



SEEDLING MORPHOLOGY AS A TOOL FOR TAXONOMIC STUDY IN SOME MEMBERS OF LEGUMINOSAE (FABACEAE).

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ABSTRACT: Seedling morphology provide additional potential data source for characterization and identification of plants. Seedling morphology of twenty-five taxa under eighteen genera of Leguminosae occurring in Salt Lake City, North 24 parganas, West Bengal has been studied. The characters of paracotyledons/cotyledons, first two leaves, subsequent leaves of seedlings, germination pattern, position of paracotyledons/cotyledons, nature of release of paracotyledons/cotyledons from the seed coat, developmental studies of leaves provide important information which has been used in construction of artificial keys for identification purpose. Cluster analysis and Principal Component Analysis have been used to determine interrelationships among the investigated taxa.

Key words: Seedling morphology, taxonomy tool, Leguminosae, Phenogram, Principal Component Analysis (PCA).

INTRODUCTION

The study of seedling morphology has become a current trend in taxonomic research. The taxonomic significance of seedling derives principally from its morphology. Juvenile stages of plants are often so strikingly different from adult stage that even with good field knowledge of plants it is hard to correlate the seedlings with an adult plant. Seedlings are rather infrequently used as sources of taxonomic characters for the purpose of systematic considerations [1, 5]. As such any group of taxa, either in part or as a whole, which are easily available locally can be considered for the preliminary study of morphology of seedlings in relation to their systematic reliability. In view of the above, some members of Leguminosae occurring in Salt Lake City, has been investigated to assess the significance of seedling morphology. Salt Lake City, the eastern garden suburb of Kolkata, was a swampy and lowland area, once used to be the bed of the river, Bidhyadhari. The city lies between 88° 25' and 88° 42' East longitude and 22° 35' & 22° 58' North latitude at the north east of Kolkata within the limits of district North 24 Parganas, occupying an area of 17,000 acres [2, 6]. A part of the flora of Salt Lake represent cultivated and avenue trees. Many of them are of medicinal and economic values and some are rare species. They reproduce by seeds giving rise to seedlings. But many of the seedlings decline due to biotic interference. If these seedlings are readily identified in the field, these may be protected or transplanted to safe site depending on their use and necessity.

Seedling characters are as important and reliable as that of floral one in the delimitation of species, genera and sometimes families. The characters of seedlings are limited in number, but their diversity is large and thus their assemblage serves the purpose of identification. Considerable works have been done on the seedling flora in tropical and temperate regions [5,7,9,13,17,20,26,27], but in India, no work has been done on seedling flora, hence an attempt has been made on the proposed topic. It is remarkable to mention that the family Leguminosae has been extensively investigated from various disciplines e.g. anatomy [11, 19, 22], embryology [3,18], palynology [10,12,23] ; chemotaxonomy [14, 15], phylogeny [8]. Correlation Coefficient of some character pairs in certain tree seedlings of Leguminosae were carried out by Paria *et. al* [21]. It is thus evident from perusal of above literature that no work has been done on seedling morphology of Leguminosae of Salt Lake City.

MATERIALS AND METHODS

In the present investigation seedlings of twenty-five taxa under eighteen genera of Leguminosae were selected. The list of investigated taxa is given below:

Leguminosae (Fabaceae)

1. *Acacia auriculiformis* A. Cunn. ex Benth.
2. *Atylosia scarabaeoides* (L.) Benth.
3. *Bauhinia purpurea* L.
4. *Butea monosperma* (Lam.) Taub.
5. *Calliandra umbrosa* Benth.
6. *Cassia alata* L.
7. *Cassia fistula* L.
8. *Cassia siamea* Lam.
9. *Cassia sophera* L.
10. *Cassia tora* L.
11. *Crotalaria pallida* W.Aiton
12. *Dalbergia sissoo* Roxb. ex DC.
13. *Delonix regia* (Bojer ex Hook.) Raf.
14. *Leucaena leucocephala* (Lam.) de Wit.
15. *Millettia ovalifolia* (Wight & Arn.) Kurz
16. *Mimosa pudica* L.
17. *Peltophorum pterocarpum* (DC.) Baker ex K. Heyne
18. *Pithecellobium dulce* (Roxb.) Benth.
19. *Pongamia pinnata* (L.) Pierre
20. *Samanea saman* (Jacq.) Merr.
21. *Saraca asoca* (Roxb.) De Wilde
22. *Sesbania cannabina* (Retz.) Pers.
23. *Sesbania grandiflora* (L.) Poir.
24. *Sesbania sesban* (L.) Merr.
25. *Tephrosia purpurea* (L.) Pers

The specimens were collected from different localities of Salt Lake City. The specimens were photographed, and documented in the form of herbarium sheets. They were compared and identified with the help of seedlings raised from identified seeds. At least five to ten specimens of each growth forms were studied from various habitats. The specimens were described following the terminology as proposed by [1,5,7,16]. Based on these characters an artificial key was constructed. Diagnostic seedling characters were scored for cluster analysis and phenogram was prepared using UPGMA (Unweighted Pair-Group method for Arithmetic Average) method with the assistance of STATISTICA program [24].

OBSERVATION

Diagnoses and key to identification of the investigated taxa

Acacia auriculiformis A.Cunn.ex Benth.

(Up to 8th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot** strongly elongating, 5.4 cm-5.5 cm long, soft, greyish white, curved, glabrous; side roots many, unbranched. **Hypocotyl** strongly elongating, 3.5 cm-4.0 cm long, terete, pinkish, glabrous.

Paracotyledons two, opposite, oblique, stipulate, sessile, coriaceous, pubescent; blade ovate-elliptic (0.7 cm-0.8 cm x 0.4 cm-0.5 cm); base deeply cleft & auricled, clasping the axis, apex rounded, margin entire; primary vein one, simple craspedodromous; surface glabrous. **Internodes** terete, green, soft, distantly minutely hairy; first internode 0.2 cm-0.3 cm long, second one 0.2 cm-0.4 cm long; next internodes elongating,, slender.

First two leaves alternate, compound, first uniparipinnate, second biparipinnate, herbaceous, stipulate, petiolate; petiole 0.5 cm-0.6 cm, terete, pubescent; blade leaflet pairs 5-6, leaflet linear oblong (1.0 cm-1.3 cm x 0.5 cm-0.6 cm), base assymetric, apex acute, margin entire; primary vein one, simple craspedodromous; surface hairy. **Subsequent leaves** alternate, third and fourth leaves as in second leaf, petiole becoming more flattened, 1.4 cm-1.8 cm long, leaflet absent in fifth and onwards leaves, petiole becoming highly flattened forming a leaf-like green lanceolate structure (phylloclade). Other characters almost same as that of first two leaves. (Pl. I: a).

***Atylosia scarabaeoides* (L.) Benth.**

(Up to 8th leaves stages)

Seedling hypogeal, cryptoscotylar. **Taproot** strongly elongating, 3.0 cm-5.0 cm long, soft, greyish white, curved, glabrous; side roots fewer in number, unbranched. **Hypocotyl** reduced, ± 0.1 cm, glabrous. **Cotyledons** two, opposite, oblique, exstipulate, petiolate, fleshy, cream coloured; petiole small, 0.3 cm-0.4 cm, flattened; blade oblong (0.5 cm-0.6 cm x 0.3 cm-0.4 cm); base auricled, apex rounded, margin entire; primary vein indistinct, surface glabrous, covered by thin deep brown seed coat, inner surface plane and outer surface convex. **Internodes** terete, green, soft, densely hairy; first internode 5.0 cm-5.3 cm long, second one 1.2 cm-1.4 cm long; next internodes increasing, slender. **First two leaves** opposite, simple, herbaceous, stipulate (interpetiolar, hairy), petiolate, herbaceous; petiole 0.4cm-0.5cm, terete, pubescent; blade ovate (1.6 cm-1.9 cm x 0.8 cm-1.1 cm), base subtruncate, apex acute, margin entire; primary vein one, brochidodromous; surface hairy. Subsequent leaves alternate, compound, trifoliolate, stipulate, petiolate, petiole terete, hairy, blade \pm elliptic, 0.8 cm-0.9 cm x 0.5 cm-0.6 cm (lateral ones), 0.9 cm-1.0 cm x 0.7 cm-0.8 cm (terminal one), base cuneate. Other characters almost same as that of first of two leaves. (Pl. I: b).

