Comparative wood anatomy of some members of the genus *Jatropha* (*Euphorbiaceae*) found in Nigeria

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Abstract. Comparative wood anatomy of five species of *Jatropha,* namely *J. curcas, J. gossypifolia, J. integerrima, J. multifida,* and *J. podagrica,* found in Nigeria was studied by light microscopy. The studies were aimed at elucidating the taxonomic value of the wood characters in the genus. The generic features of wood anatomy include diffuse porous wood, simple perforation plate with oblique endwall, paratracheal vasicentric axial parenchyma, alternate intervascular pitting, septate fibres, upright vascular ray cells, and presence of starch and crystal grains in the ray cells. There is certain uniformity in the qualitative wood anatomical characters of the taxa, while quantitative wood anatomical characters vary significantly ($p<0.05$). Wood anatomical characters reflect on the taxonomy of the genus.

Key words: comparative wood anatomy, *Jatropha,* secondary xylem, taxonomy

Introduction

Attention of late has been focused on members of the genus *Jatropha* L. because of their medicinal importance and the capacity of some to generate biodiesel. Members of the genus *Jatropha* have been reported by various researchers as having a wide range of application. *J. curcas* L. in particular contains oil that can be used to generate energy. It is reported as having over 1600 applications and has been described as a multipurpose plant and best material for future biodiesel production. According to Ochse (1980), the young leaves are eaten steamed or stewed by the people of the Dutch East Indies. The leaf juice of *J. curcas* is used externally for curing piles and against tongue inflammation in babies. Furthermore, a decoction of leaves and root is used to treat diarrhoea, while that of the bark is applied for rheumatism and leprosy. Although *J. curcas* is used as a purgative, the nut is roasted and eaten (Ochse 1980). In South Sudan, the seeds and fruits are used as contraceptives. However, the greatest asset of *J. curcas* is probably derivation of biodiesel (extracted from the seeds) which is very similar to the petrochemical-based diesel fuels. Such biodiesel is environmentally more friendly, as compared to the diesel from crude oil. The oil content of *J. curcas* is reportedly between 30 %–42 % in the seeds (Rathakrishnan & Paramathma 2009) and 50 %–60 % in the kernel, and contains 21 % of saturated fatty acids and 79 % of unsaturated fatty acids. Ingestion of *J. podagrica* Hook. seeds may cause cardiovascular failure and dehydration. The seeds of this species also yield 40 % of oil known as pinheon oil or *oil infernale* (Jourbert & al. 1984). *Jatropha integerrima* Jacq. makes a delightful shrub border plant with its eye-catching red flowers. However, it contains a potentially lethal toxin called curcin. A leaf decoction of *J. gossypifolia* L. is used routinely by herbalists, rural dwellers and some people in the towns to stop nose, gum and skin bleeding (although without due consideration for safety). Oduola & al *(*2005) have established that the stem latex of this species contains haemostatic agents used as anti-coagulants in biochemical and haematological analyses. A leaf decoction of *J. gossypifolia*

has been used for bathing wounds, while its seeds are used as purgative and for treatment of body aches. The genus *Jatropha* belongs to the subfamily *Crotonoideae* of the tribe. It is represented by eight species in West Africa (and six of these species are found in Nigeria) (Hutchinson & Dalziel 1958). The use of wood anatomy in relation to taxonomy is certainly new or recent (Sivaraja 1991). The type and arrangement of vascular bundles, type of secondary growth and various characters of the xylem and phloem elements have all been used for elucidating the phylogenetic relationship of the woody species (Sivaraja 1991). A review of the literature on this genus has revealed sparse data on the wood anatomy of this genus in Nigeria. The present study examines wood anatomy of the species of genus *Jatropha* in Nigeria in search of more characters of any diagnostic and taxonomic importance for further understanding the delimitation of its members. Therefore, the specific objectives of this study are:

i. to determine the wood anatomical features of the Nigerian species of *Jatropha* ;
ii. to determine the intra-generic similarities and differences of the studied taxa by means of the wood anatomical features and to show how they affect their current subgeneric and sectional delimitation.

