Morphometric Study of Several Species of the Genus *Jatropha* Linn. (Euphorbiaceae)

Opeyemi Saheed KOLAWOLE¹*, Abdullahi Alanamu ABDULRAHAMAN², Mahboob Adekilekun JIMOH³, Felix Aytunde OLADELE⁴

¹Federal University, Department of Biological Sciences, Kashere, Gombe State, Nigeria; kolawoleabhere@fukashere.edu.ng (corresponding author)
²University of Ilorin, Department of Plant Biology, Ilorin, Nigeria; abdulrahamanusa@unilorin.edu.ng
³Osun State University, Department of Biological Sciences, Osogbo, Nigeria; jimohmahboob@yahoo.co.uk
⁴University of Ilorin, Department of Plant Biology, Ilorin, Nigeria; fikolawole@unilorin.edu.ng

Abstract

Morphological parameters of several *Jatropha* species, namely *Jatropha curcas* L., *Jatropha gossypifolia* L., *Jatropha podagrica* Hook., *Jatropha integerrima* Jacq. and *Jatropha multifida* L. were subjected to quantitative analysis within the present study. Twelve traits of the leaves, fruits and seeds were analysed: leaf length, leaf width, leaf length/width ratio, petiole length, petiole width, fruit length, fruit width, fruit length/width ratio, seed length, seed width, fruit stalk length and fruit stalk width were subjected to Principal Component Analysis (PCA) and cluster analysis. Highly significant positive correlations have been noted, while negative correlation was observed between leaf width and leaf length/width ratio, fruit width and leaf length/width ratio. Traits such as leaf length, leaf width and leaf length/width ratio contributed significantly along with other traits to discriminate the studied *Jatropha* species. *J. podagrica* and *J. integerrima* were found to have more similarities, with a stronger coefficient of agglomeration (69.072) than *J. curcas* and *J. podagrica* with 315.028 coefficient of agglomeration respectively. The generated dendrogram showed the relationship between the studied *Jatropha* species, whereas great affinity was noted between *J. podagrica* and *J. multifida* as compared with *J. gossypifolia* and *J. integerrima* which are distantly related. The closeness observed between *J. podagrica* and *J. multifida* is in line with their current sub-generic grouping.

Keywords: cluster analysis, fruits, *Jatropha* species, leaves, PCA, seeds, taxonomy

Introduction

*Jatropha* L. is a morphologically diverse and geographically widespread genus of 150-175 woody species (Dehgan, 1982). The genus *Jatropha* belongs to the family *Euphorbiaceae* and is a very diverse subtopics and tropical genus which includes succulent, caudiciform species, herbaceous perennial and woody species (Nwokocha et al., 2011).

Hutchinson and Dalziel (1958) recognized 8 species of *Jatropha* in West-Tropical Africa, while Rath and Paramathma (2009) described 12 species of *Jatropha in* India, using morphological traits. A range of economic importance of *Jatropha* species has been reported, most especially *J. curcas* yields oil of highly marketable biodiesel value (Agarwal and Agarwal, 2007; Akbar et al., 2009). The oil is used in the manufacture of candle, soap and cosmetics industry (Nwokocha et al., 2011). *J. curcas* also has a great potentiality in the rehabilitation of degraded soil (Achten et al., 2007; Damisa et al., 2008; Kumar et al., 2008; Koyejo et al., 2010) and it is a drought resistant plant that has wide adaptability to varied climate and soils. In addition, *J. podagrica* Hook. seeds yield 40% of oil known as pinheon oil or “oil infernale” (Joubert et al., 1984). *J. integerrima* Jacq. makes a delightful shrubs border plant with its eye catching red flowers (Oladipo and Illoh, 2012) and it contains a potential lethal toxin called curcin. A leaf decoction of *J. gossypifolia* is used routinely by herbalists in the urban areas to stop nose, gum and skin bleeding. Further, leaf decoction of *J. gossypifolia* has been used for bathing wounds, while its seeds are used as purgative and for treatment of body aches.

