



Science

THE EFFECT OF SOIL CONDITIONS ON THE PHYSIOLOGICAL INDICES OF *Costus afer* Ker Gawl



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Abstract

The effect of different soil conditions on some physiological indices of *Costus afer* was studied in two locations (Otuoke and Opolo) in Bayelsa State, Nigeria. The soils physico-chemical properties as well as mineral elements and phytochemical contents in leaf samples were assessed using standard procedure. The descending order of mineral elements in location 1 were, P > Ca > Mg > K > C > H > Al > Na > N, while that of location 2 were, P > Ca > C > K > Al > H > Mg > Na > N. The contents of calcium, magnesium, sodium, potassium, nitrogen and phosphorus in leaves of *C. afer* in location 1 were significantly ($P < 0.05$) higher than those of location 2, while the iron, zinc and lead contents in leaves of the test plant in location 1 were relatively higher than that of location 2. There were also marked variations in phytochemical contents in leaves of the test plant between the two locations. This study indicates that soil factors have a considerable influence on the mineral elements and phytochemical contents of *Costus afer*.

Keywords: Soil Conditions; Physiological Indices; *Costus afer*.

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1. Introduction

The contents of nutrients in plants are affected by certain factors such as plant species, and varieties, total nutrient supply in soils and factors regulating their availability to plants (Brady and Weil, 2000, Smith and Smith, 1990). Physiological processes in plants such as respiration, assimilation, photosynthesis and metabolism are influenced by various climatic factors such as temperature, humidity, precipitation, light intensity and altitude (Agbede, 2009, Etukudo *et al.*, 2015). It is important to note that the effects of these factors vary considerably from one nutrient element to another (Ames, 1997, Etukudo and Osim., 2018). According to Martinez-Ballesta *et al.*, 2010, the contents of mineral elements present in plants are influenced by factors such as genetic properties of the crop species, climatic conditions, soil characteristics and the degree of maturity of the plant during harvest. The soil as a medium of plant growth consists of a mixture

of minerals, organic matter, water, and air in different amounts, which influence the biochemical constituents of plants (Anoliofo, 2006, Ames, 1997). In addition, the constituents of organic matter, which include living organisms, excretory products, and decay products, have much influence on the physiological composition in plants (Ames, 1997, Apoxi *et al.*, 2000).

Costus afer Ker Gawl of the Zingiberaceae family, commonly called bush sugar cane or monkey sugar cane (Nyananyo, 2006, Etukudo, 2003), is a monocot and a relatively tall, herbaceous, unbranched tropical plant with creeping rhizome. It is commonly found in moist and shady forest of West and tropical Africa (Nyananyo, 2006, Etukudo, 2003). *C. afer* is a perennial, rhizomatous herb that can attain a height of up to 4 m, and is often planted in home gardens for medicinal purposes as well as widely used for ceremonial and religious purposes (Nyananyo, 2006, Etukudo, 2003). This study was carried out to examine the effect of different soil conditions on some physiological indices of *Costus afer* in two locations (Otuoke and Opolo) in Bayelsa State, Nigeria.

2. Materials and Methods

2.1. Study Area

This research was carried out in two locations (Otuoke-L1 and Opolo-L2) in Bayelsa State, Nigeria. Yenagoa is located at coordinates of 4° 55'N and 6° 15'E, and Bayelsa State is situated in the heaviest rainfall area of Nigeria with a mean minimum monthly temperature that ranges from 25°C to 31°C (Niger Delta Source, 2014).

2.2. Collection of Samples

Soils and plant materials (leaves of *Costus afer*) were collected from the two locations, Otuoke- (location 1) and Opolo- (location 2) in Bayelsa State.

2.3. Analysis of Soil Samples

The physico-chemical properties of experimental soil were analysed using standard procedures (A.O.A.C, 1999).

2.4. Determination of Mineral Elements Contents of Plant Material

Leaf samples of *Costus afer* were kept in polybags after washing with water and rinsing with distilled water. They were dried to a constant weight in an oven maintained at 60°C. Plant materials were further crushed to powder form and stored in sample bottles for analysis. The powdered leaf samples were processed further by drying in an oven at 105°C for 2 hours, 1.0g weighed into a platinum crucible and placed in a muffle furnace maintained at 400°C. Ashing of the plant samples was done for 5 hours, followed by dissolving with 10cm³ of 1M HCL, and filtration of the resulting solution through Whatman No. 1 filter paper into 50cm³ volumetric flask. The resulting solution was made up to the required mark with distilled deionized water. The contents of mineral elements were determined using Atomic Absorption Spectrophotometer (Ano *et al.*, 2007).

2.5. Analysis of Phytochemicals

The dried and powdered leaf samples of *C. afer* were subjected to various sample preparation stages using standard laboratory procedures for determination of alkaloids, tannins, flavonoids, saponins and glycosides. Standard methods were used to determine the alkaloid [Harbone, 1973], tannin [Pearson, 1976], flavonoid [Bohn and Kocipai-Abyazan, 1994] and saponin [Obadoni and Ochuko, 2001] contents of the test plant.

2.6. Statistical Analysis

Analysis of variance (ANOVA) was used for analysis of Data obtained from the study. Least significant Differences (LSD) was used to test the differences in the means (Obi, 2003).

3. Results and Discussions

3.1. Results

The morphological and physical properties of soil in the two sampling locations are presented (Table 1). Soil samples from the two locations were assessed at 0-20cm depth. The dark greyish brown coloured soil of location 1 had a granular structure with loamy sand textural characteristics, while soil of location 2 had a yellowish brown colour with a sub-angular blocky structure and sandy loamy textural characteristics (Table 1). The soil pH at location 1 and 2 were 5.10 and 4.90, respectively. The corresponding descending order of mineral elements were $P > Ca > mg > K > C > H > Al > Na > N$ for soil of location 1, and $P > Ca > C > K > Al > H > Mg > Na > N$ for soil of location 2 (Table 1).