***Bauhinia purpurea* L.**

(Up to 8th leaves stages)

Seedling geal, phanerocotylar. **Taproot** strongly elongating, 5.0 cm-6.5 cm long, soft, greyish brown, curved, glabrous; side roots many, unbranched. **Hypocotyl** reduced, ± 0.1 cm, whitish, stout, erect, glabrous. **Paracotyledons** two, opposite, horizontal to slightly oblique, stipulate (stipule reduced to hairy whitish structure), sessile, fleshy, green; blade oblong (1.7 cm-1.8 cm x 1.3 cm-1.4 cm); base rounded, apex obtuse, margin entire; primary vein seven, actinodromous, midvein bifurcates apically, veins visible on dorsal surface, surface glaucous. **Internodes** first internode terete, next internodes angled, green, soft, hairy; first internode 5.0 cm-8.3 cm long, second one 2.5 cm-4.0 cm long; next internodes increasing, slender. **First two leaves** alternate, simple, herbaceous, stipulate (two, free lateral, lanceolate, deciduous), petiolate, herbaceous; petiole 1.0 cm-1.5 cm long, dorsally slightly grooved, pubescent; blade cordiform (1.3 cm-1.6 cm x 1.0 cm-1.3 cm), base cordate, apex emarginate, cleft length 2.3 cm long, margin entire; primary vein seven, actinodromous; surface hairy. **Subsequent leaves** alternate, dimension increasing, cleft length 2.3 cm long. Other characters almost same as that of first of two leaves. (Pl. I: c).

***Butea monosperma* (Lam.) Taub.**

(Up to 4th leaves stages)

Seedling hypogeal, cryptocotylar. **Taproot** strongly elongating, 6.0 cm-8.0 cm long, soft, whitish brown, curved, glabrous; primary roots stout, side roots fewer in number, unbranched. **Hypocotyl** ± 0.1 cm, reduced. **Cotyledons** two, secund, horizontal, exstipulate, petiolate, compressed fleshy, cream coloured; petiole 0.3 cm-0.4 cm, flattened, both the petiole fused on one side forming a boat-shaped structure outside the node and forming the sheath at the node, hairy; blade asymmetrically oblong (2.8 cm-3.0 cm x 1.3 cm-1.4 cm); base cuneate, apex truncate, margin entire; primary vein indistinct, outer surface slightly convex and glabrous, both the cotyledons firmly adpressed and enclosed within the thin papery brown seed coat. **Internodes** terete, green, soft, densely hairy; first internode 7.0 cm-16.0 cm long, second one 5.2 cm-6.4 cm long; next internodes increasing, slender. **First two leaves** opposite, simple, herbaceous, stipulate (interpetiolar, lanceolate, green, hairy), petiolate, coriaceous; petiole 0.4 cm-0.5 cm, terete, pubescent; blade wide ovate, (5.6 cm-6.9 cm x 3.5 cm-7.5 cm), base rounded, apex acute, margin entire; primary vein one, semicraspedodromous; surface hairy, upper surface more silky. **Subsequent leaves** third leaf alternate, compound, trifoliolate, stipulate (two, free lateral, green, hairy), petiolate, coriaceous, petiole terete, 5.0 cm-6.0 cm, hairy, base pulvinous; blade terminal one ovate (6.0 cm-6.9 cm x 6.5 cm-6.6 cm), base cuneate, apex acute, margin entire, primary vein one, semicraspedodromous, veins prominent on the lower surface; both surface hairy, lateral ones asymmetrically ovate, 4.9 cm-5.7 cm x 3.2 cm-4.2 cm, base obtuse and apex rounded, margin entire. Other characters almost same as that of first of two leaves. (Pl. I: d).

***Calliandra umbrosa* Benth.**(Up to 4th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot** strongly elongating, 5.0 cm-10.5 cm long, soft, greyish white, curved, glabrous; side roots fewer in number, unbranched. **Hypocotyl** strongly elongating, 3.0 cm-4.2 cm long, terete, basal part white and upper part greenish pink, hairy. **Paracotyledons** two, opposite, oblique, exstipulate, petiolate, coriaceous; petiole 0.3 cm-0.4 cm, terete, hairy, green; blade ovate (0.8 cm-1.1 cm x 0.4 cm-0.5 cm); base auriculate, apex acute, margin entire; primary vein indistinct, surface glabrous, upper surface deep green and lower surface pink to dirty pink. **Internodes** terete, green, soft, densely hairy; first internode 1.4 cm-1.5 cm long, second one 0.9 cm-1.0 cm long; next internodes increasing, slender. **First two leaves** opposite, compound, pinnate, unipinnate, paripinnate, no. of leaflets pair 6-8, herbaceous, stipulate (stipules two, free lateral, lanceolate, green, hairy), petiolate, herbaceous; petiole 0.7 cm-0.8 cm, pubescent, base pulvinate; leaflet blade oblong (1.1 cm-1.2 cm x 0.2 cm-0.3 cm), base oblique, apex rounded, margin entire; primary vein one, simple craspedodromous; surface hairy, primary vein terminates into a terminal appendage. **Subsequent leaves** alternate, compound, biparipinnate, no. of leaflet pairs eight in each pinna, blade oblong, dimension gradually increasing in upper pairs. Other characters almost same as that of first of two leaves. (Pl. I: e).

***Cassia alata* L.**(Up to 4th to 5th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot** strongly elongating, 3.0 cm-5.0 cm long, soft, greyish white, curved, glabrous; side roots profuse, unbranched. **Hypocotyl** strongly elongating, 4.5 cm-5.0 cm long, terete, yellowish-green, hairy. **Paracotyledons** two, opposite, oblique, exstipulate, petiolate, subcoriaceous, green; petiole 0.1 cm-0.2 cm, flattened; blade obovate (2.0 cm-2.1 cm x 1.7 cm-1.8 cm); base cuneate, apex rounded, margin entire; primary vein five, actinodromous; surface glabrous. **Internodes** terete, green, soft, glabrous; first internode 3.5 cm-4.6 cm long, second one 1.0 cm-1.3 cm long; next internodes increasing, slender. **First two leaves** alternate, compound, pinnate, unipinnate, paripinnate, first leaf with two pairs of leaflets, herbaceous, stipulate (stipule two, small, free lateral, orange), petiolate, herbaceous; petiole 1.2 cm-2.0 cm, terete, pubescent; blade obovate, lower pair smaller in size, 1.5 cm-1.6 cm x 0.9 cm-1.1 cm, (lower pair), 2.8 cm-3.0 cm x 2.2 cm-2.4 cm (upper pair), base asymmetric, apex obtuse, margin entire; primary vein one, semicraspedodromous; surface glabrous. **Subsequent leaves** alternate, compound, third and fourth leaves with two pairs of leaflets, number of leaflets increasing, size variable. Other characters almost same as that of first of two leaves. (Pl. I: f).