Material and methods

Small blocks of 1cm × 1 cm × 5 cm were collected from twigs of the individual plants. The blocks were boiled in water for about two hours to soften them. Ten microns thick transverse (TS), tangential and radial longitudinal sections of the stem (TLS and RLS) were made with the aid of a Reichert sliding microtome and were preserved in 50 % ethanol. The sections were stained for three minutes in Safranin O, rinsed in water and counter-stained for another three minutes in Alcian blue. The counter-stained sections were rinsed in water before serial treatment in ethanol solution of 50 %, 70 %, 80 %, 90 %, and 100 %. The dehydrated sections were transferred into absolute xylene in two series, so as to remove any remaining trace of water and ethanol. This was used for clarity and prevention of any cloudiness of the slides, as well as for facilitating the drying out of the slides. Microscope observation of each slide and especially of the general outline of the sections, distribution of tissues, and type and structure of vascular bundles was made and recorded. Photomicrographs of each slide were made by Olympus microscope with attached Amscope digital camera. Tissue and cell identification and description followed Fahn (1997). All microscope measurements were made with ocular and stage micrometers. Quantitative data from the secondary xylem of the species were subjected to one-way Variance Analysis with Duncan Multiple Range Test for mean separation. Fifty individual cells were measured for each taxon.

The Herbarium specimens cited are: *Jatropha curcas* (Isawumi, M.A; UNIFEM 809, Faremi, J.B; FHI 107996, Oladipo, O.T, 16414 IFE, *J. podagrica* (Osude, B.A;IFE 11/2704; Guile, D.P.M; IFE 578/2705; Latilo UNIFEM 202), *J. multifida* L. (Guile, D.P.M; IFE 577/2703; Sijuade, A.A; IFE 257/2703; Isawumi, M.A; UNIFEM 606 and 1306), *J. gossypifolia* (Guile, D.P.M; IFE 576/2700b; Sijuade, A.A; IFE194/2701[a]; Elufisan, A.A; UNIFEM 424 and 1379, Oladipo, O.T, IFE 16413, *J. integerrima,* Oladipo, O.T, IFE 16420.

Results

The results of the wood anatomical study of genus *Jatropha* are presented below.

Jatropha curcas L. (Plate 1A-D)

Wood diffuse porous, vessel element diffuse, oval to polygonal, with thick walls, solitary vessels 31–84 %, also in radial multiples of 2–11, and pore cluster of 5 (Plate 1A), mean vessel diameter up to 88.4 ± 4.26 μm. Vessel perforation simple, intervascular pitting alternate and bordered (Plate 1B), rays uniseriate, occasionally biseriate, predominantly homogenous (consisting of upright cells) (Plate 1D), mean ray height 46.0 ± 2.42 μm (Plate 1C). Axial parenchyma paratracheal, vasicentric, sparse, libriform fibres aseptate (Plate 1B). Crystal sand and starch grains were present and numerous in the ray cells.

Jatropha podagrica Hook. (Plate 2A-D)

Wood diffuse porous, solitary vessels 24–63 %, in radial multiples of 2–11 pores and pore clusters 3–5. (Plate 2a). Vessel elements polygonal, thick-walled with alternate pitting, bordered, perforation simple, mean vessel diameter of 68.0 ± 2.06 μm. Rays uniseriate, predominantly homocellular (upright cells), mean height 52.8 ± 2.50 μm. Axial parenchyma paratracheal and vasicentric, sparse. Libriform fibres septate. Crystal sand and starch grains were present and abundant in the ray cells.

