Journal of Stress Physiology & Biochemistry, Vol. 16, No. 2, 2020, pp. 114-120 ISSN 1997-0838

ORIGINAL ARTICLE

OPEN ACCESS

Chlorophyll, Proximate and Mineral Composition of Yam Leaves Grown under Aeroponics and Field Systems

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Received February 28, 2020

The chlorophyll, proximate and mineral compositions of four elite yam varieties grown under aeroponic and field systems were investigated. The yam varieties used were TDa 98/01176, TDr 95/18544, TDr 95/19177 and TDr 95/19158. One node vines were planted in polythene bags for four weeks and transferred to aeroponics and field system respectively. The chlorophyll a, b and total chlorophylls of field grown varieties of TDr 95/18544, TDr 95/19177 and TDr 95/19158 were all significantly lower than that of aeroponics system. Chlorophyll 'a' concentration was higher than that of chlorophyll 'b' in all the field and aeroponic grown varieties except for aeroponics grown TDr 95/19177. Leaf moisture, crude fibre content of aeroponics grown yam seedlings were significantly ($p<0.05$) higher than those of the field system. The nitrogen (N) content of TDa 98/01176 was significantly ($p<0.05$) higher for the field sample compared to that of aeroponic system. There was no significant ($p>0.05$) difference in Nitrogen composition for the other varieties. Calcium (Ca), magnesium (Mg), potassium (K), sodium (Na) and phosphorus (P) content of the field samples were not significantly different from that of aeroponics system. The differences in chlorophyll content in this study may be due to differences in exposure to sunlight. This could enhance yam mineral concentration thereby improving nutrition.

Key words: Aeroponics, chlorophyll, mineral, proximate, yam

Yam (*Dioscorea* spp) is an annual tuber crop of over 600 species with 6 species being prominent as source of food, medicine and revenue (IITA, 2009). Yam, in addition to sustaining households in Africa, has also served as a good food security crop. Apart from cassava, it is the second most cultivated crop in Nigeria (NBS, 2012). It is an important socio-cultural crop in Nigeria especially in the South eastern region. Over 60% of the Nigerians cultivate yam as a means of livelihood (IITA, 2013). Yam production is a major source of food security as it is one of the most important food crops that is largely consumed aside cassava, potato and sweet potato. Nigeria produces more than 30 million tonnes of yam from over 3 million hectares of land (IITA, 2008). Different yam species have been reportedly used in traditional medicine since 2000 BC (Craufurd *et al.,* 2001) including its constituents such as stem and leaves (Sheikh *et al.,* 2013). Leaves of some yam species are used as antiseptic for management of ulcers (Felix *et al*., 2009). Important glycosides like Diosbulbin H and Diosbulbinoside D have been identified and isolated from yam species (Komori, 1997) for production of steroid drugs. Demand for yam species has continued to be on increase following its use not only for food but also as raw materials for pharmaceutical and textile industries. However, yam production has been greatly hampered by unavailability of high quality seed yams of local and improved varieties, high cost of production, low and declining soil fertility as well as pest and disease infestation.

In the 1950s, Nigeria produced enough food for her populace (Ojo and Adebayo, 2012) but in recent times, the country is faced by the challenge of food insecurity largely arising from the ever increasing population growth. Food production has been described as key to achieving of food security in Nigeria (Verter and Becvarova, 2014) with particular emphasis on yam production. However, to produce enough food yam, insufficient clean and disease-free seed yam is a major production problem. In addition to this, yam has a very low multiplication ratio. There are many method such as minisett technique, use of yam peels that have been applied to multiply and increase the number of seed yam for cultivation. These methods are still unable to meet the quest for more seed yam. Recently, a fast and new method of seed yam multiplication has been used at the National Root Crops Research Institute, Umudike, Nigeria. This method is called Aeroponics seed yam multiplication system under the Yam Improvement for Income and Food Security in West Africa project (YIIFSWA) funded by IITA, Ibadan. I aeroponics system, nutrient solution is recirculated with limited amount of water in a soil-less environment. It offers the advantage of space maximization, water conservation and less labour (Nabeel, 2016). Since 2011, the IITA and other organizations through the 'Yam Improvement for Income and Food Security in West Africa' (YIIFSWA) project has developed and adapted novel technologies such as use of aeroponics system for production of yam seeds for cultivation by farmers. To buttress the importance of this system, the present study aimed to compare the chlorophyll, mineral and proximate composition of four elite varieties of yam leaves grown under aeroponics system and clean seed field systems. In Aeroponics system, nutrient solution is recirculated with limited amount of water in a soil-less environment. Since 2011, the IITA and other organizations through the 'Yam Improvement for Income and Food Security in West Africa' (YIFSWA) project has developed and adapted novel technologies such as use of aeroponics system for production of yam tubers of not less than 50 g to up to 1000 g to aid increased production of yam seeds for cultivation by farmers. The present study aimed to compare the chlorophyll, mineral and proximate composition of four elite varieties of yam leaves grown under Aeroponics system and Clean seed field systems.