***Cassia fistula* L.**(Up to 5th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot** strongly elongating, 5.0 cm-8.0 cm long, hardy, glabrous; side roots profuse, unbranched. **Hypocotyl** strongly elongating, 6.5 cm-6.6 cm long, terete, lower part brownish and upper part green, hairy. **Paracotyledons** two, opposite, oblique, stipulate, sessile, coriaceous, green; petiole 1.0-1.2 cm, flattened; blade oblong (2.1 cm-2.3 cm x 1.0 cm-1.2 cm); base cuneate, apex rounded, margin entire; primary vein five, actinodromous; surface glabrous. **Internodes** terete, green, soft, densely hairy; first internode 1.7 cm-3.5 cm long, second one 1.8 cm-2.3 cm long; next internodes increasing, slender. **First two leaves** alternate, compound, pinnate, unipinnate, paripinnate, two pairs of leaflets, herbaceous, stipulate (stipule two, small, free lateral,), petiolate, coriaceous; petiole 0.8 cm-1.2 cm, green, glabrous; blade ovate, lower pair smaller in size, 1.5 cm-1.7 cm x 0.5 cm-0.7 cm (lower pair), 1.8 cm-2.1 cm x 0.5 cm-0.7 cm (upper pair), base cuneate, apex acuminate, margin entire; primary vein one, semicraspedodromous, midrib terminating into a terminal appendage; surface glabrous. **Subsequent leaves** alternate, compound, no. of leaflet pairs two upto seventh to eighth leaves stages; no. of leaflet pairs increasing in subsequent leaves. Other characters almost same as that of first of two leaves. (Pl. I: g).

***Cassia siamea* Lam.**(Up to 5th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot** strongly elongating, 6.0 cm-10.0 cm long, hardy, greyish white, curved, glabrous; side roots few, unbranched. **Hypocotyl** strongly elongating, 3.5 cm-4.0 cm long, terete, lower part brownish and upper part green, glabrous. **Paracotyledons** two, opposite, oblique, exstipulate, petiolate, coriaceous, green; petiole 0.05 cm-0.1 cm, glabrous; blade orbicular (1.7 cm-1.9 cm x 1.5 cm-1.7 cm); base rounded, apex rounded, margin entire; primary vein five, actinodromous, basal, perfect; surface glabrous. **Internodes** terete, green, soft, glabrous; first internode 1.4 cm-1.5 cm long, second one 0.5 cm-0.9 cm long; next internodes increasing, slender.

First two leaves alternate, compound, uniparipinnate, leaflet pairs two, herbaceous, stipulate (stipule two, small, free lateral), petiolate, herbaceous. First leaf with petiole 1.2 cm-1.3 cm, glabrous; blade elliptic (0.7 cm-0.9 cm x 0.4 cm-0.5 cm), base assymmetric, apex acute, margin entire; primary vein one, semicraspedodromous; surface glabrous. Second leaf alternate, leaflet pairs distantly placed, leaflet size increasing. Other characters almost same as first leaf. **Subsequent leaves** alternate, uniparipinnate, number of leaflet pairs and size gradually increasing. Other characters almost same as that of first of two leaves. (Pl. I: h).

Cassia sophera L.

(Up to 5th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot** strongly elongating, 7.0 cm-8.0 cm long, soft, greyish white, curved, glabrous; side roots profuse, unbranched. **Hypocotyl** strongly elongating, 2.5 cm-3.0 cm long, terete, yellowish-green, hairy. **Paracotyledons** two, opposite, oblique, exstipulate, petiolate, herbaceous, green; petiole 0.1-0.5 cm, flattened; blade ±orbicular (1.3 cm-1.4 cm x 0.7 cm-0.8 cm); base obtuse, apex rounded, margin entire; primary vein five, actinodromous; surface glabrous. **Internodes** terete, green, soft, densely hairy; first internode 2.5 cm-2.8 cm long, second one 1.5 cm-1.7 cm long; next internodes increasing, slender. **First two leaves** alternate, compound, pinnate, unipinnate, paripinnate, with two pairs of leaflets, herbaceous, stipulate (stipule two, small, free lateral, lanceolate), petiolate, herbaceous; petiole 1.2 cm-1.4 cm, terete, pubescent; blade elliptic (1.3 cm-1.5 cm x 0.5 cm-0.7 cm), base assymmetric with pulvinous, apex obtuse, margin entire; primary vein one, semicraspedodromous; surface glabrous. **Subsequent leaves** alternate, number of leaflets increasing above five pairs, apex acute. Other characters almost same as that of first of two leaves. (Pl. I: i).

Cassia tora L.

(Up to 6th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot** strongly elongating, 3.5 cm-6.0 cm long, hardy, dark brown, curved, glabrous; side roots profuse, unbranched. **Hypocotyl** strongly elongating, 4.5 cm-5.0 cm long, terete, lower part dark brown and upper part green, hairy. **Paracotyledons** two, opposite, oblique, exstipulate, petiolate, subcoriaceous, green; petiole 0.1-0.2 cm, terete, pulvinate; blade orbicular (1.3 cm-1.4 cm x 1.2 cm-1.3 cm); base rounded, apex rounded, margin entire; primary vein five, actinodromous; surface glabrous. **Internodes** terete (first), upper internodes slightly angled, green, soft, densely hairy; first internode 2.0 cm-2.6 cm long, second one 0.7 cm-0.9 cm long; next internodes increasing, slender. **First two leaves** alternate, compound, pinnate, unipinnate, paripinnate, first leaf with two pairs of leaflets and second leaf with three pairs of leaflets, herbaceous, stipulate (stipule deciduous, free lateral,), petiolate, herbaceous; petiole 1.2 cm-2.0 cm long, terete, pubescent, pulvinate; blade obovate, 1.3 cm-1.7 cm x 0.7 cm-1.2 cm, base cuneate, asymmetric, apex obtuse, margin entire; primary vein one, semicraspedodromous; surface glabrous. **Subsequent leaves** alternate, size variable. Other characters almost same as that of first of two leaves. (Pl. II: a).

Crotalaria pallida W.Aiton

(Upto 6th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot** strongly elongating, 5.5 cm-7.0 cm long, soft, whitish grey, curved, glabrous; side roots profuse. **Hypocotyl** strongly elongating, 4.5 cm-5.0 cm long, terete, lower part light green and upper part deep green, hairy. **Paracotyledons** two, opposite, oblique, exstipulate, petiolate, coriaceous, green; petiole 0.1 cm-0.2 cm; blade oblong (1.1 cm-1.2 cm x 0.4 cm-0.5 cm); base oblique, apex obtuse, margin entire; primary vein one, semicraspedodromous; surface glabrous. **Internodes** terete, green, soft, densely hairy; first internode 0.4 cm-0.6 cm long, second one 0.8 cm-1.0 cm long; next internodes increasing, slender. **First two leaves** alternate, compound, trifoliolate, stipulate (two, free lateral, deciduous), petiolate, herbaceous; petiole 0.5 cm-0.7 cm, terete, pubescent; blade obovate (0.7 cm-0.9 cm x 0.4 cm-0.5 cm-lower pair), (1.0 cm-1.2 cm x 0.6 cm-0.7 cm-upper pair), base cuneate, apex obtuse, margin entire; primary vein one, semicraspedodromous; surface hairy. **Subsequent leaves** size of blade and petiole variable, leaflet apex retuse. Other characters almost same as that of first of two leaves. (Pl. II: b).

Dalbergia sissoo Roxb..

(Upto 6th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot elongating**, 5.0cm-5.5cm, soft, whitish grey, curved, glabrous; side roots profuse, nodulated. **Hypocotyl** elongating,, 4.0-5.5 cm long, terete, lower part light green and upper part deep green, hairy.

