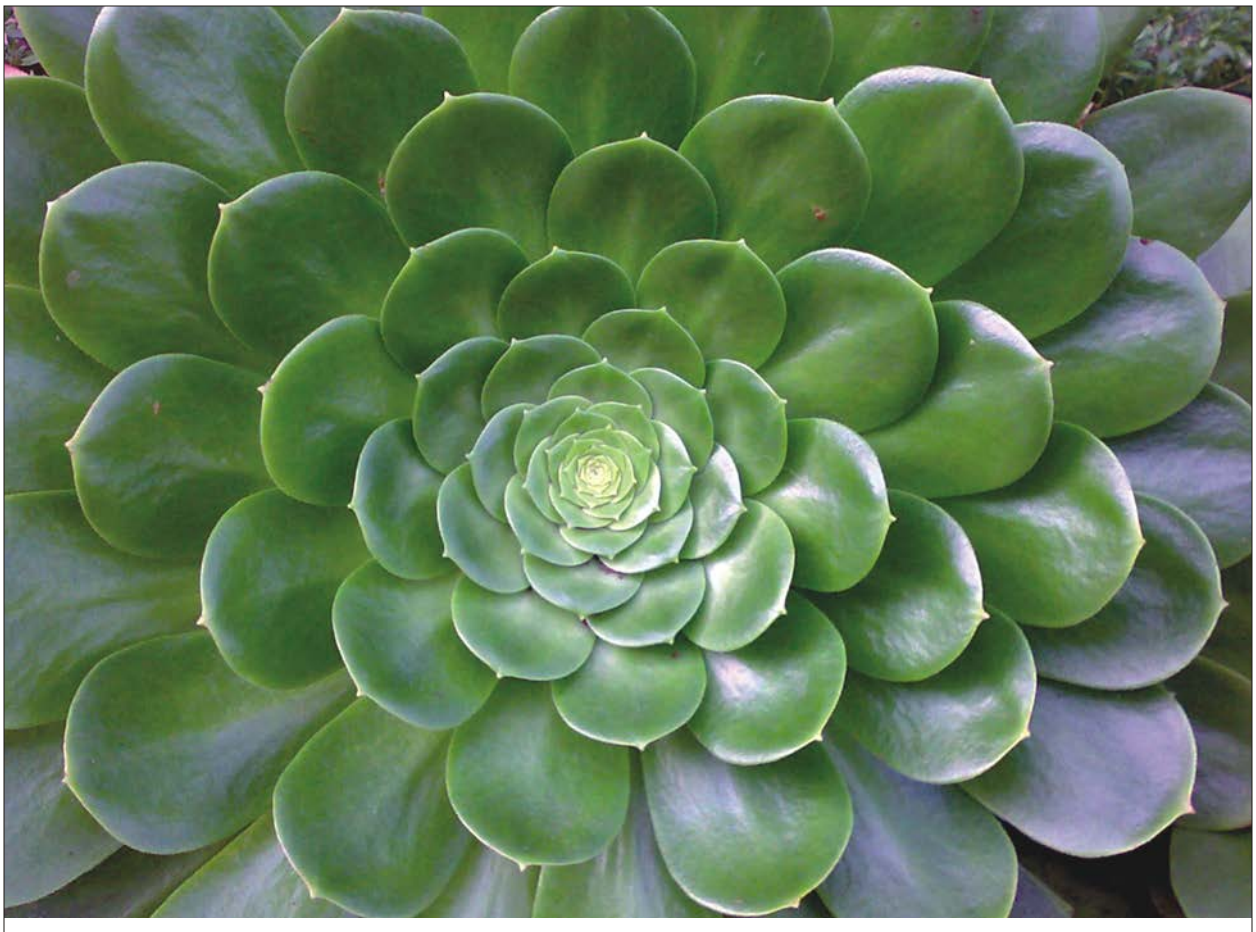

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Comparative Study of Vegetative Morphology and the Existing Taxonomic Status of *Aloe vera* L.