MATERIALS AND METHODS

Plant material

One node of yam vine each of four varieties (*TDa 98/01176, TDr 95/18544, TDr 95/19177* and *TDr 95/*19158) were planted in separate polythene bags. After for four weeks were transferred into the aeroponics system and field respectively. After eight (8) weeks, fresh matured leaves of similar yam varieties were harvested from aeroponics and field systems respectively.

Chlorophyll determination

A portion of 0.1 g of leaf was macerate in 5 ml of acetone and centrifuged for 5 minutes. Absorbance of the extract was measured at 450 nm, 645 nm and 663 nm respectively.

PROXIMATE ANALYSIS

Moisture content determination

Moisture content was determined by oven method as described by AOAC (2005). Briefly, 2.5 g of sample was dried in a hot air oven for 4-6 hours at 60-80°C until a constant weight was achieved. Loss in weight was determined and recorded as the moisture content and expressed as:

$\%$ moisture $= (W_1 - W_2) / W_1 \times 100$

Where; W_1 = Initial weight of the sample

W_2 = Weight of the dried sample

Ash content determination

The ash content was determined by the direct heating method as contained in AOAC (2005). A portion of 0.5 g of the sample were measured into a crucible of known weight and placed inside a muffle furnace for 3 h at 550°C to char. Thereafter, the crucible was brought out, cooled in a desiccator and weighed. The % Ash content was calculated as follows:

$\%$ Ash $= (W_1 - W_2)/W_1 \times 100$

Where; W_1 = Initial weight of the sample

W_2 = Weight of the dried sample

Protein content determination

The macro kjeldahl method as described by AOAC (2005) was used to determine the crude protein content. Into a digestion flask was added 1 g of dried sample, 15 ml of conc. H_2So_4, kjeldahl catalyst tablet and the tube was placed into a digestion block pre-set at 410^{o}C for 45 minutes until a clear solution was obtained. The tube was thereafter placed in a distilling unit, 50 ml of 40% NaOH was added and the digest was distilled into 25 ml of 4% boric acid for 5 minutes. Finally, the distillate was titrated against 0.47 M HCl until a grey colour was obtained.

$\%$ Total Nitrogen = [(molar mass of N_2 × (sample titre – blank titre) × N) ÷ (Sample weight)]

The value obtained was multiplied by an empirical factor of 6.25 to get the crude protein. That is: % Crude protein = % Nitrogen × 6.25

Fat content determination

Cold extraction method was employed for fat determination according to the method of AOAC (2005). Three grammes of sample was weighed into a conical flask containing 100 g of petroleum ether and allowed to stand overnight. It was filtered with whatman no 1 filter paper into a pre-weighed beaker, placed in an oven to evaporate the solvent, allowed to cool in a desiccators and re-weighed. Percentage fat was calculated as:

$\%$ Fat = (weight of extracted fat / weight of sample used) x 100

Crude fibre determination

Crude fibre was determined according to the method of AOAC (2005). The de-fated sample obtained from the fat extraction above was placed in a conical flask to which was added 200 ml of 1.25% H_2SO_4, boiled in a heating mantle for 30 minutes, filtered with a muslin cloth and washed with boiled water. The residue was transferred into a conical flask and 200 ml of 1.25% of NaOH was added, boiled for another 30 minutes and wash repeatedly with hot water. The filtrate was washed with 1% HCl and the residue placed into a pre-weighed crucible and dried in an oven. After drying, the residue was ashed at 600^{o}C for 6 hours, cooled in a desiccator and reweighed.