Paracotyledons two, opposite, oblique, exstipulate, petiolate, fleshy, green; petiole small, 0.1-0.2 cm long, flattened; blade oblong (1.5cm-1.6cm x 0.8cm-0.9cm); base oblique cuneate, apex rounded, margin entire; primary vein one, semicraspedodromous, basal, perfect; surface glabrous. **Internodes** terete, green, soft, densely hairy; first internode 2.8-2.9cm long, second one 3.7-3.8cm long; next internodes increasing, slender. **First two leaves** opposite, compound, stipulate (two, free lateral), petiolate, herbaceous; petiole 0.2cm-0.5cm long, terete, pubescent; blade obovate-elliptic, 2.5cm-2.6cm x 1.0cm-1.2cm, base cuneate, apex mucronate, margin entire; primary vein one, semicraspedodromous; surface glabrous. **Subsequent leaves** alternate, compound. Other characters same as that of first of two leaves.

***Delonix regia* (Boj. ex Hook.) Raf.**

(Upto 6th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot** strongly elongating, 5.0 cm-5.5 cm long, soft, whitish grey, curved, glabrous; side roots profuse. **Hypocotyl** strongly elongating, 5.0 cm-5.5 cm long, terete, lower part light green and upper part deep green, hairy. **Paracotyledons** two, opposite, oblique, exstipulate, petiolate, fleshy, green; petiole 0.1 cm-0.2 cm, flattened; blade oblong (2.7 cm-2.8 cm x 0.8 cm-0.9 cm); base auricled, apex obtuse, margin entire; primary vein one, semicraspedodromous; surface glabrous. **Internodes** terete, green, soft, densely hairy; first internode 1.4 cm-1.5 cm long, second one 1.7 cm-1.9 cm long; next internodes increasing, slender. **First two leaves** opposite, compound, unipinnate, stipulate (two, free lateral), petiolate, herbaceous; petiole 0.1 cm-0.2 cm, terete, pubescent; blade oblong (1.2 cm-1.3 cm x 0.3 cm-0.4 cm), base oblique, apex obtuse, margin entire; primary vein one, semicraspedodromous; surface glabrous. **Subsequent leaves** alternate, compound, uniparipinnate upto third leaf stages, next leaves bipinnate. Other characters almost same as that of first of two leaves. (Pl. II: c).

***Leucaena leucocephala* (Lam.) de Wit.**

(Upto 6th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot** strongly elongating, 5.0 cm-6.0 cm long, soft, grey-brown, curved, glabrous; side roots few. **Hypocotyl** strongly elongating, 2.5 cm-4.0 cm long, terete, lower part whitish and upper part green, hairy. **Paracotyledons** two, opposite, erect, later on oblique, exstipulate, petiolate, fleshy, green; petiole 0.1 cm-0.2 cm, green, glabrous, flattened; blade oblong (1.5 cm-1.8 cm x 1.0 cm-1.3 cm); base auricled, apex rounded, margin entire; primary vein one, semicraspedodromous; surface glabrous. **Internodes** terete, green, soft, densely hairy; first internode 1.6 cm-2.0 cm long, second one 1.5 cm-1.8 cm long; next internodes increasing, slender. **First leaf** alternate, compound, unipinnate, paripinnate, stipulate (two, lanceolate, green, free lateral), petiolate, herbaceous; petiole 1.0 cm-1.2 cm, terete, pubescent, base pulvinate, green, glabrous; blade obovate (1.3 cm-1.4 cm x 0.5 cm-0.6 cm), base oblique, apex obtuse, margin entire; primary vein three, actinodromous; upper surface deep green; leaf rachis distantly hairy, and terminating into an appendage; Second leaf-alternate, compound, bipinnate, paripinnate with single pair of pinna only, petiole ±2.0 cm long. **Subsequent leaves** alternate, compound, bipinnate. Other characters almost same as that of second leaves. (Pl. II: d).

***Millettia ovalifolia* (Wight and Arn.) Kurz**

(Upto 6th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot** strongly elongating, 3.0 cm-5.0 cm long, hardy, grey-brown, curved, glabrous; side roots profuse. **Hypocotyl** strongly elongating, 3.4 cm-5.0 cm long, terete, lower part whitish and upper part green, hairy. **Paracotyledons** two, opposite, erect, later on oblique, exstipulate, petiolate, fleshy, green; petiole 0.1 cm-0.2 cm, green, glabrous, flattened; blade ovate (1.0 cm-0.8 cm x 0.3 cm-0.4 cm); base cuneate, apex rounded, margin entire; primary vein one, semicraspedodromous; surface glabrous. **Internodes** terete, green, soft, densely hairy; first internode 0.8 cm-1.0 cm long, second one 1.1 cm-1.2 cm long; next internodes increasing, slender. **First two leaves** alternate, simple, stipulate (two, lanceolate, green, free lateral), petiolate, herbaceous; petiole 2.1 cm-2.2 cm long, terete, pubescent, base pulvinate, green, glabrous; blade wide ovate (3.3 cm-3.4 cm x 3.3 cm-3.4 cm), base rounded, apex acute, margin entire; primary vein one, semicraspedodromous; upper surface deep green. **Subsequent leaves** alternate, compound, trifoliolate. Other characters almost same as that of first two leaves. (Pl. II: e).

***Mimosa pudica* L.**

(Upto 6th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot** strongly elongating, 2.5 cm-5.0 cm long, soft, white, curved, glabrous; side roots profuse. **Hypocotyl** strongly elongating, 2.5 cm-3.0 cm long, terete, lower part whitish grey and upper part green, hairy. **Paracotyledons** two, opposite, erect, stipulate, petiolate, coriaceous, green; petiole 0.1 cm-0.2 cm, green, glabrous, flattened; blade oblong (0.4 cm-0.5 cm x 0.4 cm-0.5 cm); base rounded, apex truncate, margin entire; primary vein one, semicraspedodromous; surface glabrous.

Internodes terete, green, soft, densely hairy; first internode 0.1 cm-0.2 cm long, second one 0.3 cm-0.4 cm long; next internodes increasing, slender. **First two leaves** first leaf alternate, compound, unipinnate, paripinnate, no. of leaflet three pairs; stipulate (lanceolate, green, free lateral), petiolate, herbaceous; petiole 0.7 cm-0.8 cm, terete, pubescent, base pulvinate, green, glabrous; blade obovate-oblong (1.0 cm-1.1 cm x 0.3 cm-0.4 cm), base oblique, apex mucronate, margin entire; primary vein three, actinodromous; upper surface glabrous, lower surface hairy; leaves touch sensitive, second leaf biparipinnate. **Subsequent leaves** alternate, fourth leaf with four pairs of leaflets, fifth leaf with five pairs and sixth leaf with 7 pairs of leaflet, basal pair smaller in size. Other characters almost same as that of first two leaves. (Pl. II: f).

***Peltophorum pterocarpum* (DC.) Baker ex K. Heyne**

(Upto 6th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot** strongly elongating, 9.0 cm-11.0 cm long, slightly hardy, grey-brown, curved, glabrous; side roots profuse, **Hypocotyl** strongly elongating, 5.0 cm-6.2 cm long, terete, lower part whitish and upper part green, hairy. **Paracotyledons** two, opposite, exstipulate, subsessile, fleshy, green; petiole 0.1 cm-0.2 cm, green, glabrous, flattened; blade oblong (1.8 cm-2.0 cm x 0.6 cm-0.7 cm); base cuneate, apex rounded, margin entire; primary vein one, semicraspedodromous; surface glabrous. **Internodes** terete, green, soft, densely hairy; first internode 0.3 cm-0.5 cm long, second one 0.5 cm-0.7 cm long; next internodes increasing, slender. **First two leaves** opposite, compound, pinnate, uniparipinnate, leaflet pairs five to six, exstipulate, petiolate, herbaceous; petiole 0.5 cm-0.6 cm, terete, pubescent, base pulvinate, green, glabrous; blade oblong (0.7 cm-0.8 cm x 0.3 cm-0.4 cm), base oblique, apex obtuse, margin entire; primary vein one, semicraspedodromous; upper surface deep green, lower surface pale green, both surfaces glabrous. **Subsequent leaves** alternate, compound, uniparipinnate, pinnae pairs two to three, no. of pairs and dimension increasing. Other characters almost same as that of first two leaves. (Pl. II: g).