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Abstract: Comparative study of the vegetative characters was carried out on representative samples of different populations of *Aloe vera* L. Plant samples collected from different locations in Nigeria were separated into four morphologically recognizable groups and brought into cultivation in the screen house of the Department of Crop, Soil and Pest Management, Federal University of Technology, Akure, Nigeria. After six months of cultivation, 10 suckers of each morphological group were carefully removed and transplanted into plastic containers already filled with humus soil such that there was only one sucker in each container. The experimental design adopted is the Completely Randomized Design (CRD). New suckers produced were promptly and carefully removed from time to time, leaving only the parent plant in each container. Five years after transplanting, leaf length, leaf width, leaf thickness, stem length and stem thickness were measured using a tape graduated in millimeters and centimeters. Number of leaves per plant and number of roots per plant were counted. Mottle frequency and spine frequency were also determined. Mean values for each morphological group were calculated from five randomly selected specimens. Data collected were subjected to Analysis of variance (ANOVA) and means separated using the Duncan's multiple range test. Result shows that the groups are separated into four different taxa, each group occupying a taxon of its own. This finding is at variance with the existing taxonomy of *Aloe* and therefore, suggests further investigations, particularly in the areas of chromosome behaviour and anatomy, with a view to reappraising the existing taxonomic status of *Aloe vera*.

Key words: Comparative study, vegetative morphology, *Aloe vera*

INTRODUCTION

The genus *Aloe* L. is a member of the family Liliaceae (Tribe Aloineae). Its representatives are perennial succulent plants, often arboreal, bearing rosettes of leaves at the end of juicy green branches (Hepper, 1968). Leaves are fleshy, stiff, mottled, lance-shaped with glabrous surfaces, sharp apices and spiny edges. The leaves send out sticky exudates when they are broken or injured. The name *Aloe* is derived from the Arabic word Alloeh, meaning shining bitter substances (Ajabnoor, 1990). According to Anselm (2004), over 325 species of the genus *Aloe* have been identified by the year 2004. Basically, all the various species of *Aloe* have similar constituents but *A. vera* is more popular all over the world because it propagates itself faster than any other known species of *Aloe* (Anselm, 2004). Hence, *A. vera* is more readily available for use than any other species of *Aloe*. *A. vera* is native to Africa but was taken to other tropical climates for cultivation. It was later introduced to the Caribbean Island, India, Venezuela and Mexico. It was only during the 1970s that people in the USA started cultivating *A. vera* for its gel. *A. vera* belongs to a large class of plants known as xeroids because it possesses the

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ability to close its stomata completely to avoid loss of water. This makes the plant to have the natural ability to survive long periods of drought (Hect, 1981). *A. vera* is a monocotyledonous plant which grows to about three feet in height (Davis *et al*., 2000). It takes four to five years to mature and can live up to 25 years (Aloe vera company, 2002). Propagation is either by seed or by sucker (Duke, 1987). *A. vera* grows best in full sunshine and does not grow well at temperatures below 32°F. It requires little water for its reproduction (Shelton, 1991). The plant has been in existence for over 2000 years.