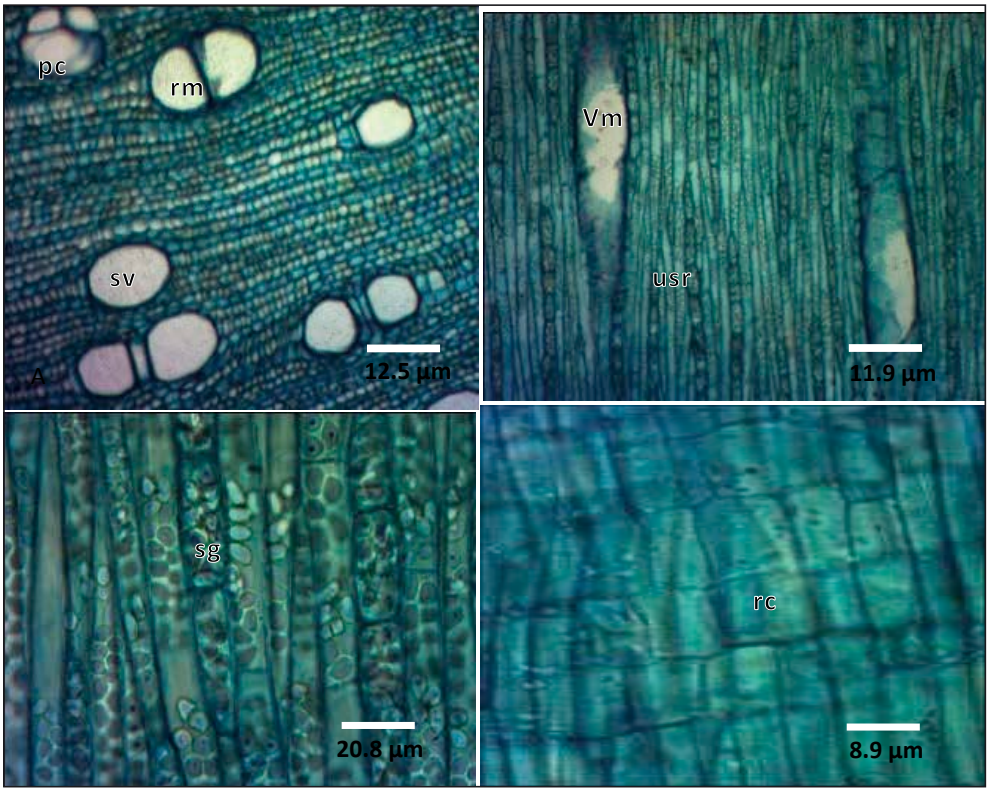

Plate 1. Wood anatomy of *J. curcas*.
Legend: **sg** – starch grain, **rc** – ray cell, **sv** – solitary vessel, **pc** – pore cluster, **rm** – radial multiple, **usr** – uniseriate rays, **vm** – vessel member. **A** = TS wood showing the wood type; **B** = TLS showing the uniseriate ray cells, oblique endwalls of vessel members; **C** = TLS (objective ×40) showing ray cell, septate fibres, crystal and starch grains in the ray cells; **D** = RLS wood (objective ×40) showing the upright ray cells.