***Pithecellobium dulce* (Roxb.) Benth.**

(Upto 6th leaves stages)

Seedling geal, cryptocotylar. **Taproot** strongly elongating, 7.0 cm-9.0 cm long, hardy, grey-brown, curved, glabrous; side roots profuse. **Hypocotyl** reduced, 0.1 cm, terete, lower part whitish and upper part green, glabrous. **Cotyledons** two, opposite, secund, exstipulate, petiolate, fleshy, green; petiole 0.1 cm-0.2 cm, green, glabrous, flattened; blade obovate (1.0 cm-1.8 cm x 0.3 cm-0.4 cm); base cuneate, apex rounded, margin entire; primary vein one, semicraspedodromous; surface glabrous. **Internodes** terete, green, soft, densely hairy; first internode 3.5 cm-5.0 cm long, second one 1.5 cm-1.8 cm long; next internodes increasing, slender. **First two leaves** First leaf alternate, compound, unipinnate, bifoliolate, stipulate (two, lanceolate, green, free lateral), petiolate, herbaceous; petiole 2.1 cm-2.2 cm, terete, pubescent, base pulvinate, green, glabrous; blade oblong (0.8 cm-1.5 cm x 0.3 cm-0.4 cm), base cuneate, apex acute, margin entire; primary vein one, semicraspedodromous; upper surface deep green. Second leaf biparipinnate, each pinna bifoliolate, glandular. **Subsequent leaves** alternate, compound, biparipinnate, dimension of leaflet, petiole and spine increasing. Other characters almost same as that of first two leaves. (Pl. II: h).

***Pongamia pinnata* (L.) Pierre**

(Upto 6th leaves stages)

Seedling geal, phanerocotylar. **Taproot** strongly elongating, 6.0 cm-9.0 cm long, hardy, grey-brown, curved, glabrous; side roots few. **Hypocotyl** shortly elongating, 1.0 cm-1.2 cm long, terete, grey, curved, hairy. **Cotyledons** two, opposite, secund, exstipulate, sessile, fleshy, green, blade asymmetrically oblong (2.3 cm-2.4 cm x 1.8 cm-2.0 cm), sinuate, outer side obtuse, apex rounded, margin entire; no. of veins indistinct; both surface glabrous; cotyledons covered by thick deep brown seed coat. **Internodes** terete, green, soft, densely hairy; first internode 4.5 cm-5.0 cm long, second one 3.5 cm-4.0 cm long; next internodes increasing, slender, cataphylls two, opposite, simple, scale-like. **First two leaves** alternate, simple, stipulate (two, scale-like, green, free lateral), petiolate, coriaceous; petiole 1.1 cm-1.2 cm, terete, pubescent, base and apex pulvinate, green, glabrous; blade wide ovate, 3.8 cm-4.0 cm x 2.1 cm-2.3 cm, base rounded, apex acuminate, margin entire; primary vein one, semicraspedodromous; upper surface deep green. **Subsequent leaves** alternate, simple upto fifth leaf, from sixth leaf trifoliolate, size increasing. Other characters almost same as that of first two leaves. (Pl. II: i).

***Samanea saman* (Jacq.) Merr.**(Upto 4th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot** strongly elongating, 4.0 cm-5.0 cm, hardy, greyish-white, curved, lower part glabrous; side roots profuse. **Hypocotyl** strongly elongating, 3.4 cm-5.0 cm long, terete, lower part glabrous and upper part minutely hairy. **Paracotyledons** two, opposite, erect, stipulate (stipule interpetiolar, very small), petiolate, fleshy, green; petiole terete, 0.05 cm-0.1 cm, green, glabrous, flattened; blade oblong (1.0 cm-0.8 cm x 0.3 cm-0.4 cm); base auricled, apex semitruncate, margin entire; primary vein indistinct; outer surface convex and inner surface plane; surface glabrous. **Internodes** terete, green, soft, densely hairy; first internode 0.2 cm-0.3 cm long, second one 1.2 cm-1.3 cm long; next internodes increasing, slender. **First two leaves** opposite, first leaf compound, uniparipinnate, stipulate (two, linear, green, free lateral), petiolate, herbaceous; petiole 0.8 cm-1.0 cm, terete, pubescent, hairy; leaflet three pairs; blade elliptic-obovate, 3.3 cm-3.4 cm x 3.3 cm-3.4 cm, base oblique, apex obtuse, margin entire; primary vein one, semicraspedodromous; upper surface deep green, lower surface pale green, rachis terminating into a appendage. Second leaf bipinnate, consists of single pair of pinna, each pinna with three pairs of leaflet, size variable. **Subsequent leaves** alternate, compound, third to eight leaves with single pair of pinnae and two pairs of leaflet and subsequent leaves with three pairs of leaflet, no. of pinna increasing from 9th leaf stage onwards, blade obliquely rhomboid. Other characters almost same as that of first two leaves. (Pl. III: a).

***Saraca asoca* (Roxb.) De Wilde**(Upto 6th leaves stages)

Seedling geal, cryptocotylar. **Taproot** strongly elongating, 9.0 cm-11.0 cm long, slightly hardy, grey-brown, curved, glabrous; side roots profuse. **Hypocotyl** strongly elongating, 5.0 cm-6.2 cm long, terete, lower part whitish and upper part green, hairy. **Cotyledons** two, secund, later on oblique, exstipulate, subsessile, fleshy, green; petiole 0.1 cm-0.2 cm, green, glabrous, flattened; blade oblong (1.8 cm-2.0 cm x 0.6 cm-0.7 cm); base cordate, apex rounded, margin entire; primary vein one, indistinct; surface glabrous. **Internodes** terete, green, soft, densely hairy; first internode 0.3 cm-0.5 cm long, second one 0.5 cm-0.7 cm long; next internodes increasing, slender. **First two leaves** alternate, compound, unipinnate, leaflet pairs five to six, paripinnate, exstipulate, petiolate, herbaceous; petiole 0.5 cm-0.6 cm, terete, pubescent, base pulvinate, green, glabrous; blade elliptic-oblong (0.7 cm-0.8 cm x 0.3 cm-0.4 cm), base obtuse, apex acuminate, margin entire; primary vein one, semicraspedodromous; upper surface deep green, lower surface pale green, both surfaces glabrous. **Subsequent leaves** alternate, compound, uniparipinnate, pinnae pairs two to three, no. of pairs and dimension increasing; blade linear oblong. Other characters almost same as that of first two leaves. (Pl. III: b).

***Sesbania cannabina* (Retz.) Pers.**(Upto 4th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot** strongly elongating, 4.8 cm-5.0 cm long, soft, grey-brown, curved, glabrous; side roots few. **Hypocotyl** strongly elongating, 2.8 cm-3.3 cm long, terete, lower part whitish and upper part green, glabrous. **Paracotyledons** two, opposite, oblique, exstipulate, petiolate, coriaceous, green; petiole 0.1 cm-0.2 cm, green, glabrous, semilunar; blade oblong (1.4 cm-1.5 cm x 0.3 cm-0.5 cm); base cuneate, apex rounded, margin entire; primary vein one, semicraspedodromous; surface glabrous. **Internodes** terete, green, soft, densely hairy; first internode 1.1 cm-1.3 cm long, second one 0.7 cm-0.8 cm long; next internodes increasing, slender. **First two leaves** first alternate, unifoliolate, stipulate (two, free, lateral, pinkish, lanceolate), petiolate, coriaceous; petiole 0.4 cm-0.5 cm, terete, pubescent, base pulvinate, green, glabrous; blade oblong (2.0 cm-2.2 cm x 0.5 cm-0.7 cm), base cuneate, apex rounded, margin entire; primary vein one, semicraspedodromous; lower surface distantly hairy. Second leaf alternate, compound, unipinnate, paripinnate, leaflet five pairs, stipulate, petiolate, pulvinate, blade obovate-oblong, upper and lower leaflets smaller in size, base slightly asymmetric, apex rounded, margin entire, primary vein one, semicraspedodromous, leaf rachis terminating into terminal appendage. **Subsequent leaves** alternate, compound, no. of leaflet pairs and size increasing. Other characters almost same as that of second leaves. (Pl. III: c).