Morphometrics represent the quantitative analysis of biological form that has been widely used in a lot of discipline including systematics (Henderson, 2006). Morphometrics, known as numerical taxonomy, is the application of various mathematical procedures to encode characters. The practice of numerical taxonomy embraces numbers of fundamental assumptions and philosophical attitudes towards taxonomic work. It has the ability to integrate data from a variety of sources such as anatomy, cytology, ecology, genetics, geography, physiology, palynology, chemistry etc. (Soladoye et al., 2010b).
The products of such determinations are often considered to be unbiased indicators of the similarity or differences between the taxa, which are used to arrange taxa in hierarchy (Quike, 1993). The method of morphometrics or numerical taxonomy has been used in classifying many plants, as well as interpreting results of the taxonomic studies (Sonibare et al., 2004; Abu Zaida et al., 2008; El-Gazzar, 2008; Soladoye et al., 2010b).

The present study has therefore aimed at using the morphometrics method to observe the differences and similarities in the morphological characters used to discriminate *Jatropha* species. The objective of the study is to determine the traits that would contributed strongly to the delimitation of the taxa based on their similarities.

**Materials and Methods**

**Plant collection**

Mature plant specimens from the field and herbarium were used for the study. The fresh specimens were collected in open vegetation, from roadsides and bushy areas in various parts of South-Western Nigeria, while herbarium specimens were accessions previously collected from different parts of Nigeria and preserved in the Forest Herbarium, Ibadan, FHI, Nigeria (Table 1). Upon collection of fresh plants, voucher specimens were prepared according to the established protocol of Soladoye et al. (2010a).

In this study, twenty-five accessions of each species were examined. Some traits which were difficult to assess accurately or were unsuitable for rapid and accurate scoring were eliminated. Thus, twelve traits were recorded as employed for the morphometric study: leaf length and width, leaf length/width, petiole length, petiole width, fruit length, fruit length/width, seed length, seed width, fruit stalk length and fruit stalk width.

**Morphometric and statistical analysis**

Morphometric analysis was carried out on field and on herbarium specimens of each of the five species of the genus *Jatropha*. The measurements regarded the length and width of leaves, petiole, fruit, seed and fruit stalk using a line ruler and an electronic digital calliper graduated in millimetres (later converted to centimetres). The length of the leaf was obtained by spreading on a white sheet of paper on the laboratory bench and the longest part was measured; the same procedure was used for the width of vegetative parts. These measurements were then compiled for each Operational Taxonomic Unit (OTU).

The cumulative Principal Component Analysis is presented in Table 4. At least three of the traits (leaf length, leaf width and leaf length/width ratio) contributed greatly to the delimitation of the studied taxa.

Differences based on morphometry of *Jatropha* species are noted in Table 5, representing the agglomeration schedule of the studied *Jatropha* species as viewed from the perspective of cluster.

The corresponding mean figures of the recorded measurements keyed into a Microsoft Excel spreadsheet and SPSS 16.0 statistical software analysis sheet. The Principal Components Analysis (PCA) and Cluster Analysis were computed based on the 12 selected quantitative traits measured.

**Results**

Morphological parameters of five *Jatropha* species (Table 1) were examined with numerical methods. The mean and standard deviation of the quantitative morphological traits employed are presented in Table 2. Similarities matrix on correlation of *Jatropha* species (Table 3) showed that close resemblance of species could be observed when certain characters are employed. For instance, when leaf length was correlated with leaf width, the degree of affinity was 0.816 and 0.338 when correlated with petiole width, but when leaf length was correlated against leaf length, it was 1.000. Similarly, when leaf width was correlated with leaf length/width ratio, the degree of resemblance was -0.317, whereas it was 0.380 when compared with fruit width and 1.000 when correlated against fruit width. The results revealed highly significant positive correlations among almost all the analysed traits. Negative correlation was observed between leaf length and leaf length/width ratio, fruit width and leaf length/width ratio.

**Table 1. Voucher information and distribution of fresh and herbarium specimens of studied *Jatropha* species**

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Herbarium specimen</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Jatropha curcas</em> L.</td>
<td>FHI 109827, FHI 109620, FHI 109865, FHI 86744, FHI 108432</td>
</tr>
<tr>
<td><em>Jatropha gossypifolia</em> L.</td>
<td>FHI 108011, FHI 108195, FHI 83442, FHI 44937, FHI 109863</td>
</tr>
<tr>
<td><em>Jatropha podagrica</em> Hook.</td>
<td>FHI 107676, FHI 64394, FHI 14509, FHI 43496, FHI 109871</td>
</tr>
<tr>
<td><em>Jatropha integerrima</em> Jacq.</td>
<td>FHI 109864, IFE 16420</td>
</tr>
<tr>
<td><em>Jatropha multifida</em> L.</td>
<td>FHI 109498, FHI 108012, FHI 96651, FHI 31400, FHI 109872</td>
</tr>
</tbody>
</table>

