TAXONOMIC SIGNIFICANCE OF THE RACHIS, PETIOLE AND PETIOLULE ANATOMY IN SOME EUPHORBIACEAE

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ABSTRACT

Anatomy of rachis, petiole and petiolule in 43 species and 20 genera of Euphorbiaceae are investigated. The mechanical tissues in these organs are invariably sclerenchymatous and collenchymatous. The xylem elements are additionally mechanical in function. The occurrence of vascular tissues is in the form of distinct bundles, only an arc-shaped strand or a continuous cylinder. The cortical bundles are noted in Aporosa and Jatropha gossypiifolia while unequal sized central vascular bundles are observed in Mallotus nudiflorus and M. philippensis. The variation in the distribution of sclerenchyma, collenchyma and vascular patterns apart from the shapes as observed in a transverse section of the leaf stalk can be used for the delineation of the taxa studied.

Key words: Anatomy, Leaf stalk, Mechanical tissues, Systematics, Euphorbiaceae.

INTRODUCTION

Euphorbiaceae sensu lato is one of the most cosmopolitan plant groups within angiosperm, consisting of about 334 genera (Webster, 1994) and over 8000 species, (Redcliffe-Smith, 2001). Many members of the family play an important role in supporting tropical rain forest, horticultural value for ornamental, traditional medicine and food resources. Taxonomic importance of nodal and petiolar anatomy is now widely recognized (Vesque, 1885; Hare, 1943; Howard, 1962, 1970; Schofield, 1968; Dickison, 1969, 1980; Datta and Dasgupta, 1979; Al-Nowaihi et al., 1980; Stuessy, 1990; Ennos et al., 2000; Shaheen, 2006; Bhadane, 2006). Many aspects of the vegetative anatomy have been covered, yet it needs further investigation in aspects that have received comparatively little attention. Very little work has been published on the petiole, rachis and petiolule anatomy of this family (Solereder, 1908; Dehay, 1935; Metcalfe and Chalk, 1950; Miller and Webster, 1962; Dehgan and Webster, 1979; Dehgan Bijan, 1982; Khatijan et al., 1996; Aguiar and Preisinger, 2000; Murillo, 2002 and Thakur and Patil, 2011). Thus, the present investigation was undertaken to record the structural details of these organs and to assess the value of this information for taxonomic purposes.

MATERIAL AND METHODS

The plant materials of Anda gomesii A. Juss., Vernicia fordii Hemsl., Phyllanthus polyphyllus Willd., Baliospermum solanifolium (Geiseler) Suresh., Phyllanthus indofischeri Bennet., Acalypha fruticosa Forssk. and Mallotus nudiflorus (L.) Kulju &Welzen were collected from Lalbagh Botanical Garden, Bangalore where as Mallotus philippensis (Lam.) Muell. Arg., Flueggea leucopyrus Willd., Flueggea
virosa (Roxb. ex Willd.) Royle., Tragia plumkenetii Radcl.-Sm., Putranjiva roxburghii Wall., Phyllanthus airy-shawii Brunel & J.P. Roux., Phyllanthus debilis Klein ex Willd. And Phyllanthus acsidus L. Skeels collected from Pachmhari. Hevea brasiliensis (Willd. ex A. Juss.) Mull. Arg. was collected from Kerala while Agrostistachys indica Dalzell., Aporosa lindleyana (Wight) Baill. and Glochidion hohenackeri (Muell. Arg.) Bedd. collected from Castlerock and that of Manihot esculenta Crantz. and Acalypha ciliata Forsk. obtained from the Pal forest. The young twigs of Jatropha curcas L., Jatropha integerrima Jacq., Jatropha multifida L., Jatropha gossypiifolia L., Jatropha podagrica Hook., Euphorbia milii Des Moul., Euphorbia nerifolia L., Euphorbia tirucalli L., Acalypha hispida Burm., Breynia nivosa (W.G. Sm.) Small., Chrozophora prostrata Dalzell & Gibson., Chrozophora rotteri (Geiseler) A. Juss. ex. Spreng., Croton bonplandianus Baill., Euphorbia indica Lamk., Euphorbia fulgens Karw. ex Klotzsche, Phyllanthus maderaspatensis L., Phyllanthus urinaria L., Phyllanthus virgatus G. Forst., Breynia retusa (Dennst.) Alston., Pedilanthus tithymaloides (L.) Poir., Euphorbia umbellata (Pax) Bruyns. and Phyllanthus reticulatus Poir. were locally collected from the botanical garden of Pratap College, Amalner. The plant materials fixed in F.A.A. were preserved in 70% alcohol. Transections at the middle of the petiole, rachis and petiolule were taken by both free hand and microtome. Sections were stained in safranin and fast green and mounted in Canada balsam after the customary dehydration. The camera lucida drawings were made.