***Sesbania grandiflora* (L.) Poir.**(Upto 5th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot** strongly elongating, 5.0 cm-10.0 cm long, soft, white, curved, glabrous; side roots many. **Hypocotyl** strongly elongating, 2.8 cm-3.0 cm long, terete, lower part whitish and upper part green, glabrous. **Paracotyledons** two, opposite, oblique, stipulate; stipule interpetiolar, hairy, pinkish; petiolate, coriaceous, green; petiole 0.1 cm-0.2 cm, green, glabrous, semilunar; blade oblong (1.8 cm-1.9 cm x 0.8 cm-0.9 cm); base cuneate, apex rounded, margin entire; primary vein three, actinodromous; surface glabrous.

Internodes terete, green, soft, densely hairy; first internode 1.0 cm-1.3 cm long, second one 0.7 cm-0.8 cm long; next internodes increasing, slender. **First two leaves** first alternate, unifoliolate, stipulate (two, free, lateral, pinkish, lanceolate), petiolate, coriaceous; petiole 0.5 cm-0.7cm, terete, pubescent, base pulvinate, green, glabrous; blade elliptic (2.0 cm-2.4 cm x 1.1 cm-1.6 cm), base rounded, apex rounded, margin entire; primary vein one, semicraspedodromous; lower surface distantly hairy. Second leaf alternate, compound, unipinnate, paripinnate, leaflet three-four pairs, stipulate, petiolate, pulvinate, blade obovate-oblong, upper leaflets smaller in size, base slightly asymmetric, apex obtuse, margin entire, primary vein one, semicraspedodromous, leaf rachis terminating into terminal appendage. **Subsequent leaves** alternate, compound, third leaf with six pairs of leaflets, no. of leaflet pairs and size increasing, lower and upper leaflets smaller in size. Other characters almost same as that of second leaves. (Pl. III: d).

***Sesbania sesban* (L.) Merr.**

(Upto 8th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot** strongly elongating, 5.0 cm-6.0 cm long, soft, grey-brown, curved, glabrous; side roots few. **Hypocotyl** strongly elongating, 3.5 cm-3.8 cm long, terete, lower part whitish and upper part green, glabrous. **Paracotyledons** two, opposite, oblique, exstipulate, petiolate, coriaceous, green; petiole 0.2 cm-0.3 cm, green, glabrous, semilunar ; blade obovate (1.3 cm-1.5 cm x 0.3 cm-0.5 cm); base rounded, apex rounded, margin entire; primary vein three, actinodromous; surface glabrous. **Internodes** terete, green, soft, densely hairy; first internode 1.0 cm-1.2 cm long, second one 0.9 cm-1.1 cm long; next internodes increasing, slender. **First two leaves** first alternate, unifoliolate, stipulate(two, free, lateral, pinkish, lanceolate), petiolate, coriaceous; petiole 0.4 cm-0.5cm long, terete, pubescent, base pulvinate, green, glabrous; blade ±obovate, 2.0 cm-2.2 cm x 0.5 cm-0.7 cm, base cuneate, apex rounded, margin entire; primary vein one, semicraspedodromous; lower surface distantly hairy. Second leaf alternate, compound, unipinnate, paripinnate, leaflet five pairs, stipulate, petiolate, pulvinate, blade oblong, leaflet even paired, base slightly asymmetric, apex mucronate, margin entire, primary vein one, semicraspedodromous, leaf rachis terminating into terminal appendage, lower and upper leaflets smaller in size. **Subsequent leaves** alternate, compound, no. of leaflet pairs increase and size increasing. Other characters same as that of second leaves. (Pl. III: e).

***Tephrosia purpurea* (L.) Pers.**

(Upto 4th leaves stages)

Seedling epigeal, phanerocotylar. **Taproot** strongly elongating, 7.8 cm-9.0 cm long, soft, grey-brown, curved, glabrous; side roots few. **Hypocotyl** strongly elongating, 2.5-2.8 cm long, terete, lower part whitish and upper part green, glabrous. **Paracotyledons** two, opposite, oblique, later on oblique, exstipulate, petiolate, coriaceous, green; petiole 0.1 cm-0.2 cm long, green, hairy, semilunar ; blade oblong (1.1 cm-1.2 cm x 0.4 cm-0.5 cm); base asymmetric, apex rounded, margin entire; primary vein one, eucamptodromous; surface glabrous. **Internodes** terete, green, soft, densely hairy; first internode 0.1 cm-0.3 cm long, second one 0.2 cm-0.3 cm long; next internodes increasing, slender. **First two leaves** first alternate, unifoliolate, stipulate (two, free, lateral, green, lanceolate), petiolate, herbaceous; petiole 0.4 cm-0.5cm, terete, pubescent, green, glabrous; blade obovate, 2.1 cm-2.3 cm x 0.6 cm-0.8 cm, base cuneate, apex retuse, margin entire; primary vein one, semicraspedodromous; lower surface distantly hairy. Second leaf alternate, , trifoliolate, stipulate, petiolate, herbaceous, pulvinate, blade obovate, terminal leaflet 1.6 cm x 0.5 cm, lateral leaflet 1.4 cm x 0.4 cm. Other characters almost similar as that of first leaf. **Subsequent leaves** alternate, compound, unipinnate, imparipinnate, trifoliolate to thirteen foliolate; size variable in subsequent leaves. Other characters almost same as that of first two leaves. (Pl. III: f).

Key to the investigated taxa

1a. Seedlings cryptocotylar:

2a. Seedlings hypogeal

3. Subsequent leaves elliptic; first two leaves with brochidodromous venation pattern.....*Atylosia scarabaeoides*

3a. Subsequent leaves ovate; first two leaves with semicraspedodromous venation pattern.....*Butea monosperma*

2b. Seedlings geal

4. Cotyledon oblong, base cordate.....*Saraca asoca*4a. Cotyledon obovate, base cuneate.....*Pithecellobium dulce*

1b. Seedlings phanerocotylar:

5. First two leaves simple

6. Subsequent leaves simple..... *Bauhinia purpurea*

6a. Subsequent leaves compound

7. First two leaves alternate.....*Pongamia pinnata*7a. First two leaves opposite.....*Millettia ovalifolia*

5a. First two leaves compound

8. First two leaves alternate

9. Eophylls not touch sensitive, after 3rd -4th leaves stages flattened to form phyllode.....*Acacia auriculiformis*

9a. Eophylls otherwise

10. First leaf unifoliolate or trifoliolate

11. First leaf elliptic or oblong

12. Cotyledons stipulate; first leaf elliptic..

.....*Sesbania grandiflora.*

12a. Cotyledons exstipulate; first leaf oblong

..... *Sesbania cannabina*

11a. First leaf obovate, with retuse or rounded apex

13. Paracotyledons with primary veins three, actinodromous; eophylls with rounded apex..... *Sesbania sesban*

13a. Paracotyledons with primary vein one;

14. Paracotyledons eucamptodromous; eophylls with retuse apex

*Tephrosia purpurea.*14a. Paracotyledons semicraspedodromous; eophylls with obtuse apex.....*Crotalaria pallida*

10a. First leaf unipinnate

15. Second leaf onwards biparipinnate.....

16. Paracotyledons stipulate, blade oblong

eophylls touch sensitive..... *Mimosa pudica*

16a. Paracotyledons exstipulate, blade obovate, leaves not touch sensitive

..... *Leucaena leucocephala*

15a. Second leaf onwards uniparipinnate

17. Paracotyledons obovate: first leaf with 2 pairs of leaflets; apex of paracotyledons rounded..... *Cassia alata*

17a. Paracotyledons elliptic, orbicular or oblong.