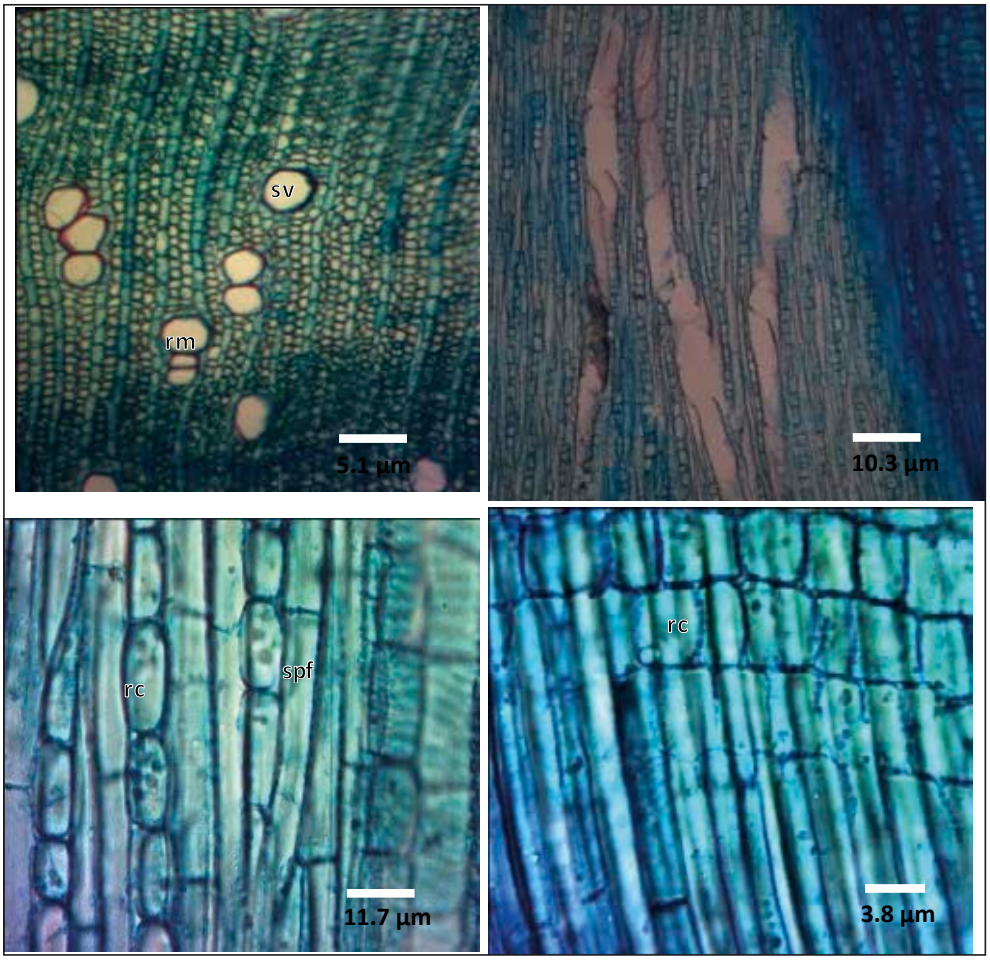

Plate 2. Wood anatomy of *J. podagrica.*
Legend: **rc** – ray cell, **sv** – solitary vessel, **pc** – pore cluster, **rm** – radial multiple, **usr** – uniseriate rays, **spf** – septate fibre. **A** = TS wood showing the wood type; **B** = TLS showing the uniseriate ray cells and oblique endwalls of the vessel members; **C** = TLS (objective ×40) showing ray cells, septate fibres, crystal and starch grains in the rays cells; **D** = RLS wood (objective ×40) showing the upright ray cells.

Jatropha multifida L. (Plate 3A-D)

Wood diffuse porous, vessels diffuse, solitary vessels 27–50 % and in radial multiples of 2–10 pores, pore clusters 2–5. Vessel elements oval to elliptic, occasionally polygonal with alternate pitting, vessel perforation simple, mean vessel diameter up to 70.5 ± 2.61µm. Rays predominantly uniseriate, homocellular, with upright cells, mean ray height 52.7 ± 3.62 µm. Axial parenchyma paratracheal, vasicentric, sparse. Libriform fibres asepate, with a simple pit. Ergastic substances like starch grains, tannins, and crystal sand grains were present and abundant in the ray and axial parenchyma cells.

Jatropha integerrima Jacq. (Plate 4A-D)

Wood diffuse porous, vessel elements oval to polygonal, thick-walled, solitary vessels 20–67 % and in radial multiples of 2–8, pore cluster of 4–5, intervascular pitting alternate, vessel perforation simple, mean vessel diameter 61.1± 2.73 µm. Rays uniseriate, largely homocellular (consisting of upright cells), mean ray height 62.6 ± 2.96 µm. Axial parenchyma paratracheal, vasicentric, sparse. Starch grains were present and numerous in the ray cells (Plates 4c and d).

Jatropha gossypifolia L. (Plate 5)

Wood diffuse porous, vessel elements diffuse, polygonal, thick-walled, solitary vessels 41–70 % and in radial multiples of 2–10, pore cluster 4–5, pitting alternate, bordered, perforation simple, mean diameter 71.9 ± 2.92 µm. Rays uniseriate, homocellular (consisting of upright cells), mean ray height 67.3 ± 3.52 µm. Axial parenchyma paratracheal, vasicentric, sparse. Crystal sand grains and tannins were present in the vessel members and axial parenchyma cells (Plate 5C).

The results of the quantitative wood anatomical features indicate a significant difference ($p < 0.05$) in the quantitative wood characters, such as vessel diameter and length, as well as in the height of vascular ray cells (Table 1). *J. multifida* has significantly longer vessels than the other species, while *J. curcas* has the shortest vessels. *Jatropha gossypifolia* has significantly longer vascular ray cells, as compared to the other taxa (Table 1).

