



Seedling Morphology of Some Species of Genus *Acacia* and Their Taxonomic Significance

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ABSTRACT

In arid areas effective seedling germination of economically important trees can help in social forestry projects as well as livelihood generation. Investigated species of *Acacia* mainly found in tropical and subtropical region of India and significantly used by local communities were taken for study. Mature seeds of four *Acacia* species belonging to subfamily Mimosoideae were grown after standard seed treatment. Germinating seedlings characters were noted up to 3rd to 4th leaf stages. Seedling features such as collet, cotyledons shape, epicotyls, phyllotaxy provide distinguishing information about particular plant species seedlings. This discrimination of plant species by seedling blastogenic characters play very important role in identification, classification, conservation and delimitation of taxa at juvenile stage of plants.

Key words:

blastogenic, identification, juvenile stage, seedling.

INTRODUCTION

Acacia is a genus of shrubs and trees belonging to the subfamily Mimosoideae of the family Fabaceae, described in Africa by the Swedish botanist Carl Linnaeus in 1773. Bentham (1840) considered that *Acacia* had become an "unwieldy, ill-defined, and comparatively unnatural assemblage of plants". His intention was to clarify Willdenow's (1806) and Candolle's (1825) broad concepts of the genus by restricting the name *Acacia* to plants with infinite, free stamens, thus excluding species now referable to tribes Mimoseae and Ingeae (Bentham 1840). This subfamily is subdivided into four tribes; *Acacieae*, *Ingeae*, *Mimoseae*, and *Mimozyantheae* and *Acacia* belong to tribe *Acacieae*. Morphological study and Classification of *Acacia* based on seed, seedlings and stipules given by Vassal (1972,

1981). *Acacia* play important role in life of local community of arid and semiarid area as it provides food, fibre, fodder, timber, gum or resin, medicine, apiculture, energy fuel, katha, tannins and also give contribution in soil erosion control, nitrogen fixation, soil improvement, intercropping, boundary or barrier or support.

There is great difficulty in *Acacia*'s in identification of species at the seedling stage as the reproductive organs by which species of *Acacias* are usually identified are absent. Seedling morphology is thus very important to conserve these plants permanently and for easy identification. Seedling description at the juvenile stage gives good data for identification and classification of these plant species. The seedling establishment of *Acacia* is technically feasible and provides methodology that can be useful for arid zone restoration projects. Troup

(1921) and Jackson (1974) had also emphasised thorough investigation of seedling morphology for better comprehension of germination, establishment and juvenile growth during the natural regeneration of vegetation. This paper focuses on four commonly found species of *Acacia* that are mostly found in arid and semiarid region of India namely *Acacia nilotica* (L.) ssp. *indica* (Benth), *Acacia raddiana* Savi, *Acacia senegal* (L.)Willd and *Acacia catechu* (L.f.) Willd (Shetty and Sing 1987).

MATERIAL AND METHODS

Species of genus *Acacia*, subfamily Mimosoideae was taken for the study. Species of genus *Acacia* usually have seeds with thick seed coat. Seeds of all these taxa were collected from identified adult plants in different seasons from different location of Rajasthan. The seed coat of *Acacia nilotica* ssp. *indica* and *Acacia raddiana* are very hard so these were germinated by pouring boiling water over the seeds, incubating for 10-15 minutes then allowing to cool down to room temperature, they were left to soak overnight, for water imbibation. Imbibed seeds were scarified with blade and cutter then placed in fresh water and soaked for additional day. These were then planted in soil mixture of pot at 20 to 25 degree for effective germination (Miller and Miller 2011). *Acacia senegal* and *Acacia catechu* seed coat are not hard and need not to go through hot water process and will grow easily in soil mixture. All these species were observed at different stage of seedling development for their taxonomic description. Some minor seedlings morphological characters were observed by Nikon eclipse e400 light microscope with 4x and 10x resolution such as glandular hair or trichome. Each seedling morphological characters were described by following the terminology proposed by Burger (1972); Hickey (1973); Dilcher (1974); Vogel (1980) that was followed by many authors for seedling description (Paria et al. (1990); and Kamilya and Paria (1993); Ahammed Paria (1996); Singh (2009); Malik (2014). These taxa seedling specimens have been deposited in the form of herbarium sheets at University of Rajasthan

Herbarium (botanical) lab (RUBL). Some morphological characters of seedlings viz. root, collet, cotyledons, phyllotaxy and number of leaflet and pinnule are found suitable to distinguish the investigated species at their juvenile stage.