18. Leaflets obovate or elliptic with acute or rounded apex; paracotyledons oblong or orbicular

19. Paracotyledons oblong, leaflets elliptic, first and second with two pair of leaflets

.....*Cassia sophera*

19a. Paracotyledons orbicular, leaflets obovate or elliptic

20. Leaflets elliptic, apex acute; leaf petiole not pulvinous..... *Cassia siamea*

20a. Leaflets obovate, apex obtuse; leaf petiole pulvinate..... *Cassia tora*

18a. Leaflets ovate with acuminate apex; paracotyledons oblong..... *Cassia fistula*

8a. First two leaves opposite

21. First two leaves with simple craspedodromous venation

22. Paracotyledons ovate; first two leaves with leaflets oblong
..... *Calliandra umbrosa*.

22a. Paracotyledons oblong; first two leaves with leaflets elliptic-ovate *Samanea saman*.

21a. First two leaves with semicraspedodromous venation

23. Paracotyledon with base oblique.....*Dalbergia sissoo*

23a. Paracotyledon with base auricled or cuneate.....

24. Subsequent leaves unipinnate up to 3rd leaf stages, next bipinnate..... *Delonix regia*

24a. Subsequent leaves unipinnate up to 7th-9th leaf stages, next bipinnate..... *Peltophorum pterocarpum*

RESULTS AND DISCUSSION

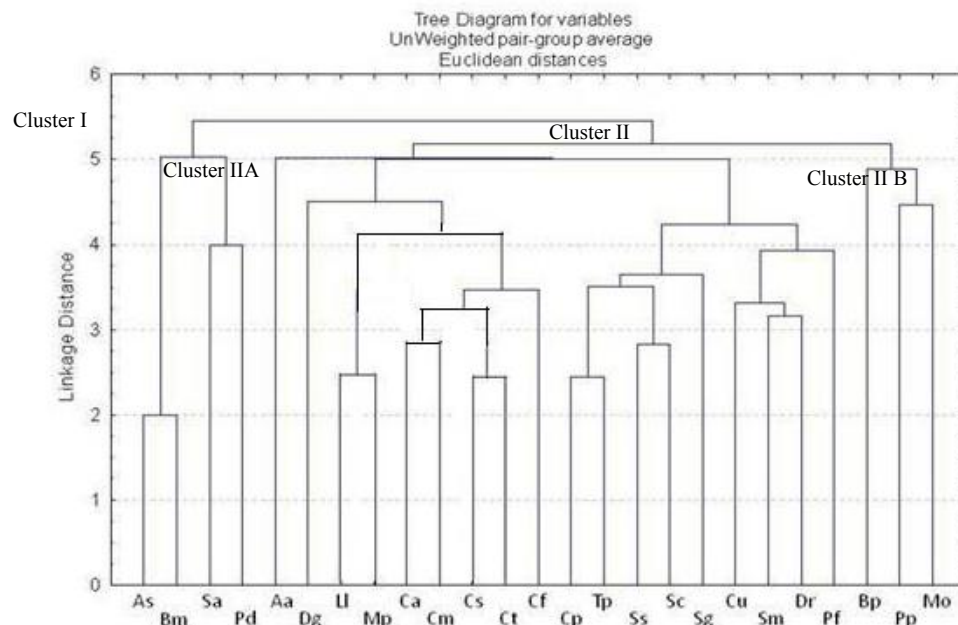


Fig: 1- Phenogram of the investigated members of the family Leguminosae using UPGMA analysis.

Abbreviations: **As-** *Atylosia scarabaeoides*, **Bm-** *Butea monosperma*, **Sa-** *Saraca asoca*, **Pd-** *Pithecellobium dulce*, **Aa-** *Acacia auriculiformis*, **Dg-** *Dalbergia sissoo*, **Ll-** *Leucaena leucocephala*, **Mp-** *Mimosa pudica*, **Ca-** *Cassia alata*, **Cm-** *Cassia siamea*, **Cs-** *Cassia sophera*, **Ct-** *Cassia tora*, **Cf-** *Cassia fistula*, **Cp-** *Crotalaria pallida*, **Tp-** *Tephrosia purpurea*, **Ss-** *Sesbania sesban*, **Cu-** *Calliandra umbrosa*, **Sm-** *Samanea saman*, **Dr-** *Delonix regia*, **Pf-** *Peltophorum pterocarpum*, **Bp-** *Bauhinia purpurea*, **Pp-** *Pongamia pinnata*, **Mo-** *Millettia ovalifolia*.

The seedling morphology of the investigated taxa exhibits some important characters. These characters are represented in Table 1. Using these features the investigated species can be distinguished with the help of artificial key. Based on seedling morphological features, all the taxa of the present study can be identified. The distinguishing characters of the seedlings include the following: germination pattern of seed (phanerocotylar or cryptocotylar), phyllotaxy of first two leaves (alternate or opposite), nature of eophylls (simple or compound), number and distribution of primary veins of paracotyledons, shape, base and apex of paracotyledon, first two leaves and subsequent leaves. A phenogram was also prepared using the above seedling features (Fig: 1). The result of the phenogram appears interesting from taxonomic point of view. The ultimate outcome of the 25 taxa through phenogram reveals the presence of two clusters among the investigated taxa, cluster I comprising of 4 taxa and cluster II of 21 taxa. These two major clusters are mainly separated from each other on the basis of the type of germination, i.e. cryptocotylar or phanerocotylar. All taxa in cluster I are cryptocotylar whereas cluster II is characterized by phanerocotylar seedlings. Cluster I is further subdivided into two subclusters—one subcluster comprising of 2 taxa i.e. As (*Atylosia scarabaeoides*), Bm (*Butea monosperma*) which differ from Sa (*Saraca asoca*) and Pd (*Pithecellobium dulce*) on the basis of position of paracotyledons. Cluster II is divided into two subclusters, IIA and IIB which differs from each other in nature of subsequent leaves. Subcluster IIA consists of 18 taxa which have first two leaves compound and Subcluster IIB consists of 3 taxa which have subsequent leaves simple. In Subcluster IIA, Aa (*Acacia auriculiformis*) again is separated from the rest of 16 taxa possessing eophylls of phyllode nature.

It is interesting to note that in another small subcluster within Subcluster IIB all the investigated species of *Cassia* genus are found to be in close proximities with each other in their seedling morphological characters. Cf (*Cassia fistula*) having ovate eophylls is separated from Ca (*Cassia alata*), Cm (*Cassia siamea*), Cs (*Cassia sophera*), Ct (*Cassia tora*) having either obovate or elliptic eophylls. This is in conformity with the study of the generic relationship among *Cassia spp* using RAPD markers by Tripathi and Goswami [25]. The closer affinity between *Leucaena leucocephala* (Ll) and *Mimosa pudica* (Mp) in subcluster IIB gets support from chemotaxonomy as seed galactomannan was found only in these two genera [4]. Again the closer affinity between *Butea monosperma* (Bm) and *Atylosia scarabaeoides* (As) due to similar germination mode i.e. cryptocotylar hypogeal could be correlated with the rbcL sequence study on Legume Phylogeny [8].