$\%$ crude fibre $= (W_1 - W_2) / W \times 100$

Where: W = weight of sample used

W_1 = Weight of sample and crucible before ashing

W_2 = Weight of crucible and ash

Determination of carbohydrate content

Carbohydrate content was determined by difference as described by AOAC (2005).

Mineral Determination

This was carried out by the use of Inductively Coupled Plasma-Optical Emission Spectrometry (Perkin-Elmer; model Optima2000 DV**)** (ICP-OES) Analysis. One gramme of oven-dried plant leaf was digested with 6ml of HNO_3 and 2 ml of H_2O_2 in a microwave digestion system. Plant sample and acid mixture were kept in inert polymeric microwave vessel that was sealed and heated for 2 minutes for 400 w, 6 minutes for 400 w, 5 minutes for 400 w, 8 minutes for

800 w and 8 minutes for vent. Thereafter, the digest was allowed to cool and diluted with 10 ml of distilled water. Thereafter, the minerals were determined in the Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES).

RESULTS AND DISCUSSION

In this study, the total chlorophyll content of all the yam leaves varieties from the aeroponics system was significantly higher compared to those from the field except for field TDa 98/01176 which was higher than that of aeroponics (Figure 1). Chlorophyll is one of the pigments contained in the mesophyll of plants. Its amount in a plant affects its colour, photosynthetic ability as well as food production. Plants usually adapt to low light intensity by developing strategies to aid them capture more light by increasing their leaf area and hence increased chlorophyll content (Johnson *et al.,* 2005; Kurtar, 2012).

Amount of chlorophyll a was higher than chlorophyll b in all except for TDr 19177 grown in aeroponics indicating that the increase in chlorophyll content was largely due to increased synthesis of chlorophyll a (Figure 2). Chlorophyll *a* absorbs light, serves as reaction center as well as a converter while chlorophyll b is primarily involved in light absorption (Zang *et al.,* 2014). Zhang *et al.* (2016) reported an increase in the content of leaf chlorophyll b of *Physocarpus amurensis* Maxim and *Physocarpus opulifolius* “Diabolo” grown under low light conditions while chlorophyll a had a non-significant change.

Leaf moisture content obtained in this study ranged from 7.99-9.19% for the field and 8.15 - 10.23% for aeroponics samples (Table 1). Moisture content of the varieties from aeroponics was higher than that of the field, indicating increased deterioration capacity (Ugo *et al.,* 2016). Ash content range of 8.75-15.90% and 1.95-18.50% was obtained for field and aeroponics samples respectively. Sample TDr 95/18544 from aeroponics had the highest ash content (18.50%). High ash content has been attributed to increased mineral content (Oduro *et al.,* 2008). The ash content obtained in this study is lower than the range (16.95-23-37%) obtained for leaves of improved cassava varieties (Koubala *et al.,* 2015). In another study, ash content range of 6.5-7.00% and 7.75-10.25% was reported for leaves of *Manihot esculenta* and Ipomoea batatas (Iyaka *et al.,* 2015). Fat content of the aeroponic grown varieties (0.29-1.36%) were higher than that of the field (0.16-0.95%). The crude fibre values ranged from 8.88-13.52% and 9.97-13.52% for field and aeroponics grown leaves respectively. A similar crude fibre range of 7.99-13.16% was reported for cassava leaves (Koubala *et al.,* 2015). Aeroponics samples had greater crude fibre content than the field samples. Crude fibre rich foods have been reported to be helpful in the management of diabetes and prevention of colon cancer (Ingabire and Vasanthakaalam, 2011). Crude protein values for field samples (10.88-15.22%) were higher than that of aeroponics (9.58-14.14%). Koubala *et al.* (2015) reported a crude protein range of 7.99-13.16% for cassava leaves.

