting pattern, and timing of operations (Valenzuela *et al.,* 1991).

The time of emergence (sprouting) of new shoot depends on the dormancy status of the planting material, which when complete before materials are planted will emerge as soon as it is planted (Ravi *et al.,* 2009).Sprouting indicates the commencement or ongoing process of renewed vegetative growth of corms after period of dormancy. From the observations of Hamadina (2012) sprouts forms on the tuber, mostly from the head region, of headless tubers and micro-tubers in *Dioscorea* spp. Some genus in the Araceae exhibit dormancy for 3-4 months after harvest and as a result planting and harvesting are done during specific periods in the year (Ravi *et al.,* 2009). Planting of cocoyam accessions was done as recommended by the cocoyam farmers in the state. This is usually during the start of the rainy season (January – March) while harvesting is done within the harmattan season when water is less available and most cocoyam shown signs of stress especially reduced growth. Sprouting is initiated by the apical meristem of the corms or cormels. For most economically important Araceae members including cocoyam planting materials are generated from harvested materials. According to Ravi *et al.* (2009) greater portion of (about 25 %) of the harvested produce is again lost as source of planting materials. This is more common in traditional agriculture system as opportune by home garden where loss of harvested materials is enormous. There is need for improvement in this sector because in Nigeria as well as other tropical and subtropical developing countries, it contributes a large percentage of their food security. More so many household depends on it for their income security. Panneerselvam and Jaleel (2008) opined that sprouts mostly occur around the head portion from the point of detachment from the mother plant because biochemical changes during dormancy (to inhibit the bud growth) and during sprouting (to initiate the bud growth) may take place at the region of bud (head portion).

Cocoyam shows numerous leaf stems sprouting from the upright tuberous root stock, or corm (de Lomas *et al.*, 2012). Large dark green velvety leaves (60 cm long and 35 cm wide) are supported by thick succulent leaf stalks (petioles), with colouring from green through red to a deep purple. Stalks are attached near the centre of the leaf base. Under ideal growing conditions, a single plant can grow up to 2.4 m tall with a similar spread in width. The leaves show alternate to round arrangement around the mother corm. Leaves retain an almost constant number throughout its growing period as leaf fall is followed by growth and spreading out of another leaf. Outer most and most mature leaves arranged towards the outside are more likely to fall off. Growth of new leaves occur at the center of the leaf arrangement arising 90^0 from the corm. The new leaves do not spread out until the older one has fallen off. The leaf count showed different levels of significance throughout the period of study (March – July). Young leaves are eaten as vegetable. They are used in soup preparation because of its impact on the taste. More so, these are obtained from home gardens as they are rarely sold in the market in Edo state. The status of moisture content especially in the vegetables roughly indicates the degree of maturity among most of the food crops including leafy vegetables' (Awasthi and Singh, 2000). The highest difference was observed in July and

April. The lowest difference was recorded in June. The leaf count values obtained within the study period varied as no particular accession retained high or low values throughout. The monthly variation could be credited to the varied amount of rainfall during the period of study. There is scarcity of data and research work on leaf count of cocoyam in literatures making it difficult to effectively compare results obtained. During storage, sprouting is one of main problems that can affect the quality of stored tuber crops and cause major losses especially for higher temperature storage (Cheema, 2010). A range of sprout-control chemicals are common but rarely used because of health implications.

CONCLUSIONS

In conclusion, this study has shown that there exists great amount of cocoyam diversity in southern Nigeria. Their leaves is an important vegetable which can be available all year round. The cocoyam accessions in Edo state can readily sprout with minimum requirements. More investigation is required to elucidate the constituents of these uncommon vegetables. Presently no formal *in situ* conservation approach exists nationwide and should be given serious consideration by mobilizing and coordinating the activities of small scale farmers.

Conflict of Interest

Conflict of interest none declared.

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