Figs 1 and 2 show the Single Linkage Cluster Analysis Dendrogram and the Principal Component Analysis Scatter Plot of the *Jatropha* species, based on the

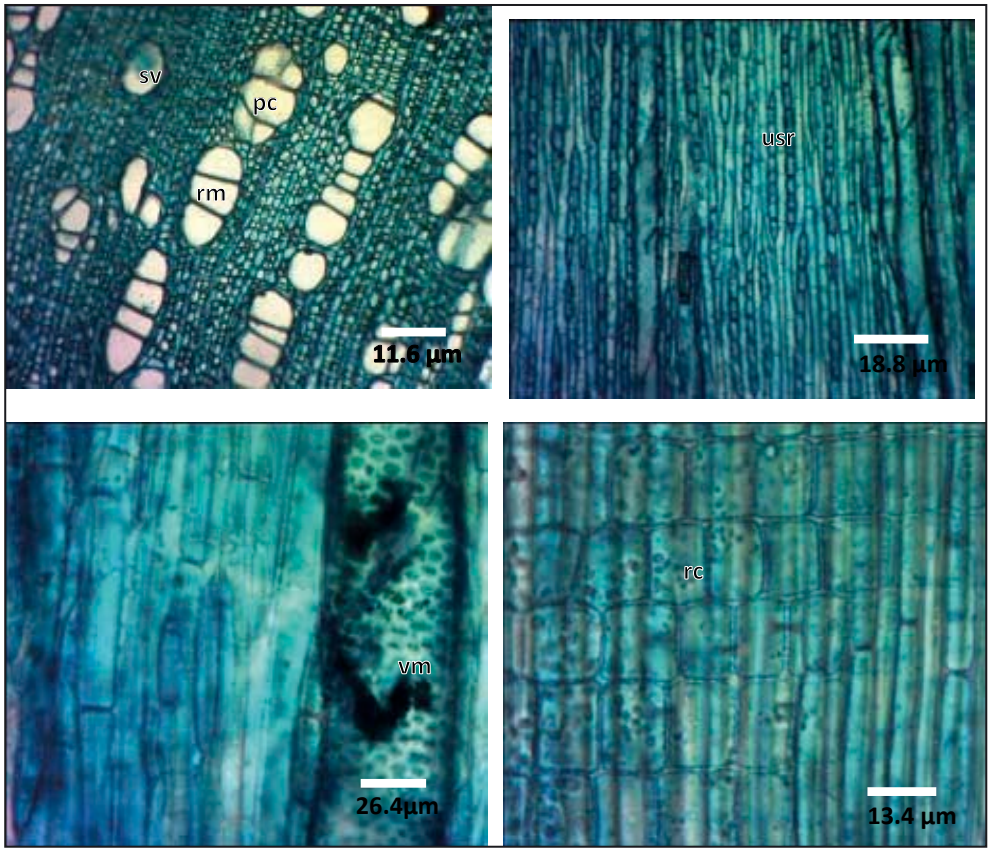

Plate 3. Wood anatomy of *J. multifida.*
Legend: **rc** – ray cell, **sv** – solitary vessel, **pc** – pore cluster, **rm** – radial multiple, **usr** – uniseriate rays. **A** = TS wood showing the wood type; **B** = TLS showing the uniseriate ray cells and oblique endwalls of the vessel members; **C** = TLS (objective ×40) showing the ray cells, septate fibres, and crystal and starch grains in the rays cells; **D** = RLS wood (objective ×40) showing the upright ray cells.

quantitative wood anatomical characters. The figures reveal a strong relationship among the members of the peltatae section (*J. podagrica* and *J. multifida),* section *Jatropha (J. gossypifolia)* and section *Platymorphae* in their wood anatomy. *J. curcas* manifests distinct wood anatomical characteristics.

