Response of Thirteen Tannia Accessions to Variations in Planting Date in the Humid Tropics

Abstract: The objectives of the study were to assess the inter-relationship between growth, yield, nutritional and anti-nutritional responses of thirteen tannia (Xanthosoma sagittifolium L.) accessions to planting date (May, June and July) in the humid tropics. Tannia corms and leaves are veritable sources of dietary fibre and starch, also essential minerals and vitamins; hence its value for security and as a cash crop for people in the humid tropics. A two-year 13-genotype × 3 planting date factorial arranged rain-fed field experiment in randomized complete block design with three replications was carried out during the 2014 and 2015 cropping seasons at Michael Okpara University of Agriculture, Umudike, Nigeria. The results indicated that planting date and accession influenced growth and yield of tannia, an indication of differential responses of the thirteen accessions to the planting dates (May, June and July). The results suggest that May is the most appropriate planting date; accessions planted during this month had the highest yields. The interaction between planting date and tannia accession was significant for some traits (number of leaves per plant and cormel weight per plant) in both years and significant for plant height, pseudo-circumference and corm weight (2014); leaf area and tannia yield (2015). The correlation analysis showed good selection characters in plant height, pseudo-stem circumference, leaf area, number of leaves per plant, corm weight, corm circumference, cormel weight and cormel circumference for high yielding varieties, while nutritional analysis (crude protein, carbohydrate, phosphorus, potassium, calcium, tannin and oxalate) exhibited lower concentrations in processed corms relative to unprocessed. The corm yield of the tannia accessions ranged from 1.49 to 13.48 Mt.ha⁻¹ in 2014 and 2.72 to 8.50 Mt.ha⁻¹ in 2015 and best four accessions judged by interaction between tannia accession and date of planting was 13 (Ikaro) > 12 (Idoani) > 3 (Ehor) > 10 (Idasen) in May 2014 compared to accessions 6 (Ewu) > 10 (Idasen) > 12 (Idoani) > 1 (Ikpoba) planted in June 2015. The differences in sequence suggest that both environment and genetic constitution contribute to Tannia yield.

Keywords: Tannia corm yield, nutritional composition, phyto-chemical analysis, proximate analysis

1 Introduction

Tannia (Xanthosoma sagittifolium), which belongs to the family Araceae is a staple food security crop with rich economic and nutritional qualities for many people living in Sub-Sahara Africa, south east Asia and the Malayan archipelagos (Onwueme 1999; Lebot 2009). Tannia is ranked sixth in the world for root crop production after cassava, potato, sweetpotato, yam and taro (Ramesh et al. 2007; Perez 2010).

According to Green (2003) and Chukwu and Nwosu (2008) the highly calorific corms of tannia are rich in carbohydrates and are nutritionally superior to other roots and tubers in terms of digestible crude protein and minerals such as calcium, magnesium, and phosphorus. The starch contained in the large corms is about 98.8 % digestible (Vinning 2003) thereby making it a veritable source of carbohydrate with low potassium and protein. Furthermore, the phyto-chemicals in tannia corms and leaves are toxic or anti-nutritional because of their acridity, a natural defensive against grazing animals (Lebot 2009).

The yield for tannia has remained low (5 to 7 t ha⁻¹) in Africa principally due to seasonal weather variability (Mutualem and WeldeMichael 2013). According to Lebot et al. (2006), one cardinal avenue to increase or at least maintain crop yield in the face of a changing climate is to adjust planting dates of crops. Thus appropriate planting date is one of the most effective and zero cost means of increasing crop yields. Khan et al. (2003) and Yadav et al.
(2007) demonstrated that an ideal planting date is one that maximizes yield by avoiding those stages of growth that coincide with periods of crop sensitivity to temperature or moisture stress. Specific knowledge of crop response to different planting dates within the ecosystem is therefore important to determine the most appropriate planting time for the crop. Lu et al. (2001), Lal (2009) and Jianchu et al. (2001) in their studies submitted that the yield of taro is largely affected by planting date with temperature being the most important factor, though this varies according to accession and the agro-ecology of the area. Studies by Mbouobda et al. (2007) have shown that genetic diversity of tannia is still poorly characterized, although studies on morphological and agronomic characterization tend to suggest a narrow genetic base.

The nutritional importance of any food product depends not only on the nutrient composition but also on the presence of anti-nutritional factors such as tannins and oxalate among others (Agueguia et al. 1992; Onokpise et al. 1999). Processing tannia corms has been reported to improve digestibility, promote palatability, improve keeping quality and also makes corms, roots and tubers safe to eat (FAO 1990; Albihn and Savage 2001). However, there is dearth information on the nutritional status of processed and unprocessed tannia corms in the humid tropics of southern Nigeria. The objectives of this study were, therefore, to determine the growth, yield and yield-component responses of thirteen tannia accessions to three planting dates and the inter-relationships among corm yield and other traits as well as the nutritional and anti-nutritional composition of the accessions.

## 2 Materials and methods

The experiment was conducted at the Department of Agronomy, Michael Okpara University of Agriculture, Umudike teaching and research farm (Lat. 05° 29′ N; Long. 07° 33′ E; Alt. 122 m) in 2014 and 2015 cropping seasons. Umudike is in the humid tropics and has a mean rainfall of about 2177 mm with mean air temperature of about 26°C per annum. The mean sunshine hours during the cropping season (April to December) was 4.2 per day while the relative humidity ranged from 34 to 88 % across the two cropping seasons (Table 1). The rainfall pattern is bimodal and characterized by a long wet season from April to July, which is interrupted by a short dry spell in August and then followed by another short rainy season from September to October tailing into early November. The dry season stretches from early November to March. Meteorological data covering rainfall, temperature, relative humidity and daily sunshine at the experimental site during 2014 and 2015 cropping seasons are shown in Table 1.