**Fig. 1. Component plot in rotated space for the twelve morphological traits examined among *Jatropha* species; Component 1: petiole width; Component 2: fruit length/width; Component 3: leaf length/width**
The cluster that exists between species 3 (J. podagrica) and species 5 (J. multifida) had a coefficient of 69.072, whereas between species 1 (J. curcas) and species 3 (J. podagrica) it was 315.025, showing a great degree of variation within their morphometry.

Table 6 showed the factor loading of the twelve quantitative morphological characters and it also reveals that some traits are more valuable comparing with others in the genus variation. Fig. 1 shows the components plots on rotated axis for the twelve quantitative morphological traits employed; it was noted that petiole width, fruit length/width and leaf length/width were contributing most to the separation among species.

The dendrogram showing the relationships established among the studied species, based on the quantitative morphological characters within the study, underlined a great affinity that exists between J. podagrica and J. multifida opposite to the one between J. gossypifolia and J. integerrima which were distantly related (Fig. 2).
Discrimination

Generally, morphometrics add a quantitative element to species descriptions, allowing more rigorous comparisons within a genus. In the numerical analysis of five Jatropha species using twelve quantitative morphological traits, the results revealed that variations in the vegetative parts and fruit traits are important. Of the quantitative parameters used, leaf length, leaf width and leaf length/width ratio had the highest values compared with the others traits, confirming their usefulness for species identification purposes. Some traits had been observed by previous studies on Ficus species (Sonibare et al., 2004), Acalypha in South-Western Nigeria (Soladoye et al., 2008), Senna species in South-Western Nigeria (Soladoye et al., 2010a) and Indigofera species (Soladoye et al., 2010b).

The studied Jatropha species exhibited variations based on samples collected from different locations. The size of the fruit and bud length was dependent on the age of plants as earlier confirmed by other reports (Irvine, 1961; Burkill, 1995). Leaf shape and size may vary within the same plant. Previous studies suggested that light intensity may affect the carbohydrate balance, which could affect the length of the cells in the direction of the long axis, thereby leading to differences in the length, shapes and width of the leaves (Soladoye et al., 2010b). Such variations observed may be due to environmental, as well as genetic factors, and the interaction among them (Nwachukwu and Mbagwu, 2006).

The closeness observed between J. podagrica and J. multifida is in line with their current subgeneric and sectional delimitations based on their vegetative morphology, epidermal and petiole anatomy (Dehgan and Webster, 1979; Dehgan, 1980, 1982). Both species belong to the subgenus Jatropha, section Peltatae. Generally, the pattern of clustering observed in dendogram using average linkage within groups was in line with the current sub generic delimitation of the taxa. Under the current classification, only J. curcas belongs to the subgenus Curcas, while the remaining taxa belong to the subgenus Jatropha. In the dendogram it can be observed that there was a close relationship between J. gossypifolia and J. integerrima in their quantitative morphological traits, although they have different sectional delimitation in taxonomy (Dehgan and Webster, 1979; Dehgan, 1980, 1982); nevertheless, Oladipo and Illoh (2012) on their research on the comparative wood anatomy on genus Jatropha underlined same findings as the current study did.

The chemotaxonomic method of using quantitative phytochemical constituent differences can also be employed in further investigation on the taxonomy of the genus Jatropha, thereby adding to the existing information on the taxonomic results of stomata parameters (Abdulrahaman and Oladele, 2010), leaf electrophoresis (Oladipo and Illoh, 2012), crude seed electrophoresis (Oladipo et al., 2008) and wood anatomy (Oladipo and Illoh, 2012) on the genus Jatropha.

Conclusions

Conclusively, numerical taxonomy provided a greater discrimination along the spectrum of taxonomic differences among Jatropha species and was also more sensitive in the delimitation of the studied taxa. The closeness observed between J. podagrica and J. multifida is in agreement with their current sub-generic grouping. In addition, the study hereby revealed more detailed information on the level of relationship within the genus Jatropha.

References

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