OBSERVATIONS

The family is very diverse in range, composed of all sorts of plants ranging from large woody trees through climbing lianas to simple weeds that grow prostrate to the ground. The taxa which are taken for investigation have mostly simple leaf. The leaves are 3-5 foliate in Anda and Hevea.

The shape of the petiole/rachis as observed in transverse section is generally circular. In Aporosa, Flueggea leucopyrus and Pedilanthus it has well - developed short lateral wings (Fig.1 b). In Acalypha ciliata and Flueggea virosa the wings are adaxially developed with median ridge between them so that longitudinal channels are formed on the adaxial surface (Fig.1 g.). The petiolute of Anda is more or less circular with a shallow notch adaxially (Fig.2 b) while in Hevea it is cylindrical in outline with two adaxial wings folded laterally forming V-shaped deep notch in between them (Fig.2 g).

The epidermis of rachis, petiole and petiolule has small cells with thick or thin cuticle layer. Epidermal cells are generally barrel shaped or rounded except in Aporosa they are squarish. Various types of glandular and non glandular trichomes are found on epidermis.

A variation in the distribution of collenchyma, sclerenchyma and vascular tissue is observed.

In the petiole, few layers of collenchyma are occurs in the hypodermal region as continuous ring in Acalypha ciliata, A. fruticosa, A. hispida, Agrostistachys, Baliospermum, Chrozophora prostrata, C. rotteri, Croton, Euphorbia fulgens, E. milii, E. umbellata, Jatropha curcas, J. gossypiifolia, J. multifida, Mallotus nudiflorus, M. philippensis, Manihot, Pedilanthus and Vernicia (Fig.1 b, f, g, h; Fig.2 a, f, h). In case of Anda and Hevea similar structure is present in both the organs- the rachis and petiolute (Fig.2 d, g). In Flueggea leucopyrus, F. virosa, Phyllanthus debilis and Tragia, 2 - 3 layered hypodermal chlorenchymatous tissue is interrupted by few layered 3-6 bands of collenchymatous tissue at adaxial, abaxial and lateral sides (Fig.1 c, e), of these adaxial ones are comparatively better developed.

A ring of sclerenchymatous patches, surrounding the vascular tissue is observed in the petirole/rachis of most of the plant studied. In Jatropha integerrima, a prominent continuous ring of sclerenchyma develops. In addition, the smaller patches or groups of sclerenchyma cells are seen scattered in the ground tissue of Euphorbia umbellata as well. In Acalypha fruticosa, A. ciliata, A. hispida, Agrostistachys, Baliospermum, Breynia nivosa, B. retusa,
Chrozophora rottleri, C. prostrata, Croton, Euphorbia neriifolia, E. indica, E. tirucalli, E. umbellata, E. fulgens, Flueggea leucopyrus, F. virosa, Glochidion, Jatropha curcas, J. multifida, J. podagrica, Mallotus nudiflorus, M. philippensis, Manihot, Phyllanthus indio-fischeri, P. maderaspatensis, P. acidus, P. polyphyllus, P. reticulatus, P. urinaria, P. virgatus, Putranjiva and Tragia, individual vascular bundle have phloic sclerenchymatous patches. However, sclerenchyma is not noted in the petiole of Euphorbia milii, Pedilanthus and Phyllanthus airy-shawii (Fig. 1b, d).
A variation in the vascular structure is observed. The vascular tissue is in the form of distinct bundles - a central solitary vascular bundle is observed in *Phyllanthus airy-shawii* and *P. urinaria* (Fig.1 d). In the petiole of *Agrostistachys*, *Breynia nivosa*, *B. retusa*, *Flueggea leucopyrus*, *F. virosa*, *Phyllanthus acidus*, *P. debilis*, *P. indofischeri*, *P. maderaspatensis*, *P. polyphyllus*, *P. reticulatus*, and *P. virgatus* an arc-shaped vascular strand is seen (Fig.1 c), while an open dissected arc of vascular bundles is noted in the petiole of *Putranjiva roxburghii* and petiolule of *Anda* (Fig.2 b, c).