Prior to planting, composite top-soil samples to a depth of 20cm were collected the experimental units using a soil auger at a depth of 0 – 20 cm. These samples

| Month   | Rainfall amount (mm) | Temperature (°C) | Relative Humidity (%) | Sunshine (Hrs) | Rainfall amount (mm) | Temperature (°C) | Relative Humidity (%) | Sunshine (Hrs) |
|---------|----------------------|------------------|-----------------------|----------------|----------------------|------------------|-----------------------|----------------|
|         | Max                  | Min              | 0900 Hrs              | 1500 Hrs       |                      | Max              | Min                  | 0900 Hrs       | 1500 Hrs       |
| April   | 78.7                 | 32.2             | 23.5                  | 79             | 66                   | 5.5              | 61.7                  | 33.4           | 23.8           | 78             | 58             | 5.18           |
| May     | 249.2                | 31.9             | 23.4                  | 81             | 69                   | 5.2              | 246.8                 | 32.7           | 23.4           | 81             | 63             | 5.88           |
| June    | 281.8                | 30.5             | 24.2                  | 81             | 74                   | 4.9              | 346.2                 | 29.8           | 23.5           | 87             | 76             | 2.2            |
| July    | 114.9                | 30.0             | 24.0                  | 86             | 79                   | 2.8              | 129.2                 | 27.3           | 22.4           | 88             | 81             | 2.2            |
| August  | 444.2                | 29.6             | 23.3                  | 85             | 78                   | 3.1              | 366.2                 | 29.0           | 24.0           | 87             | 80             | 2.3            |
| September | 405.3              | 29.8             | 22.9                  | 85             | 79                   | 2.8              | 276                   | 29.0           | 23.0           | 87             | 78             | 2.74           |
| October | 165.1                | 31.0             | 23.6                  | 82             | 71                   | 4.2              | 380.2                 | 31.0           | 24.0           | 84             | 74             | 4.63           |
| November| 147.4                | 31.6             | 23.5                  | 81             | 66                   | 3.3              | 49.7                  | 33.0           | 24.0           | 80             | 60             | 6.09           |
| December| 0.0                  | 32.7             | 21.8                  | 65             | 47                   | 5.9              | 0.0                   | 29.5           | 22.9           | 35             | 34             | 6.23           |
| Total   | 1886.6               | -                | -                     | -              | 37.7                 | 1856             | -                     | -              | -              |
| Mean    | 209.2                | 31.0             | 23.4                  | 80.5           | 69.9                 | 4.2              | 206.2                 | 30.5           | 20.7           | 78.5           | 67.1           | 4.2            |

Source: National Root Crops Research Institute Agro-Meteorological Station, Umudike Abia State Nigeria.
were analysed following standard soil science procedures (Table 2). The soil has been classified as sandy loam Ultisol (paleustalt) (USDA classification).

All tannia (*Xanthosoma sagittifolium*) accessions tested were collected from farmers in thirteen communities across five local governments in Edo State and two from Ondo State (Table 3). The experiment was a 13 × 3 factorial arranged in a randomized complete block design and the treatments comprised thirteen tannia accessions and three planting dates (May, June and July). There were thirty nine treatment combinations with three replications. The experimental field was cleared, ploughed, harrowed and ridged using a tractor. Planting was done May 10th, June 12th and July 15th (2014) and May 16th, June 12th and July 10th (2015). The plot size used was 3 x 3 m (9 m²) and the corms were planted at 1 x 1 m intra- and inter- spacing (10,000 plants ha⁻¹). The plots were kept weed free by manual weeding starting three and seven weeks after planting (WAP). 8 WAP mixed fertilizer (N:P:K:Mg 12:12:17:2) was applied at the recommended rate of 400 kg ha⁻¹, meaning that 48 kg N, 48 kg P, 68 kg K and 8 kg Mg were applied.

### 2.1 Data collection

Growth data as follows were randomly collected from a sample of four plants per plot 15 weeks after planting (WAP). This included plant height, measured by meter ruler as the distance from the ground level to the attachment point between the leaf petiole and the lamina of the

| Table 2: Soil physico-chemical properties of experimental sites in 2014 and 2015 cropping seasons |
|-----------------------------------------------|--------|--------|
| **Soil properties**                          | **2014** | **2015** |
| Texture                                      | Sandy clay loam |
| **Physical properties**                       |         |        |
| Sand (%)                                      | 76.40   | 67.20  |
| Silt (%)                                      | 7.40    | 9.00   |
| Clay (%)                                      | 14.20   | 23.80  |
| **Chemical properties**                       |         |        |
| pH (H₂O)                                     | 4.65    | 5.20   |
| Total nitrogen (%)                            | 0.15    | 0.18   |
| Organic carbon (%)                            | 1.69    | 0.50   |
| Organic matter (%)                            | 2.91    | 0.87   |
| Phosphorus (mg·kg⁻¹)                          | 35.20   | 67.80  |
| Calcium (cmol·kg⁻¹)                           | 2.00    | 2.80   |
| Magnesium (cmol·kg⁻¹)                         | 1.20    | 1.60   |
| Potassium (cmol·kg⁻¹)                         | 0.07    | 0.078  |
| Sodium (cmol·kg⁻¹)                            | 0.24    | 0.19   |
| Exchangeable acidity (cmol·kg⁻¹)              | 1.28    | 2.16   |
| ECEC (cmol·kg⁻¹)                              | 4.79    | 6.82   |
| Base saturation (%)                           | 73.24   | 68.35  |

Source: Soil Science Laboratory, National Root Crops Research Institute, Umudike, Nigeria.

| Table 3: Thirteen (13) tannia accessions and their geographical origin (community and geographical coordinates) of the area |
|---------------------------------------------------------------|----------|----------|
| **Accessions**                                                | **Town of provenance** | **LGA** | **State** | **Longitude** | **Latitude** |
| Acc. 1 (Ikpoba)                                               | Ikpoba   | Ovia South | Edo    | 5° 18′ E | 6° 15′ N     |
| Acc. 2 (Isokponba)                                            | Isokponba| Ovia South | Edo    | 5° 18′ E | 6° 15′ N     |
| Acc. 3 (Ehor)                                                 | Ehor     | Uhumwode  | Edo    | 5° 54′ E | 6° 34′ N     |
| Acc. 4 (Uhimwento)                                            | Uhimwento| Uhumwode  | Edo    | 5° 54′ E | 6° 34′ N     |
| Acc. 5(Iruua)                                                 | Iruua    | Esan Central | Edo | 6° 80′ E | 6° 45′ N   |
| Acc. 6 (Ewu)                                                  | Ewu      | Esan Central | Edo | 6° 80′ E | 6° 45′ N   |
| Acc. 7 (Evbukhu)                                              | Evbukhu  | Oredo    | Edo    | 5° 30′ E | 6° 35′ N   |
| Acc. 8 (Ekae)                                                 | Ekae     | Oredo    | Edo    | 5° 30′ E | 6° 35′ N   |
| Acc. 9 (Uselu)                                                | Uselu    | Egor     | Edo    | 6° 14′ E | 7° 15′ N   |
| Acc. 10 (Idasen)                                              | Idasen   | Edo      | Ondo   | 5° 59′ E | 7° 19′ N   |
| Acc. 11 (Uso)                                                 | Uso      | Edo      | Ondo   | 5° 59′ E | 7° 19′ N   |
| Acc. 12 (Idoani)                                              | Idoani   | Ose      | Ondo   | 5° 78′ E | 6° 95′ N   |
| Acc. 13 (Ikaro)                                               | Ikaro    | Ose      | Ondo   | 5° 78′ E | 6° 95′ N   |
highest leaf; the number of leaves per plant, obtained by counting the mean number of leaves on each plant within each 9 m² plot and leaf area, obtained by measuring the length from the sinus to widest point of individual leaves and calculated as follows:

\[ Y = K (LW) \]

where, \( Y \) (leaf area), \( K = \) constant (0.628), \( L \) (length of leaf) and \( W \) (width of leaf) according to (ReyesCastro et al. 2005).

Pseudo-stem circumference of the plants was taken with the aid of a flexible measuring rule.

At harvest, the yield parameters assessed from each 9 m² plot included weight of cormel and corm, circumference of cormel and corm, and fresh corm yield (Mt ha⁻¹). Proximate (protein and carbohydrate), mineral (phosphorus, potassium and sodium) and phytochemical (tannin and oxalate) status of the cormels from each tannia accession were also carried out.

2.2 Nutritional composition

Protein content was determined by the kjeldahl method as described by Chang (2003). Briefly, 0.5 g aliquots of raw (unprocessed) or boiled (processed) corm of each tannia accession were scooped out and mixed with 10 mL of concentrated \( \text{H}_2\text{SO}_4 \) in a digestion flask. A tablet of selenium catalyst was added prior to heating in a fume cupboard. The resulting digest was then diluted to 100 mL in a volumetric flask prior to analysis which involved mixing 10 mL of the digest with an equal volume of 45 % \( \text{NAOH} \) solution in a kjeldahl distillation apparatus. The distillate was collected into 10 mL of 4 % boric acid containing 3 drops of indicator (3 methyl red). A total of 50 mL of these distillates were collected and titrated against 0.02 N ethylenediaminetetraacetic acid (EDTA) to a green to deep red end point. A reagent blank was similarly digested, distilled and titrated. The total \( N \) was determined and the protein content was calculated using the formula below:

\[
\% \text{ Protein} = \% N \times 6.25,
\]

where,
\[
\% N = \frac{(100 \times W \times N \times 14/1000 \times V_t / V_a) \times T \times B}{V_f - V_a}
\]

where, \( W = \) Weight of tannia corm scoop (0.5 g), \( N = \) Normality of the titrant (0.02 N \( \text{H}_2\text{SO}_4 \)), \( V_t = \) Total digest volume (100 mL), \( V_a = \) Volume of digest analyzed (10 mL), \( T = \) Titre value, \( B = \) Blank titre value.

The carbohydrate contents of the tannia corm of the accessions were calculated using the formula below (James 1995).

\[
% \text{ Carbohydrate} = 100 - % (\text{protein} + \text{fat} + \text{fibre} + \text{ash} + \text{moisture content}).
\]

2.3 Mineral composition

Phosphorus in the sample was determined by the vanadomolybdate (yellow) spectrometry method (James 1995). A one millilitre sample extract was dispensed into a test tube. Identical volumes of a standard phosphorus solution or water, were put into other test tubes to serve as standard and blank, respectively. The tube contents were mixed with an equal volume of vanado-molybdate colour reagent. They were left to stand for 15 minutes at room temperature before their absorbance was measured using a Jenway electronic spectrophotometer at wave length 420 nm. Measurements were taken with the blank at zero.

Phosphorus content was given by the formula:

\[
P (\text{mg / 100 g}) = \frac{(100 \times W \times A_n / A_s \times C \times (V_f / V_a))}{V_t / V_a}
\]

where,
\[
W = \text{Weight of sample},
A_n = \text{Absorbance of the test sample},
A_s = \text{Absorbance of standard solution},
V_t = \text{Total volume of filtrate},
V_a = \text{Volume of filtrate analysed},
C = \text{Concentration of the standard in mg / mL}.
\]

Potassium and sodium were determined by flame photometry method (James 1995). The photometer was set up according to the manufacturer’s instruction. One millilitre of prepared potassium and sodium standard solutions were aspirated into the machine and sprayed over the non-luminous butane gas flame. The potassium and sodium emissions (having been appropriately filtered) from different test concentrations were recorded to construct a standard curve. Subsequently, the optical density emissions recorded from each of the samples were compared against those in the curve to extrapolate the quality of potassium and sodium in the sample.

2.4 Phyto-chemical composition

The tannin content of the corm was determined using the Folin Dennis spectro-photometric method (Pearson 1976) in
which 2 g of the powdered sample was mixed with 50 mL of distilled water and shaken for 30 minutes. The mixture was filtered and 5 mL of the filtrate measured into a 50 mL volumetric flask and diluted with 3 mL of distilled water. Similarly 5 mL of standard tanuric acid solution and 5 mL of distilled water were added separately. 1 mL of Folin-Dennis reagent was added to each of the flasks followed by 2.5 mL of saturated sodium carbonate solution. The content of each flask was made up to mark and incubated for 90 minutes at room temperature. The absorbance of the developed colour was measured at 760 nm wavelength with the reagent blank at zero. The process was replicated in triplicate to obtain the mean. The tannin content was calculated as shown below.

\[
\text{% tannin} = \left( \frac{100}{W} \times \left( \frac{A_u}{A_s} \times \left( \frac{C}{100} \times \left( \frac{V_f}{V_a} \right) \right) \right) \right) \times D,
\]

where,

- \( W \) = weight of sample analyzed,
- \( A_u \) = Absorbance of the test sample,
- \( A_s \) = Absorbance of standard solution,
- \( C \) = Concentration of standard in mg / mL,
- \( V_f \) = Total volume of filtrate,
- \( V_a \) = Volume of filtrate analysed,
- \( D \) = Dilution factor where applicable.