Apart from its use as ornament in homes, gardens and yards, *A. vera* is one of the medicinal plants widely used throughout the world (Sofowora, 1984). Biblical report, as recorded in John 19 verses 39 and 40, reveals that it was used to embalm the body of Jesus Christ. There is also a report that Alexander the Great used *A. vera* to treat the wounds of his soldiers that got injured during the war and that Cleopatra used it for the care of the skin (Ajabnoor, 1990). Works carried out on *A. vera* show that the plant is effective in the treatment of cancer (Grimando *et al*., 1997) and intestinal ulcer and has a modulating effect on Human Immunodeficiency Virus- HIV (Anselm, 2004). The sap of the plant is used to sooth the pain of burns, rashes, insect bites and other skin irritations (Womble and Helderman, 1998). *A. vera* is also used to cure such illnesses as impotence, liver and kidney problems, piles, eczema, glaucoma, jaundice and ameneorrhea. It has been established that the inner gel of the leaf contains most of its beneficial part (Swaminathan and Kochhar, 1992). McCauley (1992) reported that the eight essential amino acids that human body needs, which cannot be manufactured but can only be obtained from food, are present in *A. vera*. These amino acids are isoleucine, leucine, lysine, methioine, phenylalanine, threonine, valine and tryptophan. Enzymes that are beneficial to human metabolism such as amylase, bradykinase, catalase, cellulose, lipase, oxidase, phosphokinase, proteolytiase and carboxypeptidase can also be obtained from the plant (Blumenthal and Mark, 2000). Tyler (1994) found out that the gel of the leaf of *A. vera* is made up of 96% of water and that the other 4% consists of at least 75 different elements such as vitamin B (including B_1, B_2, B_3, B_6, B_{12}), vitamin C, vitamin E, folic acid and minerals. The minerals such as magnesium, calcium, potassium, phosphorus, sodium, manganese, zinc, copper, nitrogen, iron and chromium found in the gel all contribute to the healing property of *A. vera*. Hect (1981) found out that the plant contains cineole, cariofilene and pinene which are essential oils needed by human body. The plant also contains glutamic acids, aspartic acid, aloetic acid, formic acid, palmitic acid, estearic acid and ascorbic acid all of which are essential components of food (Davis *et al*., 2000). *A. vera* is commonly referred to as miracle plant for its numerous uses, particularly in the area of man's health.

By mere visual observation, it is commonly noticed that a number of differences, particularly in their vegetative morphology, do occur among the various *A. vera* plants. This observation raises a number of questions: (I) are the differences observed due to mere differences in environmental factors? (ii) are the differences brought about by gene rearrangement or genic recombination? (iii) are the differences a product of speciation? None of the studies carried out on *A. vera* so far has attempted to provide answers to these questions. If the morphological differences observed are due to speciation or gene rearrangement/genic recombination, they will, ineluctably, bring about minor or major differences in the chemistry of the various *A. vera* representatives. The differences in the chemistry will, in turn, affect the nutritional and medicinal values of these plants. The objective of this research, therefore, is to carry out a comparative study of the vegetative features of the various *A. vera* plants with a view to providing initial answers to the questions raised above.

MATERIALS AND METHODS

In 2001, representative samples of different populations of *A. vera* were collected from different locations in Nigeria and brought into the screen-house of the Department of Crop, Soil and Pest Management, Federal University of Technology, Akure, Nigeria. Places from which collections were

made are Ilorin, Kano, Yola, Ibadan, Ado, Akure, Port Harcourt and Jos (Fig. 1). Based on visual observation, plant samples were separated into four morphologically recognizable groups and transplanted. Six months after transplanting, ten suckers of each morphological group were carefully removed and transplanted into plastic containers already filled with humus soil. The transplanting was such that there was only one sucker in each plastic container, making a total of 40 suckers in all. The containers were then labeled appropriately, arranged in a completely randomized design and suckers allowed to grow for five years to attain maturity. Plants were watered adequately on a regular basis and weeds found growing in the plastic containers were removed manually. All the new suckers produced in each container were being carefully removed from time to time, leaving only the parent plant.

Five years after transplanting, leaf length, leaf width, leaf thickness, stem length and stem thickness were measured using a tape graduated in millimeters and centimeters. Number of leaves per plant and number of roots per plant were counted. Mottle frequency and spine frequency were determined according to the method of Akinyele (1998). In each case, mean value for each morphological group was calculated from five replicates. Data were later subjected to analysis of variance and means separated using the Duncan's multiple range test.