**Abbreviation used:** CB – Cortical bundle, Co – Collenchyma, Cr – Crystals, MB – Medullary bundle, Sc – Sclerenchyma, SC – Secretary cell
An arc shaped distinct median and two smaller bundles occur in Glochidion and Croton while in Euphorbia indica, Euphorbia milii, E. nerifolia, E. tirucalli and E. umbellata and Pedilanthus, three distinct vascular bundles are observed (Fig.1a, b). Five distinct vascular bundles in an arc shape are noted in E. fulgens.

A ring of discrete bundles is observed in Acalypha ciliata, A. fruticosa, A. hispida, Baliospermum, Chrozophora prostrata, C. rottleri, Jatropha curcas and Tragia (Fig.1 e, f, g, h; Fig.2 a) while in Jatropha multifida, J. podagrica, and Manihot few bundles of vascular ring get interconnected (Fig.2 e). In Anda, Aporosa, Hevea, Jatropha integerrima, J. gossypiifolia and Vernicia there is a continuous vascular cylinder (Fig.2 d, h, g) where as in the species of Mallotus a discontinuous vascular cylinder is observed (Fig.2 f).

The medullary bundles in the petiole are three in Mallotus nudiflorus and two in M. philippensis (Fig.2 f). The cortical bundles are located at the adaxial side of petiole in Aporosa and Jatropha gossypiifolia (Fig.2 h).

The crystals, both solitary and/or clustered occur in the majority of the plants. Secretary cells are of common occurrence. Idioblasts are also seen in the taxa Euphorbia umbellata.

**DISCUSSION**

The taxa which are taken for investigation have mostly simple leaf. The leaves are 3-5 foliate in Anda and Hevea. The shape of the petiole/rachis as observed in transverse section is generally circular. In Aporosa, Flueggea leucopryus and Pedilanthus it has well - developed short lateral wings. In Acalypha ciliata and Flueggea virosa the wings are adaxially developed with median ridge between them so that longitudinal channels are formed on the adaxial surface. The petioloile of Anda is more or less circular with a shallow notch adaxially while in Hevea it is cylindrical in outline with two adaxial wings folded laterally forming V- shaped deep notch in between them.

The epidermis of rachis, petiole and petioloile has small cells with thick or thin cuticle layer. Epidermal cells are generally barrel shaped or rounded but in some cases they are squarish. Trichomes are variable.

The present study exhibits an interesting variation in the organization of mechanical tissues in the petiole and rachis. A similarity in the internal structure of the petiolo/petiolule and rachis is noted. The mechanical tissue is sclerenchymatous and collenchymatous. The xylem elements are additionally mechanical in function.

The distribution of collenchyma is of much significance. In the petiole, few layers of collenchyma occurs in the hypodermal region as continuous ring in Acalypha ciliata, A. fruticosa, A. hispida, Agrostistachys, Baliospermum, Chrozophora prostrata C. rottleri, Croton, Euphorbia fulgens, E. milii, E. umbellata, Jatropha curcas, J. gossypiifolia, J. multifida, Mallotus nudiflorus, M. philippensis, Manihot, Pedilanthus and Vernicia. In the rachis and petioloile of Anda and Hevea also, a continuous ring of hypodermal collenchyma is present. Instead of a ring, four bands of hypodermal collenchyma are developed on the adaxial and abaxial side in the species of Flueggea. In Phyllanthus debilis, three band of collenchyma are developed, of them two are at adaxial corners and one is on abaxial side. In Tragia hypodermal collenchyma is interrupted at regular intervals by chlorenchyma and form six bands of collenchyma. Of these, the adaxial one is comparatively better developed.

The absence of any hypodermal mechanical tissue in Aporosa, Breynia, Euphorbia indica, E. nerifolia, E. tirucalli, Glochidion, Jatropha integerrima, J. podagrica, Phyllanthus acidus, P. airy-shawii, P. indofischeri, P. maderaspatensis, P. polyphyllus, P. reticulatus, P. urinaria, P. virgatus, Putranjiva is to be noted. Here, the petiole are adopted to support the weight of leaf lamina and therefore are inextensible and naturally possess the mechanical tissue at the central region.