The level of oxalate in the corms of the thirteen tannia accessions was determined following the titrimetric method of Day and Underwood (1986) in which 150 mL of 15 N \( \text{H}_2\text{SO}_4 \) was added to 5 g of the pulverized sample and the solution was gently stirred intermittently with a magnetic stirrer for 30 minutes and then filtered using Whatman No. 1 filter paper. Twenty five mL of filtrate was collected and titrated against 0.1 N KMnO\(_4\) solution until a faint pink colour appeared and persisted for 30 seconds.

### 2.5 Statistical Procedures

The variables assessed were subjected to analyses of variance using SAS statistical software (SAS Institute 2007) to estimate accession and planting date main effects. Interactions between crop characters were measured with tannia accession and planting date as fixed variables in each year analysis. The differences in means were tested with F-tests (LSD) at \( P \leq 0.05 \) according to Obi (2002). Pearson correlation coefficients between tannia corm yield and other plant attributes were calculated using the PROC CORR of SAS (SAS Institute 2007) and the significance between them tested by referring to the standard table (Snedecor and Cochran 1980) with \( n - 2 \) degrees of freedom, where \( n \) is the total number of observations.

### Ethical approval

The conducted research is not related to either human or animal use.

### 3 Results

Analysis of variance in both years (Table 4) indicated that the main effects (planting date and tannia accession) were generally affected all the tested variables (plant height, number of leaves/plant, leaf area and pseudo-stem circumference) in both seasons; the only exceptions being pseudo-stem circumference in 2014, and plant height /leaf area in 2015 that were non-significantly (\( P>0.05 \)) affected by tannia accessions. The interaction between accession and planting date affected all the tested variables except leaf area (2014) and plant height and pseudo-stem circumference (2015). Across the planting date as a main factor; plant height, number of leaves per plant, and pseudo-stem circumference of tannia in both cropping seasons were highest when tannia accessions were planted in May compared with the other planting dates. Plant height ranged from 41.25 to 51.01 cm (2014) and 29.3 to 46.41 cm (2015); accession 10 (Idason) had the highest number of leaves per plant and leaf area in 2014 cropping season. but this trend was not apparent n the 2015 cropping season. In both years, there was significant variation in pseudo-stem circumference with accession 1 (Ikpoba), exhibiting the biggest values amongst the different accessions.

#### 3.1 Plant height and pseudo-stem circumference

The interaction between tannia accessions and planting date (Table 5) significantly (\( P<0.05 \)) affected plant height of tannia in 2014. Tannia accessions planted in May were taller compared with same accessions planted in June or July. Accession 3 (Ehor) closely followed by Accessions 7 (Evbukhu) and 4 (Uhimwento) planted in May were the tallest tannia accessions among the thirteen evaluated in the study while accession 13 (Ikaro) planted in July gave the shortest plants. The same trend was recorded in pseudo-stem circumference with accession 3 (Ehor) under May planting exhibiting the largest pseudo-stem circumference compared with the other treatments, especially accession 9 (Uselu) under July planting date.
The interaction between tannia accession and planting date (Table 6) significantly affected the number of leaves per plant in both cropping seasons but leaf area in 2015 only. The number of leaves per tannia plant ranged from 2.83 to 7.00 (2014) and 2.56 to 16.44 (2015) while leaf area ranged from 170 to 1053 per cm² in 2015 cropping season. Accession 1 (Ikpoba) planted in June had the highest number of leaves per plant in 2014 while accession 3 (Ehor) had the highest number of leaves per plant under May planting in 2015. However, accession 3 (Ehor) had a small leaf area (smaller by 32.4% than that for accession 1 (Ikpoba), which exhibited the highest leaf area when planted in June 2015. Furthermore leaf area, of the

**Table 4: Genotype and planting date effect on vegetative growth of tannia at 15 WAP\(^1\) in 2014 and 2015 cropping seasons**

| Treatment          | 2014          | 2015          |
|--------------------|---------------|---------------|
|                    | Plant height  | Leaf area     | Pseudo-stem circumference |
|                    | (cm)          | (cm\(^2\))    | (cm)                      |
| Planting date (PD) | Number of leaves/plant | Leaf area (cm\(^2\)) | Pseudo-stem circumference (cm) |
| May                | 55.21         | 10.24         | 870                        | 18.78         | 46.93         | 5.500          | 809             | 19.18          |
| June               | 42.39         | 4.67          | 354                        | 11.82         | 43.28         | 5.135          | 616             | 15.86          |
| July               | 36.65         | 4.59          | 303                        | 10.14         | 31.13         | 4.081          | 344             | 10.97          |
| Mean               | 44.75         | 6.50          | 509                        | 13.58         | 40.45         | 4.905          | 589             | 15.34          |
| LSD\(_{(0.05)}\)   | 3.199         | 0.643         | 119.6                      | 2.978         | 5.560         | 1.0128         | 278.9           | 4.713          |
| Tannia Accessions (TA) |              |               |                            |               |               |                |                 |
| Acc. 1 (Ikpoba)    | 42.26         | 5.74          | 459                        | 12.86         | 48.84         | 5.806          | 684             | 19.37          |
| Acc. 2 (Isokponba) | 46.18         | 4.85          | 539                        | 13.75         | 41.25         | 4.806          | 782             | 17.32          |
| Acc. 3 (Ehor)      | 51.01         | 7.67          | 434                        | 14.62         | 46.41         | 5.472          | 656             | 17.63          |
| Acc. 4 (Uhimwento) | 47.76         | 6.76          | 401                        | 13.40         | 41.34         | 5.028          | 555             | 15.06          |
| Acc. 5 (Irrua)     | 44.98         | 5.96          | 507                        | 12.52         | 44.78         | 5.278          | 701             | 16.96          |
| Acc. 6 (Ewu)       | 43.42         | 4.72          | 412                        | 12.13         | 39.80         | 5.583          | 525             | 15.66          |
| Acc. 7 (Evbukhu)   | 46.31         | 4.43          | 508                        | 14.17         | 43.71         | 5.833          | 570             | 17.23          |
| Acc. 8 (Ekae)      | 44.46         | 6.85          | 543                        | 13.02         | 43.10         | 5.250          | 603             | 15.27          |
| Acc. 9 (Uselu)     | 43.55         | 5.56          | 443                        | 13.13         | 41.21         | 5.000          | 589             | 14.76          |
| Acc. 10 (Idasen)   | 41.25         | 7.84          | 623                        | 14.12         | 29.30         | 4.222          | 529             | 13.51          |
| Acc. 11 (Usa)      | 42.42         | 8.20          | 529                        | 13.79         | 32.38         | 3.583          | 411             | 10.82          |
| Acc. 12 (Idoani)   | 46.90         | 9.50          | 562                        | 14.46         | 33.45         | 3.686          | 418             | 11.1           |
| Acc. 13 (Ikoro)    | 41.89         | 6.41          | 657                        | 14.57         | 40.25         | 4.222          | 636             | 14.69          |
| Mean               |                |               |                            |               |               |                |                 |
| LSD\(_{(0.05)}\)   | 6.495         | 2.245         | 157.5                      | ns            | ns            | 0.9494         | ns              | 4.379          |
| PD x TA            | 11.040        | 3.762         | Ns                         | 4.713         | ns            | 1.7783         | 436.4           | ns             |
| ANOVA              |                |               |                            |               |               |                |                 |
| Main effects       | ***           | ***           | ***                        | **            | ***           | *              | *               | *              |
| PD                 | *             | ***           | *                          | ns            | ns            | ***            | ns              | **             |
| TA                 | ***           | *             | ns                         | ns            | ***           | ns             | ***             | ns             |
| Interaction effects| PD x TA       | **            | Ns                         | *             | *             | *              | *               | ns             |