RESULTS AND DISCUSSION

Places from which collections were made are shown in Fig. 1. Most of the *A. vera* plants encountered (Fig. 2) were grown in plastic containers as ornaments in homes. Hence, population stands represented definite morphological groups. Due to rapid production of suckers, as observed by

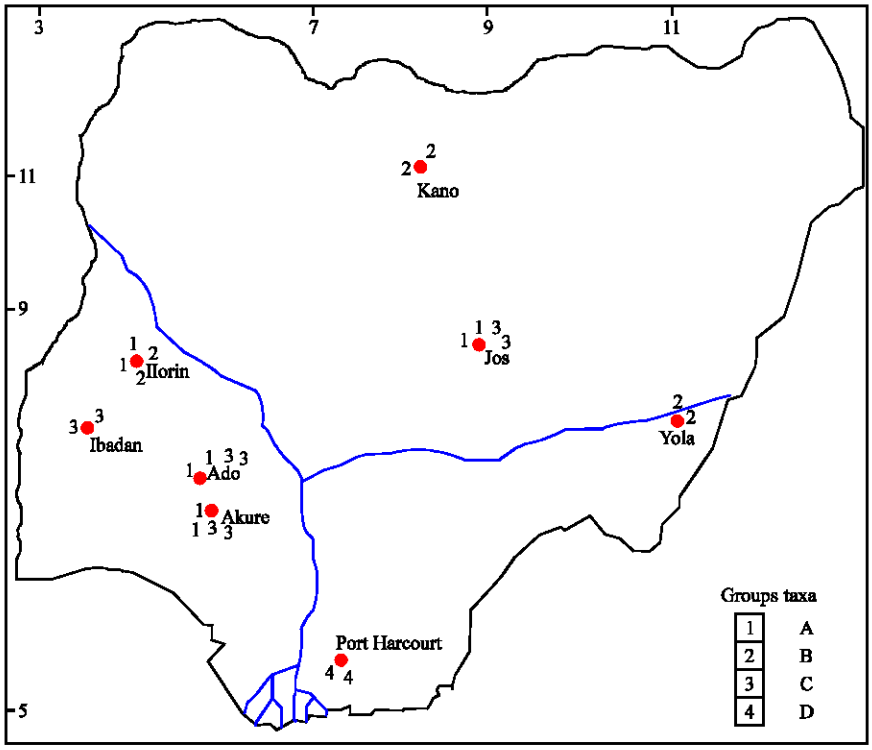

Fig. 1: Map of Nigeria showing places from which collections of *Aloe vera* samples were made

Table 1: Mean values of measurements of *Aloe vera* vegetative characters

Plant group	Leaf length (cm)	Leaf width (cm)	Leaf thickness (cm)	No. of leaves per plant	Mottle frequency	Spine frequency	Stem length (cm)	Stem thickness (cm)	No. of roots per plant
A	35.46±1.42^{c}	3.64±0.26^{b}	1.10±0.13^{b}	12.40±0.75^{b}	1.00±0.32^{a}	8.10±0.46^{a}	9.90±0.49^{c}	2.38±0.09^{b}	24.60±1.44^{c}
B	26.26±1.23^{a}	3.00±0.16^{a}	0.96±0.05^{b}	9.60±0.51^{a}	7.20±0.37^{d}	8.70±0.20^{a}	16.20±0.78^{d}	1.97±0.08^{a}	12.54±1.33^{a}
C	31.34±0.90^{b}	3.14±0.10^{ab}	0.45±0.02^{a}	13.80±0.37^{b}	4.60±0.17^{c}	8.68±0.26^{a}	6.06±0.31^{b}	2.02±0.12^{a}	16.24±0.95^{b}
D	24.90±0.50^{a}	3.60±0.16^{b}	0.60±0.04^{a}	10.54±0.51^{a}	2.45±0.17^{b}	8.80±0.26^{a}	2.54±1.16^{a}	1.87±0.02^{a}	16.80±0.52^{b}

Values are means±SEM for five replicates. Mean values in the same column followed by different superscripts are significantly different ($p<0.05$)

Fig. 2: Vegetative habit of representatives of the four *A. vera* groups

Akinyele (1998) and Anselm (2004), members of all the groups were usually found crowded. Where two or more populations of different morphological groups were found growing together, representatives of each group were easily recognizable. Generally, leaves are thick, fleshy, mottled on the surface and sharply toothed on the margins (Hepper, 1968). Nine vegetative characters were investigated and results are presented in Table 1, which reveals taxonomic significance of information supplied.

