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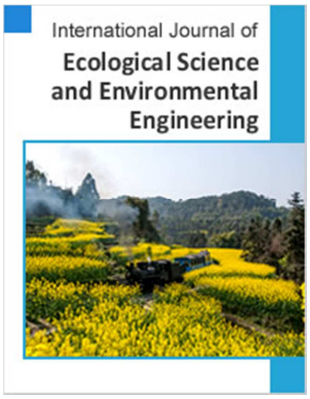

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Comparative Studies on the Pedological Characteristics, Morphological Traits and Productivity Indices of Three Species of the Genus *Ipomoea* in Uyo Metropolis, Akwa Ibom State, Nigeria

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Abstract

Comparative studies on the pedological characteristics, morphological traits and productivity indices of three species of the genus *Ipomoea* was done in Uyo metropolis, Akwa Ibom State, Nigeria. Morphological parameters (leaf length, leaf width and leaf area index) and productivity indices (chlorophyll a, b carotenoids and Chlorophyll Concentration Index (CCI)) of these species were determined using standard methods. The results showed that amongst the three species studied *Ipomoea mauritiana* had the highest values in leaf length (21.60±1.34 cm) leaf width (19.57±1.92 cm) and Leaf Area Index (LAI) (191.5±19.94 cm^2) while *I. muricata* had the least values in terms of leaf length (7.5±0.31 cm) leaf width (7.00±0.42 cm) and LAI (24.08±3.00 cm^2). Considering the productivity indices, the results further reflected a similar trend with *Ipomoea mauritiana* having the highest concentration of chlorophyll a (1.34±0.035), chlorophyll b (0.97±0.025), carotenoids (0.75±0.019) and CCI (53.84±1.38) while *Ipomoea muricata* had the least values for chlorophyll a (0.93±0.058), chlorophyll b (0.67±0.042), carotenoids (0.52±0.033) and CCI (37.30±2.34). *Ipomoea batatas* had intermediate values for all morphological and productivity parameters. Using leaf area index as surrogate for morphological traits, linear regression technique was employed to establish relationships with productivity indices of *Ipomoea* species studied. Positive relationships were established between the productivity indices and the morphological characters and this underscored the influences of chlorophyll pigments on the growth morphology of the leaves. The results obtained in this study provide a baseline information on the habitat (soil) and environmental preferences of these species as well as their evolutionary variations and can be useful in delineating the modern trends in habitat ecology and plant physiology.

1. Introduction

The family Convolvulaceae as reported by [24] consists of 58 genera and approximately 2,000 species. They are cosmopolitan in distribution [8] and are found abundantly in Asia and America [28]. Within this family, the genus *Ipomoea* L. comprises of about 650 species all over the world [14]. Vast number of the species occur in the Americas and Africa [3] while over half are distributed in the Americas [4]. According to [6], the genus *Ipomoea* is a large and diverse group with common names including morning glory, sweet potato, bindweed, moonflower, etc. Its most widespread common name is morning glories, but there are also species in related genera bearing the same common name. The genus occurs throughout the tropical and subtropical regions of the world, and comprises of annual and perennial herbaceous plants, lianas, shrubs and small trees; most of which are twining climbing plants [17]. Amongst this genus includes *Ipomoea mauritiana, Ipomoea muricata* and *Ipomoea batatas* which are the species of interest in this research. These species have diverse economic importance ranging from ornamentals, food crops, medicinal values and food additives.

Environmental (soil) conditions play a vital role in the growth morphology and productivity of various plant species [1]. Morphological characterization is important in the identification of accessions and detection of unique traits [21]. It helps in the identification of duplicates, studies of genetic diversity patterns and correlation with characteristics of agronomic importance [21]. Morphological characterization is an important step in the assessment of plant species but has certain limitations due to morphological plasticity [19] which is the tendency of a species to physically change appearance in response to environment. High morphological diversity evidenced among a particular genus may not be a conclusive indication of genetic diversity [30], as variations in environmental conditions such as soil types and fertility levels, light, temperature, and moisture regimes could still allow for different results to be obtained if morphological characterization is repeated in time and space [18].

The economic importance of *Ipomoea* species has triggered the inquisitiveness of many researchers who have reported extensively on the genus, *Ipomoea*. These studies have bordered on proximate, biochemical and taxanomic aspects of this vast group of plants. In spite of this, there is a dearth in information on habitat preference of these species within our immediate environment. Also, little or no information exist as to on the morphology-productivity relationships in the genus. This research is therefore carried out in order to elucidate such environmental relations in Uyo, Akwa Ibom State.