RESULTS

A key to the species of *Acacia* based on seedling morphology is given below.

1. (a) Cotyledon shape rounded big with index 1.1cm by 1.5cm.....*Acacia senegal*.
 - (b) Cotyledon shape rounded small with index 9cm by 1.1cm.....*Acacia catechu*.
2. (a) Cotyledon shape elliptical, top obtuse; Phyllotaxy pinnate : bipinnate, alternate, 1st and 2nd leaf alternate, bipinnate, 1st leaf 5 pair of leaflets*Acacia raddiana*.
 - (b) Cotyledon shape ovate with cordate base; Phyllotaxy pinnate: pinnate, opposite, 1st and 2nd leaf opposite, unipinnate, 1st leaf 8 pair of leaflets*Acacia nilotica* ssp. *indica*.
3. (a) Stipules spinous, Rachis glabrous*Acacia nilotica* ssp. *indica*, *Acacia raddiana*.
 - (b) Stipules not spinous, Rachis hairy.....*Acacia catechu*, *Acacia senegal*.

The seedling characters of all the four species under study is given in Table. 1.

1. *Acacia nilotica* subsp. *Indica* (Benth.) Brenan in kew Bull. 12: 84. 1957. *A. arabica* (Lam.) Willd. var. *Indica* Benth. In Hook. Lond. Journ. Bot. 1: 500. 1842. *A. arabica* auct. non (Lam.) Willd. 1808; Bedd. Fl. Sylv. T. 47. 1870; Baker in Hook. f. Fl. Brit. Indica 2: 293. 1878; Duthie, Fl. Gangetic plain 1: 314. 1903. Local name: Kikar, Babul (in Hindi).

Seedlings type epigeal, phanerocotylar (PEF); stinking, 7.5cm total height at first two leaves, 2.9 cm above collet. *Roots* (at first leaf)tap root, primary root thin, length 4.3cm, later tubercled

and nodulated, white turning yellow, collet disk shape, lateral roots few and unbranched. *Hypocotyl* epigeous, erect, straight, thick, length 3cm, tapering upwards thickened or disk-shaped at base, terete, moderately hard, glabrous, pale green and white at base. *Cotyledons* foliaceous, 2, epigeous, equal, petiolate, petiole length 1-2 mm, brown light green, glabrous; blade shape ovate or elliptic, blade thickness at margin 1mm and 2 mm at centre, somewhat fleshy, blade convex above and concave beneath, apex rounded, base auriculate and arrow shaped (sagittate), without nerved, entire, dark green above, dull light green beneath, glabrous, deciduous at the 6-7 leaf stage. *Epicotyls* very short, 3 mm. *Stem* (at 2nd and 3rd leaf stage) erect, green, obtusangular connection of internodes, tapering upwards, angular near top, green or red, terete, glabrous. *Phyllotaxy* alternate or spiral but 1st two leaves have pinnate: pinnate phyllotaxy and opposite at cotyledonary node, higher leaves distichous alternate. *Leaves* 1st two leaf (including 1st and 2nd leaf) opposite, pinnately compound, paripinnate; stipulate, two stipule spinous or thorn shape; rachis length 1.5cm, slightly thickened at base, glabrous; 8 pairs of leaflet, opposite, shape oblong with index 4 mm by 2 mm, very shortly petiolulate, base asymmetrically rounded, thin, apex mucronet, pinnately nerved (unipinnate), glabrous, color dark green above, light green beneath. 3rd leaf alternate biparipinnate., stipulate, two spinous, 1mm; primary rachis length or petiole 5mm, secondary rachis length 1cm, slightly thickened at base, rachis color dark green above, light green beneath; 1 pair of pinnae, opposite, 8 pairs of leaflet, petiolulate, smaller, green, thin, blades oblong, asymmetrical, middle leaflet largest in size, apex mucronet or minutely acute, base asymmetrically rounded, palmately nerved, entire, glabrous, dark green above, light green beneath. 4th leaf 2 pair of pinnae and in upcoming leaves number of leaflets and pair of pinnae increases (Photo a).