The calcium range for all the yam leaves were all higher than those of aeroponics except for TDr 95/19158 grown in the field that was greater than that grown in aeroponics, however the increase was not significant. The calcium values obtained in this study (2150-3010 mg/100g for field and 1710-2800 mg/100g for aeroponics) were lower than that (3457-4255 mg/100g) reported by Mwanri *et al.* (2011) for sweet potato leaves. The result suggests that the field provided the plants with more calcium than the aeroponic system did. Magnesium is associated with chlorophyll content in leaves (Turan *et al.,* 2003). The magnesium concentration obtained in this study (990-2520 mg/100g for field and 570-2800 for aeroponics) was considerably higher than the range (21.22-35.42 mg/100g) reported by Iyaka *et al.* (2015) for sweet potato and cassava leaves. Potassium concentrations obtained in this study were 151.-1800 mg/100g (for field) and 1020-1670 mg/100g (for aeroponics). This range is higher than 244-396 mg/100g reported for improved cassava leaf varieties (Koubala *et al.,* 2005). The sodium concentration of the field grown varieties (0.10-0.14 mg/kg) were higher than that grown in aeroponics system (0.08-0.13 mg/kg) but lower than the range (5.22-8.09 mg/kg) reported for cassava leaves (Koubala *et al.,* 2015). The phosphorus content of the field grown varieties (437.17-611.79 mg/kg) were higher than that grown in the aeroponics system (347.15-568.28 mg/kg).

Table 1: Proximate composition of yam leaves

	Fat (%)	Ash (%)	Moisture (%)	Crude Fibre (%)	Protein (%)
F1	0.16±0.01	8.75 ± 0.21	7.99± 0.13	13.52±0.22	14.41± .24
A1	0.29±0.03	1.95 ± 0.35	9.71 ±0.07	13.52±0.22	9.58±0.29*
F2	0.42±0.02	15.90±0.42	8.93± 0.12	9.39 ± 0.08	15.22±0.99
A2	1.04±0.05	18.50±0.42	10.23±0.02	11.53±1.69	14.14±0.66
F3	0.95±0.07	15.25±0.07	9.19 ± 0.04	8.88 ± 0.77	10.88±0.58
A3	1.25±0.35	12.15±0.35	9.92 ± 0.11	11.95±0.39	11.11±0.45
F4	0.46±0.04	12.35±0.35	7.64 ± 0.06	11.80±1.69	12.74±2.75
A4	1.36±0.04*	15.50±0.71	8.15 ± 0.35	9.97 ± 0.51	11.31±0.69

*Values are mean ±standard deviation of duplicate determinations. Values marked astericks (*) are significantly different.*

F1=TDa 98/01176 field, A1=TDa 98/01176 aeroponics, F2= TDr 95/18544 field, A2= TDr 95/18544 aeroponics, F3= TDr 95/19158 field, A3= TDr 95/19158 aeroponics, F4= TDr 95/19177 field, A4= TDr 95/19177 aeroponics

Table 2. Mineral composition of yam leaves

Sample	Ca (%)	Mg (%)	K (%)	Na(mg kg^{-1})	P (mg kg^{-1})
F1	2.85±0.05	0.99± 0.02	1.71± 0.03	0.13± 0.00	578.90±9.75
A1	1.71±0.32	0.57± 0.12	1.02± 0.19	0.08± 0.02	347.15±5.83
F2	3.01±0.20	1.05± 0.07	1.80± 0.12	0.14± 0.01	611.79±2.86
A2	2.80±0.13	2.80± 0.05	1.67± 0.08	0.13± 0.01	568.28±1.84
F3	2.15±0.12	2.15± 0.04	1.29± 0.07	0.10± 0.01	437.17±9.35
A3	2.20±0.09	0.75± 0.03	1.32± 0.05	0.10± 0.00	446.52±4.10
F4	2.52±0.54	2.52± 0.20	1.51± 0.33	0.12± 0.03	511.85±4.35
A4	2.24± 014	0.77± 0.05	1.34± 0.08	0.11± 0.01	456.92±9.92

Values are mean ±standard deviation of duplicate determinations

F1=TDa 98/01176 field, A1=TDa 98/01176 aeroponics, F2= TDr 95/18544 field, A2= TDr 95/18544 aeroponics, F3= TDr 95/19158 field, A3= TDr 95/19158 aeroponics, F4= TDr 95/19177 field, A4= TDr 95/19177 aeroponics