2. Materials and Methods

2.1. Study Area

This study was carried out Uyo, Local Governmnent Area the capital of Akwa Ibom State, Nigeria. Uyo lies at latitude 5° 2' 0" N and longitude 7° 55' 0" E. It is geographically bounded on the East by Uruan Local Government Area, Abak Local Government Area in the West, Ibiono Ibom Local Government Area in the North and Ibesikpo Asutan Local Government Area in the South.

2.2. Soil Sampling

Soil samples were collected using a soil auger in a ring form at the base of each study plant at a rooting depth of 30 cm and stored in labeled ziploc bags before being taken for digestion and analysis in the laboratory.

2.3. Measurement of Plant Morphological Traits Parameters of the Test Plants

The length and width of four leaves of each species were measured using a measuring tape and the mean of the replicates calculated.

For the leaf Area Index (LAI), the length and width of four leaves per each species were measured with a measuring tape and the product multiplied by a correlation coefficient of 0.45.

2.4. Measurement of Productivity Indices of the Test Plants

Productivity indices such as Chlorophyll Concentration Index (CCI), chlorophyll a, Chlorophyll b and Carotenoids contents were read off directly from SPAD-502 Chlorophyll meter.

2.5. Physicochemical Analysis of Soil Samples

Soil samples were analyzed using approved standard methods. Soil Particle sizes, organic carbon, total nitrogen and available phosphorus were determined using the Hydrometer method, Walkey Black wet oxidation method, Micro-Kjeldahl method and Bray No 1 method [11]. Electrical conductivity, exchangeable acidity and pH were determined using a conductivity meter (Jenway Pcm 128723 model), titration with 1N KCL [12] and Beckman's glass electrode pH meter [16], respectively. Total Exchangeable Bases were determined by EDTA titration method while sodium and potassium were determined by photometry method. The Effective Cation Exchange Capacity (ECEC) was calculated by the summation method (that is summing up of the Exchangeable Bases and Exchange Acidity (EA). Base Saturation was calculated by dividing total Exchangeable Bases by ECEC multiplied by 100.

2.6. Statistical Analysis

Mean and standard error were computed from replicates of physico-chemical parameters using Statistical Package for Social Sciences (SPSS 20.0) and MS Excel 2013. Regression analysis was used to establish the relationship between morphological traits and productivity indices.

3. Results

The mean values obtained for morphological parameters of *Ipomoea* species are shown in Table 1. It reveals that the leaves of *I. mauritiana* had the highest values in terms of length (21.6 cm), width (19.57 cm) and Leaf Area Index (LAI) (191.5 cm^2) while *I. muricata* had the least values with respect to length (7.50 cm), width (7.00 cm) and LAI (24.08 cm^2). *I. batatas* had intermediate values for all morphology parameters.

With respect to productivity indices, Table 2 further shows that the leaves of *I. mauritiana* had the highest concentrations of Chl. a (1.34), Chl. b (0.97), carotenoids (0.75) and CCI value (53.84) while the leaves of *I. muricata* had the least concentrations of Chl. a (0.93), Chl. b (0.67), carotenoids (0.52) and CCI value (37.30). *I. batatas* had intermediate values for all productivity parameters.

Table 1. *Mean ± (S. E) of morphological parameters of Ipomoea species.*

Morphological traits	*I. muricata*	*I. batatas*	*I. mauritiana*
Leaf length (cm)	7.5±0.31	11.83±0.95	21.6±1.34
Leaf width (cm)	7.00±0.42	11.47±0.71	19.57±1.92
LAI (cm^2)	24.08±3.00	61.37±6.25	191.5±19.94

Table 2. *Mean ± (S. E) of productivity indices of Ipomoea species.*

Productivity Indices	*I. muricata*	*I. batatas*	*I. mauritiana*
Chlorophyll a	0.93±0.058	1.24±0.037	1.34±0.035
Chlorophyll a	0.67±0.042	0.89±0.026	0.97±0.025
Carotenoids	0.52±0.033	0.70±0.021	0.75±0.019
CCI	37.30±2.34	49.77±1.46	53.84±1.38