2. *Acacia senegal* (L.) Willd. Sp. Pl. 4:1077.1806; Baker in Hook.f. Fl. Brit. India 2: 295. 1878; Duthie, Fl. Gangetic Plain 1: 317.

1903; Basu, Ind. Med. Pl. t. 379.1918. Local name: Kumbat, Kumatiyo (In Hindi).

Seedlings type epigeal, phanerocotylar (PEF), stinking, 7cm total height at first two leaves, 3cm above collet. *Roots*(at first leaf) tap root, primary root comparatively thick, 4 cm length, white turning yellow, smooth, collet present, lateral roots at 1st stage few and unbranched. *Hypocotyls* epigeous, erect, straight, length 3cm, thickened at base slightly disk shape, terete, color pale green, and white at base, glabrous. *Cotyledons* foliaceous, 2, epigeous, equal, petiolate, length 2 mm, thickness 1.5mm, broadened, brown light green, glabrous; blade shape rounded, blade thickness at margin 1mm and centre 2 mm, somewhat fleshy, blade concave above and convex beneath, apex rounded, an arrow-shaped base (sagittate), auriculate, indistinctly nerved, entire, dull dark green above, beneath light green, glabrous. *Epicotyls* short, 5 mm, two opposite spinous outgrowth from just before 4th node to above nodes. *Stem* (at 2nd and 3rd leaf stage) erect, green, hard, glabrous, tapering toward above node, spiral obtusangular internodes connection, terete, angular near top, green, with small thorn shape out growth at outer surface and with glandular hair or trichom. *Phyllotaxy* alternate, but 1st two leaves have pinnate: pinnate phyllotaxy (opposite to each other), higher leaves distichous alternate. *Leaves* 1st two leaf (including 1st and 2nd leaf) opposite, supracotyledonary, paripinnate, pinnately compound; stipulate, two stipule leafy; rachis length 1.7cm, slightly thickened at base, trichomatous; 8 pairs of leaflet, opposite, very shortly petiolulate, 5mm, asymmetrical, oblong with index 4.2 mm by 2.3 mm, thin, apex mucronet, base asymmetrically rounded, pinnately nerved, glabrous, color green above, dull light green beneath, glabrous. 3rd Leaf alternate, biparipinnate, stipulate, two stipule, leafy; primary rachis or petiole 4 mm, secondary rachis 1.1cm, slightly thickened at base, trichomatous, color dark green above, light green beneath; 1 pair of pinnae, opposite, 8 pairs of leaflet, petiolulate, opposite, blade smaller, blades oblong, asymmetrical, largest leaf blade

size in middle, thin, apex rounded, base asymmetrically rounded or oblique, palmately nerved, entire, glabrous, above dark green, beneath light green. 4th leaf alternate biparipinnate, stipulate, primary rachis 5mm, secondary rachis 1cm trichomatous; 2 pairs of pinna, opposite, shape oblong or lanceolate, asymmetrical, middle leaflet largest then margin, apex rounded or minutely apiculate, asymmetrical rounded base, palmately nerved, entire, glabrous (Photo 2).