Data analyzed with Least Squares Means and means separated with LSD.

Ns, non-significant; *, significant at \(P < 0.05\); **, significant at \(P < 0.01\); ***, significant at \(P < 0.001\). WAP\(^1\) = Weeks after planting.

### 3.2 Number of leaves and leaf area

The interaction between tannia accession and planting date (Table 6) significantly affected the number of leaves per plant in both cropping seasons but leaf area in 2015 only. The number of leaves per tannia plant ranged from 2.83 to 7.00 (2014) and 2.56 to 16.44 (2015) while leaf area
Table 5: Effect of interaction between planting date and tannia accessions on plant height and pseudo-stem circumference of corm in 2014 cropping season

| Tannia accessions | Plant height (cm) | Pseudo-stem circumference (cm) |
|-------------------|-------------------|-------------------------------|
|                   | x May | June | July | x May | June | July |
| Acc. 1 (Ikpoba)   | 57.5  | 35.13| 34.15| 19.80 | 8.94 | 9.83 |
| Acc. 2 (Isokponba)| 54.78 | 42.45| 41.31| 17.49 | 12.93| 10.84 |
| Acc. 3 (Ehor)     | 63.81 | 44.61| 44.61| 21.79 | 10.11| 11.96 |
| Acc. 4 (Uhimwento)| 58.76 | 44.19| 40.35| 17.89 | 12.37| 9.94 |
| Acc. 5(Irrua)     | 56.94 | 41.09| 36.90| 19.60 | 10.12| 7.82 |
| Acc. 6 (Ewu)      | 54.30 | 40.68| 35.28| 17.70 | 9.34 | 9.33 |
| Acc. 7 (Evbukhu)  | 58.99 | 41.97| 37.96| 19.99 | 11.30| 11.22 |
| Acc. 8 (Ekae)     | 51.08 | 44.45| 37.85| 15.90 | 10.93| 12.23 |
| Acc. 9 (Uselu)    | 55.25 | 39.04| 36.37| 18.97 | 11.87| 8.54 |
| Acc. 10 (Idasen)  | 50.27 | 39.97| 33.52| 19.02 | 12.26| 11.08 |
| Acc. 11 (Uso)     | 46.46 | 46.04| 34.75| 15.01 | 14.99| 11.36 |
| Acc. 12 (Idoani)  | 55.61 | 45.98| 39.11| 20.78 | 12.88| 9.71 |
| Acc. 13 (Ikaro)   | 53.94 | 45.50| 26.22| 20.17 | 15.61| 7.94 |

LSD(0.05) = 11.04  LSD(0.05) = 4.713

Data in interaction analyzed with Least Squares Means and means separated with LSD. Two-way ANOVA

Table 6: Effect of interaction between planting date and tannia accessions on number of leaves/plant in 2014 and 2015, and on leaf area in 2015 cropping seasons

| Tannia accessions | Number of leaves/plant | Leaf area (cm²) |
|-------------------|------------------------|-----------------|
|                   | 2014 | 2015 | 2015  | 2015 | 2015 | 2015 |
|                   | x May | June | July | x May | June | July | x May | June | July |
| Acc. 1 (Ikpoba)   | 6.00  | 7.00 | 4.42 | 9.56  | 3.34 | 4.33 | 773  | 1053 | 226 |
| Acc. 2 (Isokponba)| 5.42  | 5.58 | 3.42 | 7.33  | 2.67 | 4.56 | 1003 | 901  | 444 |
| Acc. 3 (Ehor)     | 6.00  | 6.25 | 4.17 | 16.44 | 3.33 | 3.22 | 712  | 924  | 333 |
| Acc. 4 (Uhimwento)| 5.25  | 5.50 | 4.33 | 12.11 | 3.11 | 5.04 | 585  | 657  | 422 |
| Acc. 5(Irrua)     | 4.83  | 5.67 | 5.33 | 10.22 | 4.11 | 3.55 | 710  | 843  | 552 |
| Acc. 6 (Ewu)      | 6.75  | 4.42 | 5.58 | 7.89  | 3.05 | 3.22 | 900  | 316  | 360 |
| Acc. 7 (Evbukhu)  | 5.42  | 6.25 | 5.83 | 7.00  | 2.61 | 3.67 | 451  | 670  | 526 |
| Acc. 8 (Ekae)     | 5.08  | 5.83 | 4.83 | 12.00 | 2.56 | 6.00 | 974  | 398  | 438 |
| Acc. 9 (Uselu)    | 6.33  | 5.50 | 3.17 | 10.22 | 2.78 | 3.67 | 881  | 682  | 204 |
| Acc. 10 (Idasen)  | 5.58  | 3.83 | 3.25 | 8.89  | 8.44 | 6.18 | 1001 | 409  | 178 |
| Acc. 11 (Uso)     | 4.42  | 5.50 | 3.25 | 8.89  | 8.44 | 6.18 | 1001 | 398  | 438 |
| Acc. 12 (Idoani)  | 5.00  | 3.08 | 2.97 | 11.34 | 10.56| 6.61 | 822  | 263  | 170 |
| Acc. 13 (Ikaro)   | 5.417 | 4.333| 2.917| 10.67 | 5.56 | 3.00 | 1054 | 494  | 360 |

LSD(0.05) = 1.7783  LSD(0.05) = 3.762  LSD(0.05) = 436.4

Data in interaction analyzed with Least Squares Means and means separated with LSD. Two-way ANOVA.
accessions planted in July were low compared with May and June planting dates.