Table 3 shows the mean concentrations of soil characteristics of the three (3) *Ipomoea* species. With respect to particle size, the sand fraction was the most abundant with a mean range of 71.30% – 86.00%. Silt fractions had a mean range of 6.60% to 11.70%. Clay fragment ranged between 7.40% and 17.40%. The pH of the soils ranged from weakly acidic to slightly neutral (6.00 – 7.20). Total nitrogen ranged between 0.06% – 0.46% while organic matter content of the sites ranged from 1.87% to 3.04%, respectively in the study area. Available phosphorus was high in these soils ranging between 86.52 mg/kg up to 99.48 mg/kg. The value for electrical conductivity ranged between 0.015 ds/m up to 0.129 ds/m. The most abundant cation in these soils was calcium ranging between 3.0 cmol/kg and 7.20 cmol/kg. This was followed by magnesium (1.7 cmol/kg – 2.50 cmol/kg) while sodium (Na) was the least abundant cation (0.06 cmol/kg to 0.09 cmol/kg) in these soils. The effective cation exchange capacity ranged from 7.38 – 11.91 cmol/kg in these soils.

Table 3. *Mean (± S. E) Soil characteristics of Studied Varieties of Ipomoea species in Uyo.*

Soil properties	*I. muricata*	*I. batatas*	*I. mauritiana*
Sand (%)	72.00±3.70	71.3±1.30	86.0±0.4
Silt (%)	10.60±1.30	11.7±0.50	6.6±1.6
Clay (%)	17.40±2.30	17.0±0.01	7.4±0.02
pH	7.20±1.50	7.10±0.10	6.0±1.5
EC (ds/m)	0.129±0.01	0.119±0.00	0.015±0.0
Org. C (%)	2.41±0.14	3.04±0.60	1.87±0.04
Tot. N (%)	0.060±0.002	0.113±0.02	0.47±0.13
Av. P (mg/kg)	91.91±1.9	86.52±2.30	99.48±2.5
Ca (cmol/kg)	7.2±1.10	6.1±0.80	3.0±0.4
Mg (cmol/kg)	2.4±0.40	2.5±0.30	1.70±0.2
Na (cmol/kg)	0.06±0.00	0.09±0.02	0.07±0.00
K (cmol/kg)	0.14±0.02	0.27±0.01	0.11±0.00
ECEC (cmol/kg)	11.91±2.30	8.96±1.40	7.38±1.30
Texture	Sandy loam	Sandy loam	Sandy loam

S. E = Standard Error, EC= Electrical conductivity, Org. C = Organic carbon, Tot. N = Total nitrogen, Av. P = Available phosphorus, ECEC = Effective Cation Exchange Capacity.

The relationships between the morphological character (LAI) and productivity indices in *Ipomoea* species are represented in Figures 1 to 4. It revealed positive relationships between the productivity indices (Chlorophyll a, b, carotenoids and CCI) and the leaf Area Index (LAI).