3. *Acacia raddiana* Savi, Acad. Egiz. Mem. 1. f. A-G. 1830. *Mimosa tortilis* Forssk. Fl. Aegypt.-Arab. 176. 1775. *A. tortilis* (Forssk) Hayne, Darst. Beschr. Arzneyk. Gebrauchl. Gewachse 10. T. 31. 1827, in part. Local name- Israil babul (in Hindi).

Seedlings type epigeal, phanerocotylar (PEF), stinking, 8cm total length at first two leaves, 2cm above collet, 6cm beneath. *Roots* (at first leaf) taproot, primary root thin, length 6cm, whitening yellow, collet disk shape, many lateral roots present, unbranched. *Hypocotyls* epigeous, erect, straight, length 2.4cm tapering upwards, usually abruptly thickened and disk-shaped at base, terete, pale green, white at base, glabrous. *Cotyledons* foliaceous, 2, epigeous, equal; petiolate, petiole length 1-2 mm, thickness 1.5mm, broadened, brown light green; blade elliptic, somewhat fleshy, blade convex above and concave beneath, apex round, cotyledon base auriculate and arrow shaped base (sagittate), indistinctly nerved, entire, above dark green, beneath light green, glabrous, deciduous at 5-6 leaf stage. *Epicotyls* very short, 4mm, glabrous. *Stem* (at 2nd and 3rd leaf stage) erect, green, spiral and obtusangular connection of internodes, terete, angular near top, brownish green, glabrous. *Phyllotaxy* alternate and pinnate: bipinnate phyllotaxy, first leaf pinnate, second and higher leaves bipinnate. *Leaves* stipulate, spiny, petiolate, small, green, glabrous. *Leaves* 1st leaf alternate, pinnate, paripinnate, pinnately compound; stipulate, two, spinous or needle shape; rachis length 1.4cm, hold in ocre, slightly thickened at base, glabrous; 5 to 6 pair of

leaflets, opposite or alternate, very shortly petiolulate, blade shape oblong or obovate, asymmetrical, thin, apex mucronet or rounded, base asymmetrical rounded, above dark green, beneath light brown, glabrous, smooth. 2nd leaf alternate, biparipinnate; stipulate, 2mm, spinous; petiolate; primary rachis or petiole length 5mm, secondary rachis length 8mm, slightly thickened rachis base, rachis color above dark green, beneath light green; 1 pair of pinnae, 5 pair of leaflets, opposite, very shortly petiolulate, blades oblong or obovate, asymmetrical, largest leaflets blades size in middle order, thin, apex rounded or mucronet, base asymmetrically rounded, palmately nerved, entire, glabrous, above dark green, beneath light green. 3rd leaf alternate, biparipinnate; stipulate, length 3mm, spinous; primary rachis length 6 mm, flattened, breadth 1.5mm, secondary rachis 1cm, color above green, beneath brown, slightly thickened rachis base, glabrous; 1 pair of pinna, opposite, 5 pair of leaflets, opposite, shortly petiolulate, blades elliptic or obovate, asymmetrical, largest leaflet blade size below the terminal leaflet pair, thin, apex mucronet or acuminate, base asymmetrically rounded, palmately nerved, entire, glabrous, color dark green above, light green beneath. 4th leaf 1 or 2 pair of pinnae and in upcoming leaves number of leaflets and pair of pinnae increases (Photo 3).

4. *Acacia catechu* (L.f.) Willd. Sp. Pl. 4: 1079. 1806; Baker in Hook. f. Fl. Brit. India 2: 295. 1878; Duthie, Fl. Gangetic Plain 1: 316. 1903; Mahesh. Illus. Fl. Delhi f. 83. 1966. *Mimosa catechu* L. f. Suppl. Pl. syst. Veg. 439. 1781. Local name - Khair, Katha (in Hindi).