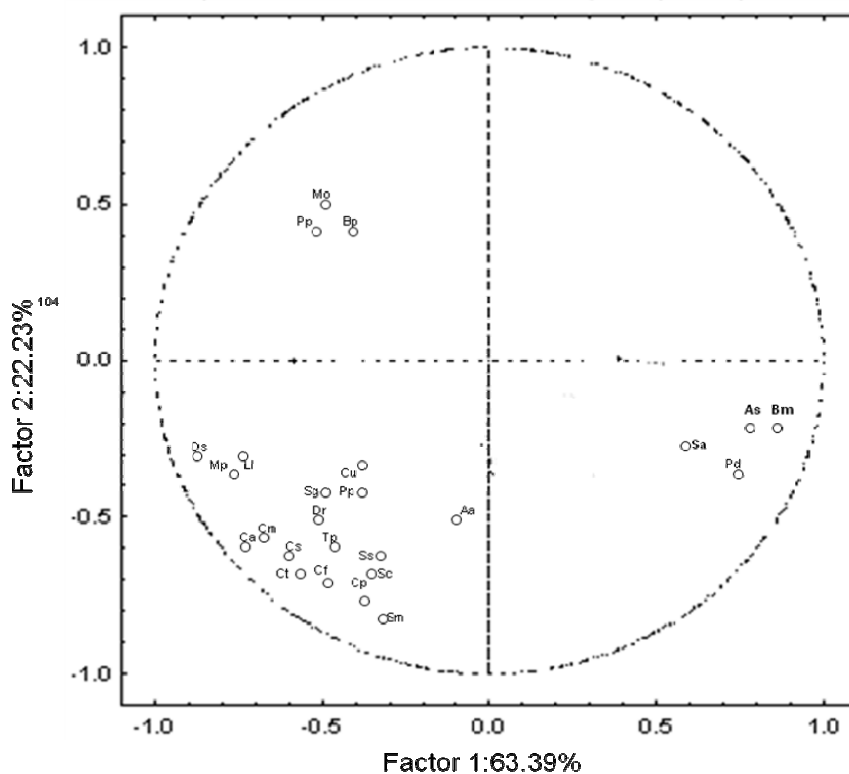
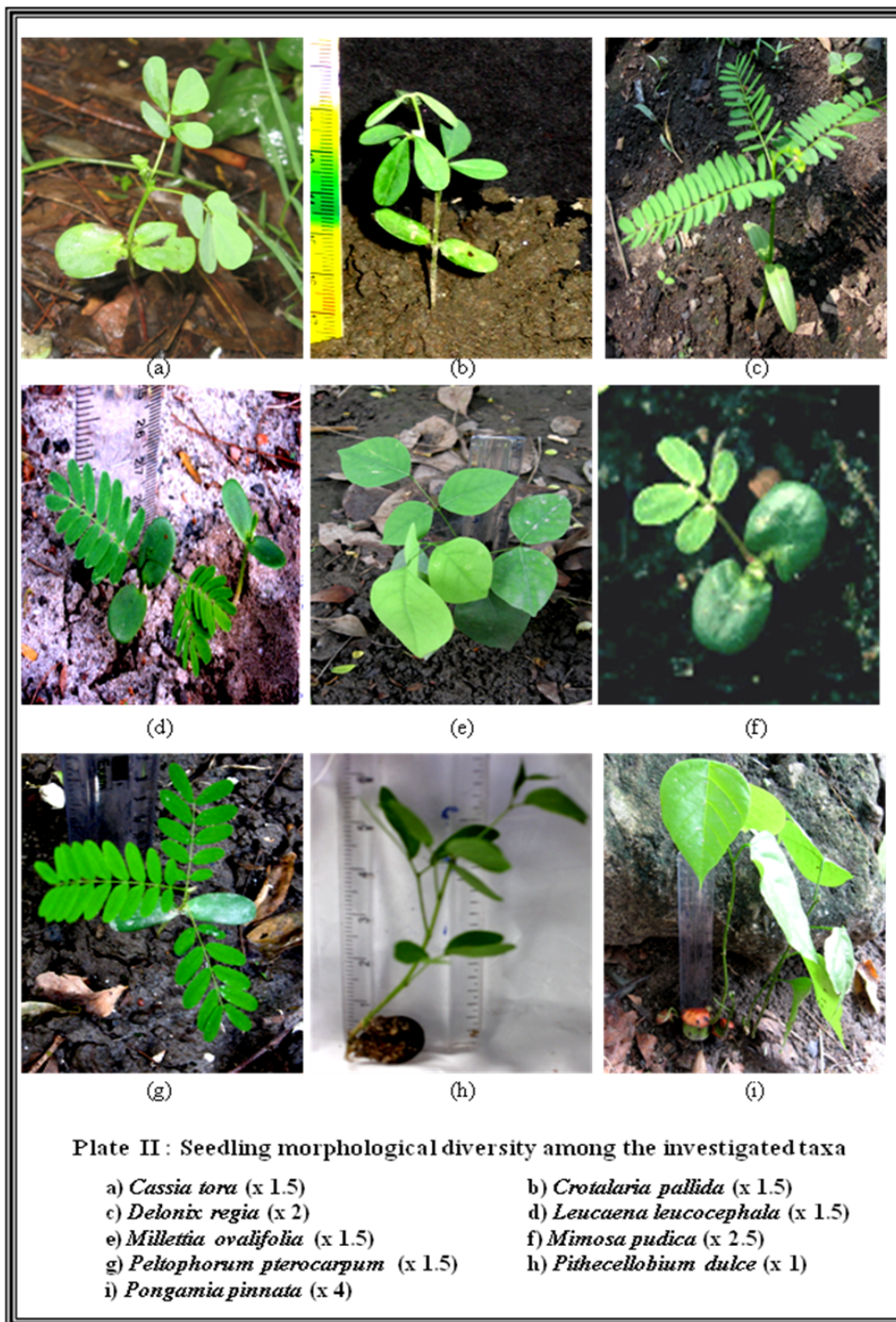


Fig.2 PCA plot based on seedling data showing relationships among the taxa studied.

The results of PCA confirmed the results of Phenogram. Principle components having eigen values above 1.00 have been considered. It was found that the first two components accounted for 63.39% and 22.23% of the variance respectively. The two dimensional diagram showed that As(*Atylosia scarabaeoides*), Bm(*Butea monosperma*), Sa(*Saraca asoca*) and Pd(*Pithecellobium dulce*) is clearly apart from the other taxa. The characters responsible for this separation includes cryptocotylar germination as indicated in phenogram (Fig.1). From the present investigation it appears that various exomorphic characters are available in the investigated members of Leguminosae. These characters are of value and most significant in the preparation of artificial keys so as to reflect interrelationships amongst the investigated species. On the other hand based on phenetic analysis, these taxa represent branching pattern which is interesting in terms of apparent phylogeny of the taxa. The content of such phenogram is also supported by chemotaxonomic studies [4] and molecular findings [8].





CONCLUSION

Knowledge of the morphology of seedlings has much to contribute to both systematic and ecological studies of flowering plants. In taxonomic studies, seedling characters have been virtually neglected. An array of seedling features contributes much to knowledge of seedling taxonomy which enables to identify the plants at juvenile stage i.e much before flowering and fruiting. Further, the study involves the use of less sophisticated and expensive instruments, and can be carried out easily in the field and experimental garden. Such study is, undoubtedly, an advancement over the conventional system of plant identification which is done in flowering and fruiting stages. This study also promotes importance of seedling features in determining interrelationships between the investigated taxa. In addition, the essence of seedling morphological study may be useful in the the management of phytodiversity as well as biodiversity conservation.

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