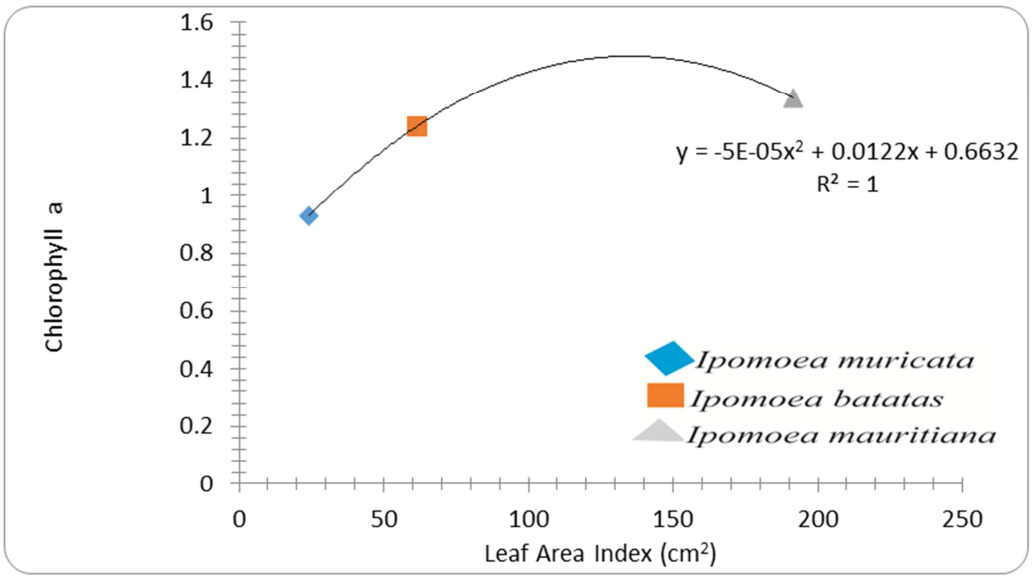

Figure 1. *Regression of Chlorophyll a with leaf area index.*

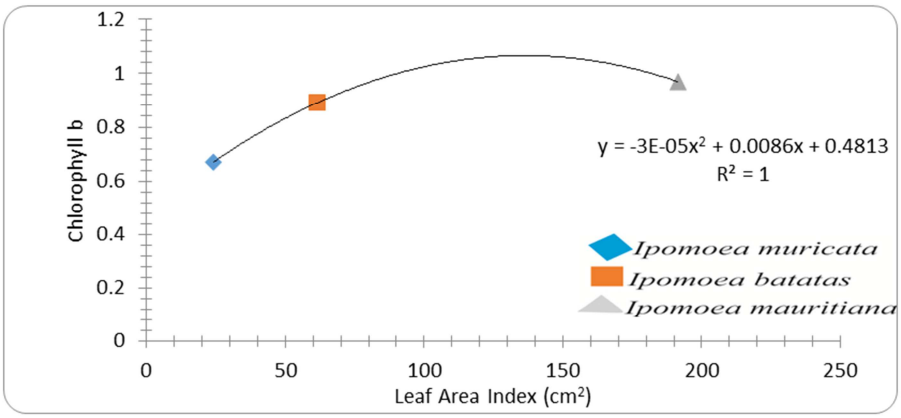

Figure 2. *Regression of Chlorophyll b with leaf area index.*

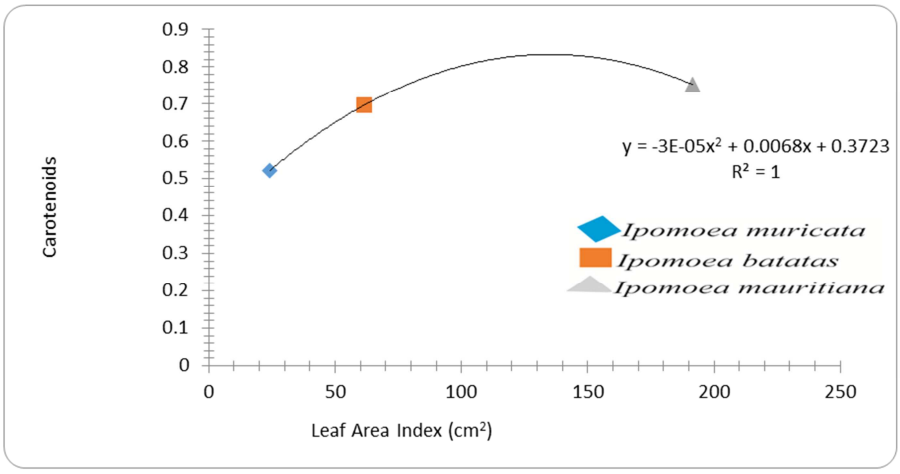

Figure 3. *Regression of carotenoids with leaf area index.*

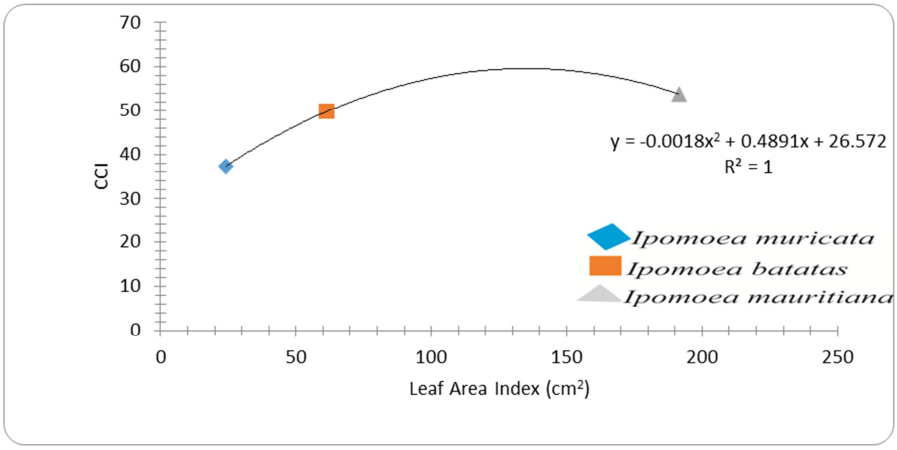

Figure 4. *Regression of CCI with leaf area index.*

4. Discussion

This study shows that there are different species of *Ipomoea* growing in Uyo metropolis. [8] opined that *Ipomoea* species are cosmopolitan in nature and are adapted to a number of varying environmental conditions. This is evidenced in this study. This cosmopolitan nature could be linked to their morphological expressions such as brightly coloured flowers which favours pollination and mass dispersal by human activities, insects and avian species. The ability of these species to grow in varying soil and environmental conditions may point to the fact that they possess a wide phenotypic plasticity and ecological amplitude. This had been affirmed by [4]. The presence of *Ipomoea batatas* in some of the locations is quite diagnostic of anthropogenic influence. This is not only so because the plant tubers are useful sources of carbohydrate but also due