A. vera is not native to Nigeria but was brought to Nigerian climates for cultivation. It is possible, therefore, that interaction between its genotype and new open niches to exploit might have evolved the morphological differences observed among the groups which are presumed to have originated in the same way. This argument is corroborated by the finding of Oyewole (1971) that the three West African species of *Albuca* L., associated with three distinct ecological areas, namely the savannah, the montane and the sudan vegetation zones, migrated into West Africa from an ancestry of *Albuca* in an ancestral area, most probably in Southern Africa. Therefore, the morphological resemblances among the four *A. vera* groups investigated are possibly an indication that their progenitors must have been morphologically similar and that each group has retained most of the ancestral features.

Fresh suckers from parent plants were cultivated for five years in the screen-house before biometric investigations were carried out. It was expected that by the end of the five-year period, all environmentally-induced morphological differences would have faded away. Hence, measurements recorded for each group after the five-year period should be seen as characterizing that particular group and, at the same time, distinguishing it from any other group. Out of the nine characters investigated, the only one that is stable across the groups is the spine frequency. It is the only character that recognizes members of the four groups as belonging to the same taxon. It follows, therefore, that spine frequency is likely to be under a strong influence of the genotype of the plant. Though all the other

eight characters vary more or less continuously from one extreme to the other within each group, they exhibit discontinuities which are very distinct, stable, clearly recognizable and correspond to definable taxonomic limits. While the leaf width, leaf thickness, number of leaves per plant and stem thickness see the various *A. vera* representatives as belonging to two taxa, they are separated into three taxa by leaf length and the number of roots per plant. Both the mottle frequency and the stem length separate the four groups into four taxa such that each group occupies a taxon of its own. It is noteworthy that this work consistently showed the characteristics found associated with each group to characterize the particular group. This characterization, according to Mustapha (1991), is a further taxonomic feature which may provide additional information in the recognition of the four groups of *A. vera* as distinct taxa.

The effect of variation in environmental factors has been removed by using fresh suckers produced right within the screen house and growing these same suckers under the same weather and soil conditions for five years in the screen-house. Therefore, any differences observed among the four groups at the end of the five-year period of cultivation are most likely to be genetically induced. Hence, it is logical to argue that the differences in the vegetative features represent genetic differences between the different groups within the framework of their common ancestry. This finding is at variance with the existing taxonomy of *Aloe*. Therefore, there is need to reappraise the existing taxonomy of the plant. If the four *A. vera* groups belong to different genetic systems as is being suggested by the available information, then their chemistry will vary from one group to the other. The differences in their chemistry will, no doubt, affect their nutritional and medicinal values. Since no single set of data provides sufficient information for taxa delimitation, it would be shortsighted and rash indeed to base final judgment on only the vegetative morphology from which the set of data used in this study was obtained. According to Heslop-Harrison (1955) and Adeyemi (1981), correlation of one set of data with others would make the correlated characters good parameters for species delimitation. Therefore, the taxonomic worth of the set of data amassed in this investigation would be better assessed when it is interpreted alongside other contributory sets of data. Hence, it is being suggested that further investigations should be made, particularly in the areas of chromosome behaviour and anatomy, with a view to reappraising the existing taxonomic status of *A. vera*.

CONCLUSION

After considering all the information supplied by data collected in this investigation, all the available evidence point to the conclusion that the vegetative morphological differences observed among the four *A. vera* groups represent genetic differences within the framework of their common origin and are, therefore, not environmentally-produced differences. Hence, the four *A. vera* groups investigated in this research indeed represent four different taxa, each group occupying a taxon of its own.

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