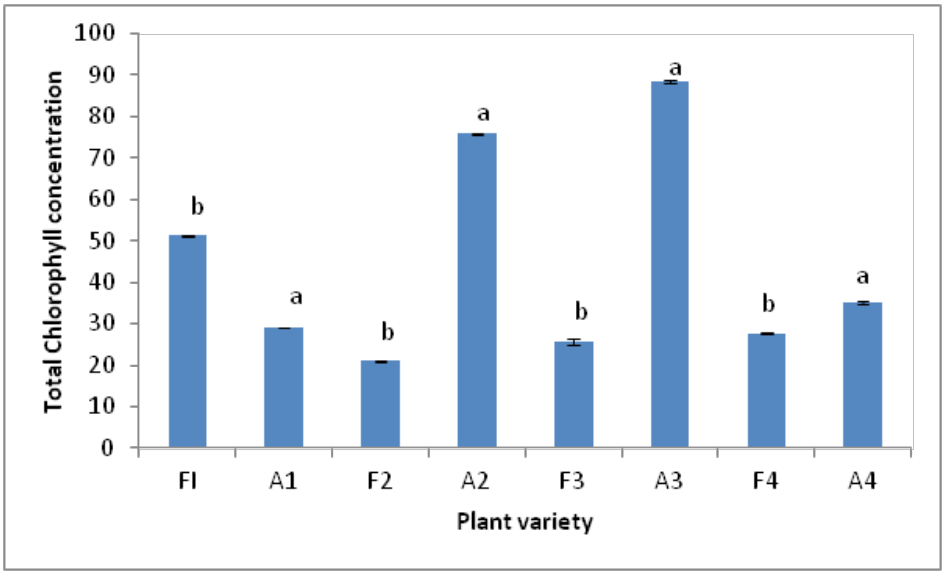

Figure 1: Total Chlorophyll. Values are mean ± standard deviation of duplicate determinations. Bars denoted with different alphabets are significantly different from control.

F1= Field TDa 98/01176, A1= Aeroponic TDa 98/01176,
F2= Field TDr 95/18544, A2= Aeroponic TDr 95/18544,
F3= Field TDr 95/19158, A3= Aeroponic TDr 95/19158,
F4= Field TDr 95/19177 A4= Aeroponic TDr 95/19177

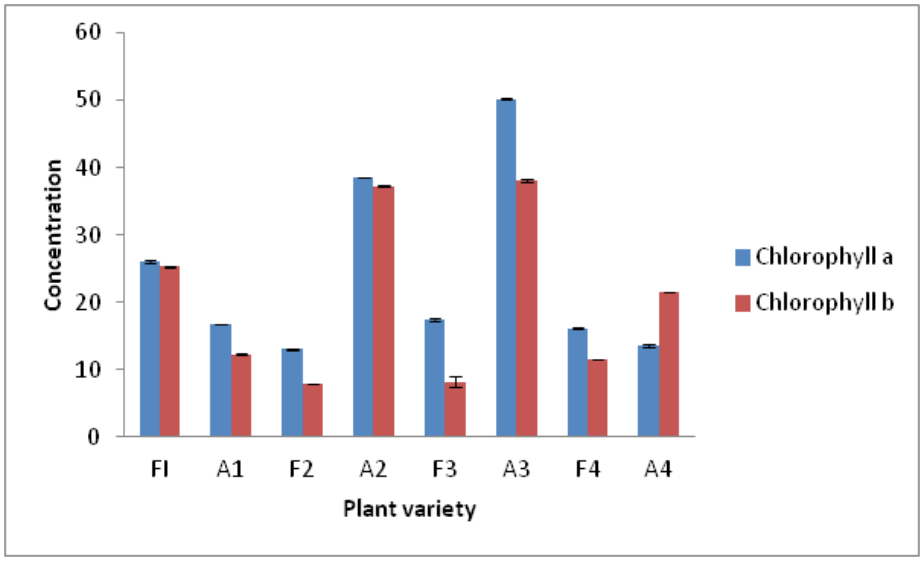

Figure 2: Chlorophyll *a* and *b*. Values are mean ± standard deviation of duplicate determinations. Bars denoted with different alphabets are significantly different from control.

F1= Field TDa 98/01176, A1= Aeroponic TDa 98/01176,
F2= Field TDr 95/18544, A2= Aeroponic TDr 95/18544,
F3= Field TDr 95/19158, A3= Aeroponic TDr 95/19158,
F4= Field TDr 95/19177, A4= Aeroponic TDr 95/19177

CONCLUSION

The aeroponics system favours increased chlorophyll, moisture and mineral retention in the leaves of the yam varieties which could positively influence the tuber mineral concentration of the yam varieties and hence improve nutrition.

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