to the fact that the leaves also serve as food wraps in the area [2].

Variations were also observed in the pedological properties in their different habitats and this could be linked to anthropogenic pertubations at varying intensities. Similar assertions were made by [15]. The result from the physico-chemical properties of the soils also revealed that *Ipomoea* species thrive well in soils with weakly acidic to neutral pH. This view coincides with the findings of [27]. The conspicuous dominance of sandy substrates in this study over other particle size classes (silt and clay) is not unprecedented as [29] had earlier reported that these species thrive best in well-drained soils. This researcher also reported that some species of *Ipomoea* grow best in sandy-loam substrates. This is synonymous in this study. The conspicuous low levels of organic carbon and total nitrogen may be affiliated to runoff, soil erosion, leaching and land clearing as these have been reported by several researchers to be the major agents of nutrient loss in the soil [13], [7], [9]. Also the sandy nature of these soils may further contribute to these nutrient loss as it is porous with low aggregate stability to nutrient retention [23]. In addition to this, the presence of litter in minute quantity and its slow decomposition rate in these plots may also expound the low nitrogen status evidenced in the study. This view corroborates with the findings of [5] that organic carbon through litter decomposition is a major source of nitrogen in the soil. This invariably implies that there is a synergistic relationship between organic carbon and nitrogen in the soil.

There were variations in the morphological attributes of *Ipomoea* species. This may hint that the morphological characteristics of these species could be of taxonomic importance. The marked differences in the leaf length, width and other morphological parameters of the plant may point to a significant genetic and evolutionary variations amongst the species over time. This is consistent with findings of [17] where the researcher reported in a related research that ecological factors, gene mutation, chromosomal repatternings and possible ploidy level are responsible for morphological diversity evidenced in *Ipomoea* species. Also the dominating influences of soil and other environmental factors may have further contributed to the variations evidenced in their morphological traits. [22] noted that variations at the intraspecific level among accessions of similar or same species at different locations is not always certain but that when comparing species the reverse is likely to be the case. This synchronizes with this result. The high values for all morphological and productivity parameters observed in this study for *Ipomoea mauritiana* over other species may not deviate from the fact that this species has a high acclimatization potential to the soil substrate and environment where it grows.

The relationship between the morphological and productivity variables established using regression analysis revealed that all regression coefficients obtained for productivity indices (chlorophyll a, chlorophyll b, carotenoids and CCI) with Leaf Area Index (LAI) were positive. The positivity of the regression coefficients implies that these parameters have a synergistic relationship with each other [10], [25]. Again the positive relationships obtained for the different species of *Ipomoea* while considering their morpho-productivity interactions are not unprecedented but rather it can be deduced to mean that chlorophyll is the most essential constituent in plants facilitating their photosynthetic pathways and foliage growth [26]. The high similarity expressed in the constant values of coefficient of determination (R^2) and shape of the polynomial curve relating chlorophyll concentration with leaf area of the variants of this genus confirms that there is sufficient and considerable taxonomic patterning in the classification of the studied plants.

5. Conclusion

The whole essence of ecology is to explore nature through scientific aids with a view to revealing significant relationships. This is applicable in this research which showed that there are a number of *Ipomoea* species growing in Uyo metropolis. Also, these species differed in their morphological parameters. This study also showed that these characteristics might be useful in the identification of the species. It further revealed that *Ipomoea* species grow on a number of soil types thus proposing some sort of wide adaptability for the taxonomically diverse species. Ultimately, this study related morphological traits to productivity indices of these species using leaf area index (LAI) and photosynthetic pigments of the plants. Conclusively, the result of this study has established that there is a relationship existing between the morphological characteristics and productivity indices of *Ipomoea* species. Upon the findings of this research, further ecological and genetic analysis to reveal phylogenetic evolutionary relationships and habitat requirements of the species should be carried out.

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