### 3.3 Corm and cormel weight

Analysis of variance (Table 7) indicated that tannia accession and planting date main effects as well as their interaction effect exhibited various degrees of significance on cormel weight per plant in 2014 cropping season while the interaction effect indicated that accession 12 (Ikaani) planted in May had the heaviest cormels (156.80 g) closely followed by accessions 13 and 10 (Ikaro and Idasen) that were also planted in the same month. The trend indicated that in both years, a May planting date increased cormel weight per plant compared to the other planting dates (June and July). Tannia accession by planting date interaction was significant (P < 0.05) in 2014 but not in 2015. Accession 12 (Ikaani) planted in May 2014 had the heaviest corm per plant (heavier by 86% relative to accession 6 (Ewu)) the lightest corm weight per plant following a July, 2014 planting date. With the exception of tannia accession, planting date and interaction between accession and planting date were non-significant (P > 0.05) in 2015. Among the accessions, accession 7 (Evbukhu) exhibited the highest corm weight per plant in 2015 closely followed by accessions 1 (Ikpoba) and 9 (Uselu).<ref>

### 3.4 Corm yield

The effect of planting date and tannia accession on corm yield (Table 8) indicated that planting date significantly affected corm yield in both years in contrast to tannia accession and the interaction effects that affected yield only in the 2015 cropping season. Tannia accessions planted in the month of May gave greater corm yield compared to other planting dates studied, with accession 13 (Ikaani) followed by accessions 12 (Ikaani), 3 (Ehor) 10 (Idasen) and 7 (Evbukhu) in decreasing order in 2014 and accession 6 (Ewu) followed by accessions 10 (Idasen), 12 (Ikaani), 1 (Ikpoba) and 2 (Isokponba) in decreasing order in the (2015) cropping season exhibiting the highest corm yield. The interaction between accession and planting date indicated that accession 11 (Usu) planted in July had the lowest corm yield, (lower by 68% compared with
accession 6 (Ewu) planted in May 2015 which had the highest corm yield.

### 3.5 Inter-relationships between growth and yield characters

The correlation matrix between yield and other attributes (Table 9) indicated that with the exception of corm weight and cormel weight in 2014, corm yield exhibited a highly significant (P≤0.001) and positive association with all the other measured variables (plant height, pseudo-stem circumference, leaf area, number of leaves/plant, corm weight, corm circumference, cormel weight, cormel circumference and corm yield). The correlation coefficients for the same variables ranged from 0.59 to 0.82 and 0.27 to 0.79 in 2014 and 2015 cropping seasons, respectively. The trend was similar amongst all the other variables with the exception of the relationship between corm yield and these variables (corm circumference, cormel circumference and cormel circumference), as well as cormel weight and cormel circumference in 2014 and corm circumference and corm weight in 2015.

### 3.6 Nutritional characteristics of corm accessions

The nutritional and anti-nutritional status of the accessions (Table 10) indicated significant difference (p<0.05) in proximate, mineral and phyto-chemical compositions of unprocessed and processed tannia accessions with unprocessed tannia corms exhibiting greater values in all the attributes analysed relative to the processed accessions. Among the unprocessed accessions, accession 1 (Ikpoba) had the highest amount of crude protein and potassium and tannin compared with the other accessions. Tannia accessions 6 (Ewu), 7 (Evbukhu) and 9 (Uselu) showed carbohydrate amounts that were higher than 38 mg 100 g⁻¹ raw corm while the lowest amount of phosphorus and sodium were seen in accession 5 (Irrua). The oxalate content ranged from 2.35 to 4.55 mg 100 g⁻¹ raw corm with accession 4 (Uhimwento) exhibiting highest values.

The crude protein content in the processed tannia accessions, ranged from 3.46 to 4.89 mg 100 g⁻¹ processed corm, with accession 12 (Idoani) producing the highest amount of crude protein compared with the other accessions. Among the processed tannia corms, accession 7 (Evbukhu) had the highest carbohydrate content, higher
by 23% relative to accession 8 (Ekae) which had the smallest amount of carbohydrate. Among the mineral attributes evaluated, potassium was the most abundant ranging from 138.62 to 154.62 mg 100 g⁻¹ of processed corm with accession 10 (Idasen) having the highest but lowest sodium content. Phosphorus content ranged from 21.94 to 32.84 mg 100 g⁻¹, with accession 1 (Ikpoba) having the highest amount compared to the others. Results from the phyto-chemical analysis of the tannia accessions indicated that accession 10 (Idasen) had the least tannin (0.06 mg 100 g⁻¹) relative to others, however, it exhibited the highest oxalate content (0.45 mg 100 g⁻¹), which was higher by 87% relative to accession 11 (Uso) that also had the lowest oxalate content.

4 Discussion

Previous studies by Lebot et al. (2006) and Omenyo et al. (2013) showed that yield differences due to planting date can be ascribed to variation in weather conditions. This study confirms that rainfall was more abundant in the months of May and June than in July for both 2014 and 2015 cropping season. Also, plants sown earlier had more time for growth under suitable moisture and temperature that tannia required for increased corm yield. Similar studies on two potato cultivars (Kawakami et al. 2006) showed that delaying planting date reduced tuber yield mainly because of a shortened growing period. Furthermore, Balali et al. (2008) who had compared three three planting dates (November, December and February) on mini-tuber production of Marfona potato (Solanum tuberosum cv. Marforna) in South Africa, reported that November was optimal and delay reduced mini-tuber yield significantly.

Although plant height was higher after a May planting date for both years, there wasn’t a very wide difference compared to June planting. Deblonde and Ledent (2001) reported that the taller potato plants observed with May and June planting dates when rainfall was high confirmed that plant height was sensitive to moderate drought conditions and found that plants exposed to low water stress were tallest.