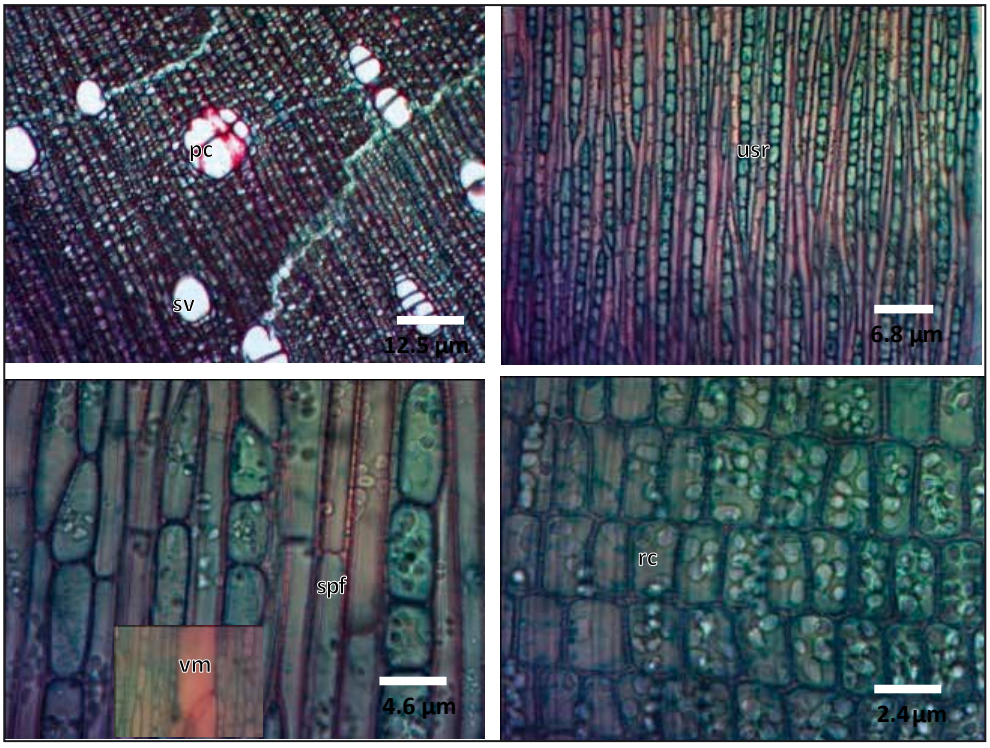

Plate 4. Wood anatomy of *J. integerrima.*
Legend: pc – pore cluster, **spf** – septate fibre, **sv** – solitary vessel, **usr** – uniseriate ray, **rc** – vascular ray cell. **A** = TS wood showing the wood type; **B** = TLS showing the uniseriate ray cells and oblique endwalls of vessel members (inset); **C** = TLS (objective ×40) showing the ray cells, septate fibres, crystal and starch grains in the rays cells; **D** = RLS (objective ×40) showing the upright ray cells.