There were significant differences ($P < 0.05$) in contents of calcium magnesium, sodium, potassium, nitrogen and phosphorus in leaves of *Costus afer* between location 1 (23.01, 12.73, 27.60, 16.63, 3.87 and 0.62 mg /100g) and location 2 (20.26, 10.19, 23.72, 12.49, 1.27 and 0.43 mg/100g), respectively. These values recorded in leaves of the test plant in location 1 were relatively higher than those of location 2 (Table 2).

The alkaloid, flavonoid, saponin and glycoside contents in leaves of *C. afer* in location 1 were significantly ($P < 0.05$) higher than those of location 2, while the tannin content in leaves of the test plant in location 2 was relatively higher than that of location 1 (Table 3).

Table 1: Soil physico-chemical properties in the two locations

Soil properties	Location 1	Location 2
Depth (cm)	0-20	0-20
Mottle	None	None
Colour	Very dark greyish brown	Yellowish brown
Structure	Granular	Sub-angular blocky
Clay (g/kg)	38.00±0.21	48.00±0.27
Silt (g/kg)	152.00±0.33	188.00±0.20
Sand (g/kg)	810.00±0.12	765.00±0.26
Textural class	Loamy sand	Sand loam

pH	5.10±0.72	4.90±0.36
Organic carbon (%)	1.98±0.44	1.49±0.60
N (%)	0.136±0.12	0.122±0.40
P (mg/kg)	9.12±0.17	5.18±0.24
Ca (Cmol/kg)	3.62±0.33	2.27±0.21
Mg (mg/kg)	2.49±0.40	0.50±0.20
Na (mg/kg)	0.39±0.22	0.23±0.10
K (mg/kg)	2.07±0.59	1.48±0.27
H (mg/kg)	0.82±0.06	0.62±0.03
Al (mg/kg)	0.43±0.04	0.63±0.02

Mean ± standard errors from 3 replicates

Table 2: Mineral elements in leaves of *Costus afer* from the two locations

Mineral elements (mg/100g)	Location 1	Location 2
Calcium	23.01±0.16	20.26±0.10
Magnesium	12.73±0.24	10.19±0.43
Sodium	27.60±0.39	23.72±0.49
Potassium	16.63±0.22	12.49±0.36
Nitrogen	3.87±0.17	1.27±0.20
Phosphorus	0.62±0.05	0.43±0.07
Iron	0.24±0.02	0.32±0.07
Manganese	0.044±0.01	0.030±0.02
Copper	0.022±0.01	0.017±0.03
Zinc	0.56±0.02	0.73±0.04
Lead	0.002±0.01	0.004±0.01

Mean ± standard error from 3 replicates

Table 3: Phytochemicals in leaves of *Costus afer* from the two locations

Phytochemicals (%)	Location 1	Location 2
Alkaloids	34.00±0.27	30.14±0.46
Tannins	23.00±0.52	26.46±0.21
Flavonoids	20.26±0.77	18.24±0.59
Saponins	12.04±0.10	16.20±0.33
Glycosides	11.08±0.41	8.12±0.20

Mean ± standard error from 3 replicates

3.2. Discussion

Soil structure has a strong influence on plant growth and nutrient distribution in the soil as indicated in this study. There is a strong relationship between soil aggregation and soil nutrient such that good soil aggregation is related to the amount of useful organic matter and to biological processes in the soil (Ames, 1997, Agbede, 2009). Poor compaction in soil reduces plant growth and decreases uptake of nutrients by plants as well as distorts root growth and activity due to insufficient aeration and mechanical destruction (Cox, 1990, Smith and Smith, 1990). Thus, the efficient absorption of nutrients by plants roots is restricted due to partial root contact with soil particles and the soil solution. The soil texture also has greater influence on the amount of air,

water and nutrients held in the soil. In soils where large particles of sand dominate, the penetration of air, water and roots occurs much more readily through the soils (Agbede, 2009, Brady and Weil, 2002, 2000, Ames, 1997). Therefore, these may have contributed to the differences in nutrients in the test plant between the two locations.

Differences in pH may also contribute to variation in nutrients and phytochemicals in plants. Soil pH is known to vary in time and space, and has a major influence on solubility and availability as well as potential phytotoxicity of metals (Atwell, 1999, Etukudo and Osim., 2018). The availability of nutrient elements is strongly affected by soil pH, such that magnesium and zinc contents of plants decreases greatly with increasing pH (Anoliofo, 2006, Pajevic *et al.*, 2004). Differences in soil moisture conditions may also bring about variation in the contents of nutrients and phytochemicals between the two locations. A dry soil reduces nutrient adequacy for plant use while waterlogged soils affect the transformation of nutrients (Ames, 1997, Brady and weil, 2000). In waterlogged soils, nutrients such as phosphorus, nitrogen and oxygen becomes limiting, and gases such as carbon iv oxide can accumulate to toxic levels in the soils (Ames, 1997, Agbede, 2009). Similarly, differences in content of organic matter may also leads to the variation in the plant content of elemental nutrients. This is because organic matter act as a storage medium for soil nutrients, supply food for decomposers of soil organic material and replenishes the soil fertility (Ames, 1997, Etukudo *et al.*, 2015).

4. Conclusions and Recommendations

There were marked variations in mineral element and phytochemical contents of *Costus afer* between the two locations. This study indicates that soil factors have a considerable influence on the mineral element and phytochemical contents of *Costus afer*.

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