The increased corm and cormel weights after May planting may be attributed to the early increased leaf growth as a result of higher rainfall, temperature and relative humidity during the period. Higher significant leaf area accrued, implies more area of photosynthetic activity hence increased corm formation. In 2014, the leaf area after May planting was almost doubled that of June and July planting dates. These results are in agreement with previous findings by Bussell and Bonin (1998) from their studies on taro (Colocasia esculenta) in New Zealand; (Mcfarland and Barko 1990) on cocoyam in India, and Rinaldi (2003) on sugar beet (Beta vulgaris) in Italy who suggested that increased leaf area due to earlier planting may be associated with higher and amount and longer duration of rainfall, warmer air temperature and higher relative humidity experienced during the juvenile growth period of the crops, which invariably influenced corm yields. Furthermore, the present findings indicate that corm and cormel weight over 2 consecutive years decreased delayed planting. Similarly, studies by Lu et al. (2001) on taro, Khan et al. (2003) on some potato

### Table 9: Correlation coefficients between different growth and yield attributes of tannia accessions (above diagonal) in 2014 and (below diagonal) 2015 cropping seasons

| Year | Plant characteristics | Plant height (cm) | Pseudo-stem circumference (cm) | Leaf area (cm²) | No. of leaves/plant | Corm weight (g) | Corm circumference (cm) | Cormel weight (g) | Cormel circumference (cm) | Corm Yield (Mt·ha) |
|------|----------------------|------------------|-------------------------------|----------------|---------------------|----------------|------------------------|-------------------|-------------------------|------------------|
| 2015 | Plant height (cm)    | 1.00             | 0.85**                       | 0.75**         | 0.61**              | 0.59**         | 0.67**                 | 0.51**            | 0.49**                  | 0.65**           |
|      | Pseudo-stem circumference (cm) | 0.88**         | 1.00                         | 0.87**         | 0.67**              | 0.61**         | 0.71**                 | 0.64**            | 0.57**                  | 0.78**           |
|      | Leaf area (cm²)       | 0.84**           | 0.91**                       | 1.00           | 0.66**              | 0.64**         | 0.72**                 | 0.69**            | 0.59**                  | 0.82**           |
|      | No. of leaves/plant  | 0.83**           | 0.89**                       | 0.75**         | 1.00                | 0.37**         | 0.52**                 | 0.46**            | 0.41**                  | 0.59**           |
|      | Corm weight (g)       | 0.63**           | 0.74**                       | 0.71**         | 0.65**              | 1.00           | 0.04ns                 | -0.06ns           | -0.04ns                 | 0.01ns           |
|      | Corm circumference (cm) | 0.69**          | 0.77**                       | 0.72**         | 0.72**              | 0.17ns         | 1.00                   | 0.63**            | 0.45**                  | 0.79**           |
|      | Cormel weight (g)     | 0.53**           | 0.65**                       | 0.73**         | 0.48**              | 0.29**         | 0.60**                 | 1.00              | -0.05ns                 | -0.01ns          |
|      | Cormel circumference (cm) | 0.49**          | 0.57**                       | 0.62**         | 0.49**              | 0.27**         | 0.55**                 | 0.54**            | 1.00                    | 0.85**           |
|      | Corm Yield (Mt·ha)    | 0.65**           | 0.78**                       | 0.79**         | 0.64**              | 0.27**         | 0.74**                 | 0.71**            | 0.74**                  | 1.00             |

**Ps0.01, ns = not significant (2-tailed).
(Solanum tuberosum) cultivars and Scheffer et al. (2005) on Japanese taro indicated that there was a strong and positive association between weight of corms and tubers on water availability and temperature, which was directly related to planting date. The variation in yield and yield attributes seen among accessions in the present work corroborates the findings of Ogbonna et al. (2015) in their studies on Nigerian taro.

Looking at the inter-relationships between characters in the present work indicated that most exhibited highly significant and positive correlations in both 2014 and 2015. Similarly, Pandey et al. (1996), Fantaw et al. (2014) as well as Paul and Bari (2015) in studies on cocoyam reported a positive and highly significant correlation between growth characters. Also, the strong correlation between these traits suggests that they could be used as selection indices.

### Table 10: Proximate, mineral and phyto-chemical analysis of unprocessed (raw) and processed (boiled) tannia accession corms

| Tannia accession | Proximates | Minerals | Phyto-chemicals |
|------------------|------------|----------|-----------------|
|                  | Crude Protein | Carbohydrate | Phosphorus | Potassium | Sodium | Tannia | Oxalate |
| Unprocessed (Raw) |            |           |              |           |        |        |        |
| Acc. 1 (Ikponba) | 5.74       | 36.81     | 38.73        | 145.84    | 13.57  | 0.84   | 3.77   |
| Acc. 2 (Isokponba) | 4.93       | 34.84     | 36.68        | 165.56    | 11.57  | 0.58   | 4.47   |
| Acc. 3 (Ehor) | 3.85       | 32.96     | 37.87        | 152.71    | 18.29  | 0.81   | 3.46   |
| Acc. 4 (Uhimwento) | 4.14       | 36.89     | 36.63        | 149.21    | 14.79  | 0.73   | 4.55   |
| Acc. 5 (Irrua) | 4.87       | 34.99     | 35.80        | 180.39    | 10.69  | 0.58   | 3.89   |
| Acc. 6 (Ewu) | 3.73       | 38.04     | 41.72        | 174.69    | 12.78  | 0.69   | 3.15   |
| Acc. 7 (Evbukhu) | 4.17       | 38.33     | 40.79        | 158.63    | 11.88  | 0.84   | 2.86   |
| Acc. 8 (Ekae) | 3.63       | 37.11     | 41.71        | 172.71    | 11.37  | 0.65   | 2.90   |
| Acc. 9 (Useleu) | 4.68       | 38.74     | 45.80        | 170.49    | 12.80  | 0.71   | 3.62   |
| Acc. 10 (Idasen) | 4.65       | 35.49     | 41.85        | 171.77    | 13.75  | 0.57   | 2.35   |
| Acc. 11 (Uso) | 3.93       | 36.40     | 48.25        | 168.77    | 12.77  | 0.35   | 3.35   |
| Acc. 12 (Idoani) | 4.75       | 37.13     | 43.82        | 165.87    | 13.67  | 0.37   | 2.77   |
| Acc. 13 (Ikaro) | 3.79       | 37.97     | 47.59        | 167.81    | 14.72  | 0.30   | 2.81   |
| LSD (0.05) | 0.0491     | 0.1456    | 0.2452       | 0.3016    | 0.151  | 0.0223 | 0.0568 |