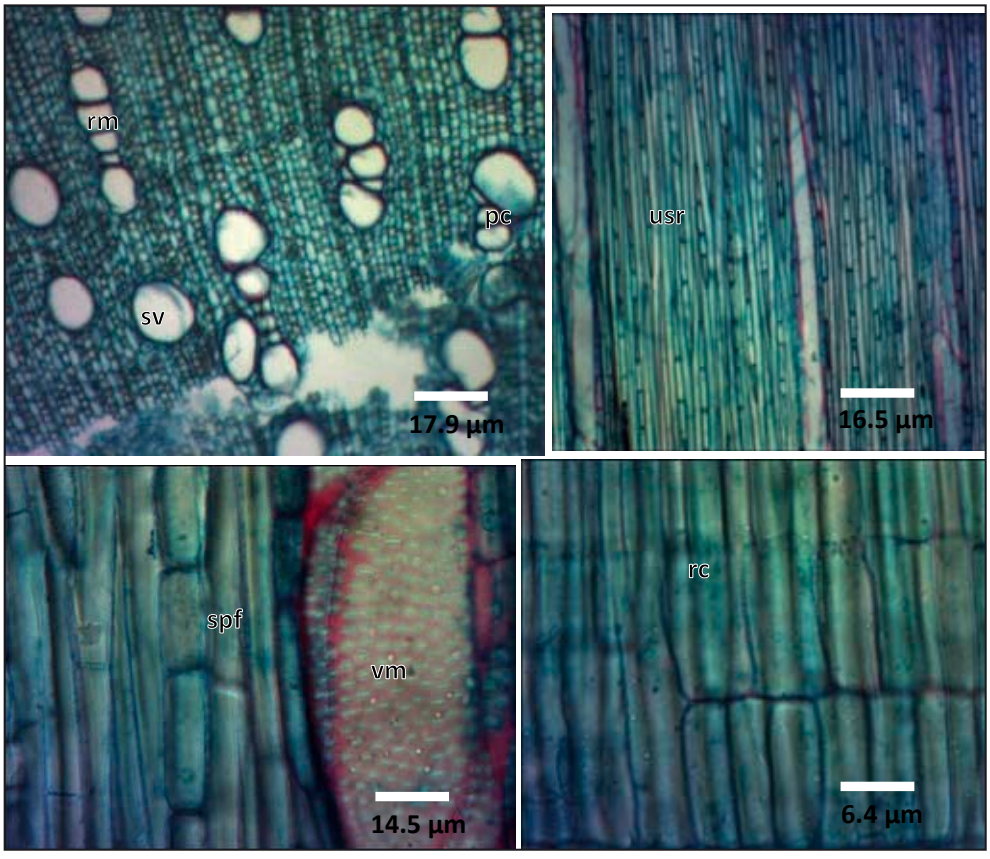

Plate 5. Wood anatomy of *J. gossypifolia.*
Legend: vm – vessel member, **pc** – pore cluster, solitary vessel, **rc** – vascular ray cell, **usr** – uniseriate ray, **spf** – septate fibre, **rm** – radial multiple pores. **A** = TS wood showing the wood type; **B** = TLS showing the uniseriate ray type; **C** = TLS (objective ×40) showing the ray cells, septate fibres, crystal and starch grains in the rays cells and a vessel member; **D** = RLS wood (objective ×40) showing the upright ray cells.

Table 1. Mean quantitative wood anatomical characters of the Jatropha species achieved by Duncan Multiple Range Tests (the means carrying the same alphabet along a column are not significantly different).

Species	Vessel diameter (µm)	Vessel length (µm)	Ray height (µm)
J. curcas	89.18 ± 4.33^{a}	402. 56 ± 18.4^{c}	46.01± 2.42^{c}
J. podagrica	67.98 ± 2.06^{bc}	492.44 ± 21.1^{ab}	52.78 ±2.50^{bc}
J. multifida	70.49 ± 2.61^{bc}	527.62 ± 15.3^{a}	52.66 ± 3.62^{bc}
J. gossypifolia	72.07 ± 3.01^{b}	443.01 ± 19.7^{bc}	67.34 ± 3.52^{a}
J. integerrima	60.99 ± 2.73^{c}	456.58 ± 26.2^{bc}	62.60 ± 2.96^{a}

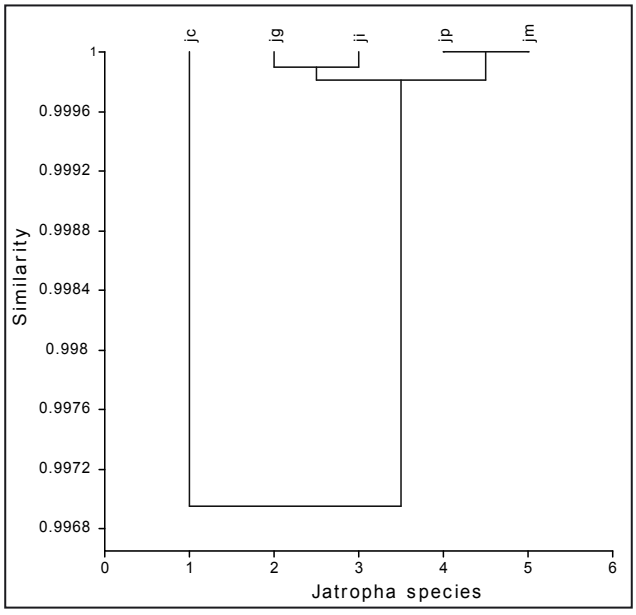

Fig. 1. Dendrogram of the *Jatropha* species based on the quantitative wood anatomical characters of the species.
Legend: **jc** – *Jatropha curcas;* **jp** – *J. podagrica;* **jm** – *J. multifida;* **jg** – *J. gossypifolia;* **ji** – *J. integerrima*

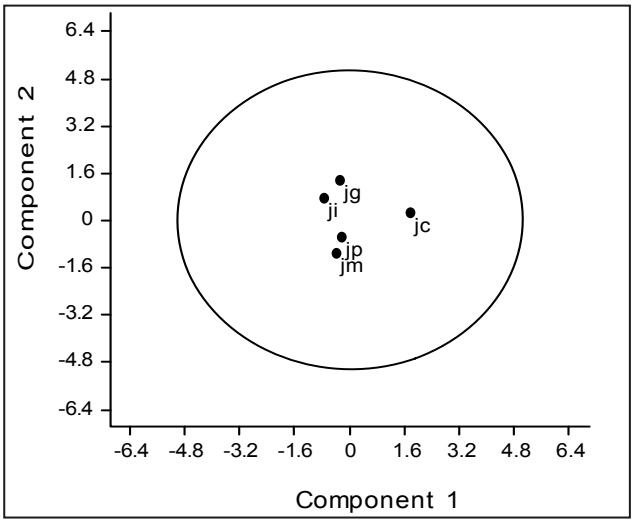

Fig. 2. Principal Component Analysis Cluster Plot of the *Jatropha* species using the quantitative wood anatomical characters.