The considerable variability in distribution of sclerenchyma is noticed in petiole/ rachis of...
studied taxa. Phloic sclerenchymatous patches on individual vascular bundles are observed in most of the plants studied. A ring of sclerenchymatous patches, surrounding the vascular tissue is observed in Anda, Aporosa, Hevea, Jatropha gossypifolia, Mallotus philippensis, M. nudiflorus and Vernicia. In Jatropha integerrima, a prominent continuous ring of sclerenchyma develops. In addition, the smaller patches or groups of sclerenchyma cells are seen scattered in the ground tissue of Euphorbia umbellata as well. However, sclerenchyma is not noted in the petiole of Euphorbia milii, Pedilanthus and Phyllanthus air-y-shawii. Apart from these, varying quantum of vascular tissue - xylem acts together with the sclerenchyma as a sort of central skeleton for the petiole/rachis.

Comparatively higher amounts of vascular variability are noticed in the petiole. The vascular tissue is in the form of a ring of discrete bundles in Acalypha ciliata, A. fruticosa, A. hispida, Baliospermum, Chrozophora rotteri, C. prostrata, Jatropha curcas, J. multifida and Tragia. In the species of Mallotus, Jatropha podagrica and Manihot a discontinuous vascular cylinder is observed. There is a continuous vascular cylinder in Anda, Aporosa, Hevea, Jatropha gossypifolia, J. integerrima and Vernicia. An arc-shaped vascular bundle reported in Agrostistachys, Breynia nivosa, B. retusa, Flueggea leucopyrus, F. virosa, Phyllanthus acidus, P. debilis, P. indosicheri, P. maderaspatensis, P. polyphyllus, P. reticulatus, P. virgatus and Putranjiva. An arc-shaped distinct median and two smaller bundles occur in Croton and Glochidion while a central solitary vascular bundle is observed in Phyllanthus air-y-shawii and P. urinaria. Vascular bundles are reported three in number in the centre of petiole of Euphorbia indica, E. milii, E. nerifolia, E. tirucalli, E. umbellata and Pedilanthus, their number is five in Euphorbia fulgens.

In the certain taxa, the medullary and cortical bundles occur in the petiole. The medullary bundles are three in numbers in Mallotus nudiflorus, whereas two in Mallotus philippensis. Solereder (1908) and Metcalfe and Chalk (1950) have recorded medullary bundles in the petiole of Ricinus. Similarly, Khatijah et al., (1996) and Thakur and Patil (2011) also reported presence of central bundles in the petiole of Mallotus species. The cortical bundles are notable in Aporosa lindleyana and Jatropha gossypifolia, which is located at the adaxial side. Such bundles are also reported in the species of Jatropha studied by Dehgan (1982).

Lignier (1887) is of the opinion that the vascular arc increases in size within the petiole to develop folds, which separate towards inner and outer side to result in the medullary or cortical bundles.

The present study reveals comparatively higher amount of vascular variability than that of other tissues. It is presumed that the structure of the rachis/petiole of different taxa is related to the mechanical requirement of the leaf/leaflets.

In the comprehensive survey of petiole anatomy, De Candolle (1879) recognized a principle and accessory system, the latter composed of the cortical and or the medullary bundles. The principle system has open and closed types. According to Petit (1886, 1887) an open system is one in which vascular bundles are distinct or separated and closed system has fused bundles. Petit holds that herbaceous plants show distinct bundles and shrubby or woody taxa exhibit fused (closed) bundles to form an arc or ring. Further, he noted that perivascular or pericyclic sclerenchyma is lacking in herbaceous plants and occurs in woody taxa.

This investigation demonstrates the variable vascular pattern- the accessory bundles in Mallotus nudiflorus, M. philippensis, Aporosa lindleyana and Jatropha gossypifolia apart from the variation in the main vascular system. These attributes along with the distribution of sclerenchyma, occurrence of collenchyma in some species and the shapes in the transverse section of the rachis, petiole and petiolule can be used as adjuncts for the delineation of the taxa studied. Howards (1962) upheld the importance of petiolar vasculature as an aid to horticultural taxonomists. The study on petiole structure
emphasizes its utility in Meliaceae (Bhadane, 2006).

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