| Processed (Boiled) |            |           |              |           |        |        |        |
|---------------------|------------|-----------|--------------|-----------|-------|-------|-------|
| Acc. 1 (Ikponba) | 4.26       | 25.93     | 32.84        | 140.73    | 10.75 | 0.14  | 0.33  |
| Acc. 2 (Isokponba) | 4.31       | 25.77     | 30.26        | 143.85    | 10.75 | 0.07  | 0.43  |
| Acc. 3 (Ehor) | 3.46       | 22.59     | 31.31        | 138.77    | 11.35 | 0.11  | 0.28  |
| Acc. 4 (Uhimwento) | 3.87       | 25.68     | 29.62        | 141.31    | 9.53  | 0.09  | 0.37  |
| Acc. 5 (Irrua) | 4.14       | 22.11     | 28.43        | 153.28    | 8.64  | 0.08  | 0.28  |
| Acc. 6 (Ewu) | 3.49       | 26.08     | 29.77        | 149.72    | 9.31  | 0.09  | 0.22  |
| Acc. 7 (Evbukhu) | 3.86       | 28.69     | 31.45        | 138.62    | 8.76  | 0.12  | 0.19  |
| Acc. 8 (Ekae) | 3.47       | 22.07     | 30.54        | 145.23    | 8.58  | 0.09  | 0.15  |
| Acc. 9 (Useleu) | 4.33       | 26.17     | 31.62        | 153.62    | 8.76  | 0.08  | 0.20  |
| Acc. 10 (Idasen) | 4.17       | 24.53     | 29.80        | 154.62    | 7.84  | 0.06  | 0.45  |
| Acc. 11 (Uso) | 3.48       | 26.36     | 34.18        | 152.31    | 8.47  | 0.07  | 0.06  |
| Acc. 12 (Idoani) | 4.89       | 25.62     | 25.82        | 149.30    | 9.17  | 0.07  | 0.39  |
| Acc. 13 (Ikaro) | 3.82       | 25.96     | 21.94        | 153.64    | 9.42  | 0.07  | 0.13  |
| LSD (0.05) | 0.0419     | 0.3873    | 0.0348       | 0.0366    | 0.04142 | 0.0056 | 0.0151 |
for yield improvement. Further observations by Pandey et al. (2009) and Paul and Bari (2011) on cocoyam, which are corroborated in the present study showed that selection for an increase in one trait will most likely lead to an increase in other traits as significant and positive association between two characters under consideration indicates that these characters can be improved simultaneously in a selection programme.

Owing to the emphasis placed on the nutritional value of tannia, the present findings show that there were variations between accessions on their proximate, mineral and phyto-chemical analyses. Previous studies by Agueguia (2000) showed that the presence of minuscule bundles of crystals of calcium oxalate in tannia corms creates an irritating effect when consumed. Hence it is imperative that corms and cormels must be processed by boiling, roasting or baking before consumption. Comparing results of the accessions analysed in the unprocessed and processed states, indicates that processing can uniformly decrease proximate, mineral and phyto-chemical. These findings corroborate previous crop yield analyses by FAO (2013) in which they reported that cooking may reduce the nutritional value of crops as a result of losses and changes in the major nutrients during cooking. This implies that there is need to develop tannia processing technologies that can reduce anti-nutritional properties while retaining nutritional qualities. Also, in contrast to the low nutritional and anti-nutritional values obtained by Sefa-Dedeh and Agyr-Sackey (2004) in their analyses on the chemical composition of Xanthosoma sagittifolium and Colocasia esculenta cormels; the proximate, mineral and phyto-chemical values obtained from this study were relatively higher. Furthermore, findings by Muniat et al. (2009) in their analytical works on cooked and uncooked accessions of Colocasia esculenta exhibited higher nutritional values contrary to the results obtained in this study.

The strong variations observed in the mineral contents of the accessions is in agreement with work by Fennema (1988) and Quero-Garcia et al. (2004) in which they submitted that such variations may be due to the difference in the genetic potential of each accession to obtain nutrients from the soil. Other factors might include the concentration of minerals in the soil and the age of the plant. This indicated uniformity in soil and age of tannia plants in the experiment. The most abundant mineral element in the corms was potassium, which was in consonance with FAO (1990) analysis of nutrients in cocoyam. The ratio of sodium (Na) to potassium (K) was less than unity, which implied that consumption of processed tannia corms may contribute to reduction in high blood pressure because Na:K was less than one as recommended by Food and nutrition board, Institute of Medicine (FND 2002). This study indicated that corm processing regardless of accession type, reduced concentrations of phyto-chemicals such as oxalate.

The results agreed with Albihn and Savage (2001), Owusu-Darko et al. (2014) as well as Boakye et al. (2017) who reported from their various studies that maximal reduction in oxalate content in cocoyam occurred after processing, which resulted in considerable cell rupture thereby facilitating the leakage of soluble oxalate into the processing solution. Furthermore, Albihn and Savage (2001) submitted that processing oca tubers (Oxalis tuberosa) by boiling considerably reduced the oxalate concentration in the whole tuber.

5 Conclusions

The planting date significantly affected growth, yield and yield components of tannia. Hence, May planting seems to be best in the farming systems present in the hot, humid tropical lowlands of south-east Nigeria. The interaction between planting date and tannia accession was significant for some of the plant attributes studied, an indication that the accessions exhibited differential responses to different planting date in both years in the agro-ecological region.

In both years, the highest weighted yields were recorded after a May planting date while accessions 13 (Ikaro), closely followed by 12 (Idoani), were superior in yield characteristics. The correlation indicated that all the attributes (plant height, pseudo-stem circumference, leaf area, number of leaves per plant, corm weight, corm circumference, cormel weight and cormel circumference exhibited good selection characteristics for developing high yielding varieties of the crop. Also, crude protein, carbohydrate, phosphorus, potassium and sodium of tannia showed that processed corms exhibited low nutritional qualities and very low tannin and oxalate relative to the unprocessed corms, hence farmers are encouraged to cook the corms prior to eating. Further work is also warranted to develop processing technologies that will maximize the nutritional value of tannia and at the same time minimize any anti-nutritional effects.

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