Discussion

In his study of the anatomy of vegetative organs of flowering plants Metcalfe (1968) observed that anatomy of the vegetative organs could help in establishing the inter-relations of the taxa at infra- and supra-specific levels. Similarly, Jayeola & al (2009) observed that the gross structure of wood can provide potentially useful characters that could be employed to identify the Nigerian timber trees, whether fresh, dry or enquiry samples. Wood anatomy of the studied members of genus *Jatropha* has shown marked consistency and uniformity not only in tissue composition but also in the distribution or arrangement of tissues. The intrageneric wood anatomical characters of the genus include: diffuse porous wood, simple perforation plate, alternate and bordered intervascular pitting, as well as oval to polygonal vessel elements. Constancy of simple perforation between the vessel elements and alternate intervascular pitting and presence of libriform wood fibres indicate a trend towards phylogenetic specialization in some cells and tissues (William 1967).

Preponderance of solitary vessels against the other types of vessels (grouped vessels) in *J. curcas* indicates primitiveness. This corroborates the general perception of the species as the most primitive member of the genus and a possible progenitor from which other taxa have evolved (Dehgan & Webster 1979). It is of interest to note that *J. curcas* has the widest and shortest vessel members, as seen in Table 1. This could possibly explain the clear delimitation of the taxon from the remaining studied taxa (Fig. 1). According to Metcalfe & Chalk (1950), vessel lengths show evolutionary advancement in plant species. Elongated or narrow vessels are regarded as primitive characters, while short or wide vessels as advanced characters. According to this study, *J. multifida* has shown the least specialised vessel.

Though Metcalfe & Chalk (1950:cited by William 1967) had observed heterogeneity in the anatomical structure of members of family *Euphorbiaceae,* in line with the diversity of habits, the results of wood anatomy of the genus in this study run contrary to this observation, because of the marked uniformity or similarities in the wood anatomical features of the members of this genus. However, despite uniformity of the qualitative wood anatomical attributes of the members of genus *Jatropha*, the results of quan-

titative attributes (Table 1) indicate that the species could be delimited by their quantitative wood characters. It could be concluded from the quantitative wood anatomical characters that character dimensions are taxon-specific. The range of values reported for quantitative wood anatomical characters, such as vessel member length (402.56–527.62 μm), vessel diameter (60.99–89.18 μm) and ray height (46.01–67.34 μm) are compared below to values reported for similar characters in certain *Jatropha* species in Mexico by Barajas-Morales (1985). Barajas-Morales (1985) reported 200–216 μm for the vessel diameter in *Jatropha* sp. and *J. chamelensis*. Similarly, 680–778 μm was reported for the vessel member length in the two taxa by the same author (1985). Disparities observed in the range of values reported in this study and by Barajas-Morales (1985) could be connected with the type of wood materials (branches) used in this study and the physiology of Nigerian taxa.

The Single Linkage Cluster Analysis (Fig. 1) and the Principal Component Analysis (Fig. 2) show that the clustering of *Jatropha podagrica* and *J. multifida* is in agreement with the current subgeneric and sectional delimitation of the taxa based on the morphological and petiole anatomical features (Dehgan & Webster 1979; Dehgan 1980, 1982). In the current sectional classification of the genus *Jatropha,* both *J. podagrica* and *J. multifida* belong to the section *peltatae*. However, it merits attention that there is a close relationship between *J. gossypifolia* and *J. integerrima* in their wood anatomical characters, though they have different sectional delimitation based on their vegetative morphology and epidermal and petiole anatomy ((Dehgan & Webster 1979; Dehgan 1980, 1982). The distribution of starch grains on the ray cells and other cells is classificatory in the genus. *J. curcas, J. integerrima* and *J. multifida* showed numerous starch grains, contrary to *J. podagrica* and *J. gossypifolia* which were with scanty or fewer starch grains. The absence of many variations in the wood anatomy of the genus members largely supports their generic delimitation and current taxonomic treatment of the taxa based on morphology and foliar anatomical evidence.

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