Seedlings epigeal, phanerocotylar (PEF), stinking, 7.4cm total length at first two leaf, 2.2cm above collet. *Roots* (at first leaf) tap root, primary root moderately thick, white or brown turning yellow, later tubercled or nodulated, collet absent, few lateral roots, unbranched. *Hypocotyls* epigeous, erect, straight, length 1.6 cm, terete, smooth, glabrous, slightly thickened at base, color brownish green. *Cotyledons* foliaceous, 2, epigeous, equal, petiolate, petiole length 3 mm, petiole thickness 1.5mm, petiole

color pale green, glabrous; cotyledon blade shape rounded, coriaceous or fleshy, cotyledon blade convex above and concave beneath, apex rounded top, base an arrow shaped base, indistinctly nerved, entire, color above dull dark green, beneath light green, glabrous. *Epicotyl* reduced 2mm hairy, two opposite spinouse outgrowth from just before 4th node to above nodes. *Stem* (at 2nd and 3rd leaf stage) erect, green, obtusangular connection of internodes, terete, angular near top, highly haired. *Phyllotaxy* alternate, bipinnate: bipinnate phyllotaxy, first leaf, second leaf and higher leaves have bipinnate phyllotaxy, distichous alternate. *Leaves* 1st leaf alternate, biparipinnate; stipulate, two stipule, stipule needle shape; primary rachis or petiole length 5mm, slightly thickened rachis base, secondary rachis length 7mm trichomatous or hairy; 1 pair of pinnae, 7 pair of leaflets, very shortly petiolulate, asymmetrical, oblong, thin, apex rounded or minutely apiculate, asymmetrically rounded, palmately nerved, hairy, green. 2nd Leaf alternate, biparipinnate; stipulate, leafy or needle shape; primary rachis or petiole 5mm, hairy, green, secondary rachis 1.2 cm, green, slightly thickened rachis base,

rachis colour green or brown, hairy; 1 pair of pinnae, 8 to 9 pair of pinnule, opposite, petiolulate, blades asymmetrically oblong, largest leaf blades in middle, thin, apex mucronet or minutely apiculate, base rounded asymmetrical, palmately nerved, margin entire hairy, glabrous, dark green above, light green beneath, smaller. 3rd leaf alternate, biparipinnate; stipulate, leafy or needle shape, primary rachis 9 mm, hairy, secondary rachis 1.5cm, terete, green, hairy; 1 pair of pinnae, opposite, very shortly petiolulate, 10 to 11 pair of leaflets, opposite, blade oblong asymmetrical, largest pinnae on upper terminal side, thin, apex obtuse or rounded, base asymmetrically rounded, palmately nerved, margin entire hairy, glabrous, color above and beneath green. 4th leaf alternate, biparipinnate; stipulate, leafy; primary rachis, 2 cm, 1.5cm secondary rachis, hairy, mucronet, teret, green; 2 pair of pinnae, 9 to 10 pair of leaflets, opposite, blade asymmetrically oblong, largest pinnae on upper terminal side, thin, apex rounded or minutely acuminate, base asymmetrical, palmately nerved, margin entire hairy, glabrous, color above and beneath light green (Photo 4).



Photo (1) Seedling stage of *Acacia nilotica* ssp. *indica*. Seedling germination period 15-25 days. Seeds source: identified adult plants and seeds. (rt. root, col. collet, hpt. hypocotyl, cotl. cotyledon, ep. eophyll, PEF. Phanerocotylar epigeal foliaceous seedlings.)



Photo (2) Seedling stage of *Acacia senegal* (L.) Willd. Seedling germination period 20-25 days. Seed source: identified adult plants and seeds. (rt. root, col. collet, hpt. hypocotyl, cotl. cotyledon, ep. eophyll, PEF. Phanerocotylar epigeal foliaceous seedlings.)



Photo (3) Seedling stage of *Acacia raddiana*. Seedling germination time 25-30 days for 6th and 7th leaf stages. Seed source: from identified adult plant and seeds (rt. root, col. collet, hpt. hypocotyl, cotl. cotyledon, ep. eophyll, PEF. Phanerocotylar epigeal foliaceous seedlings.)

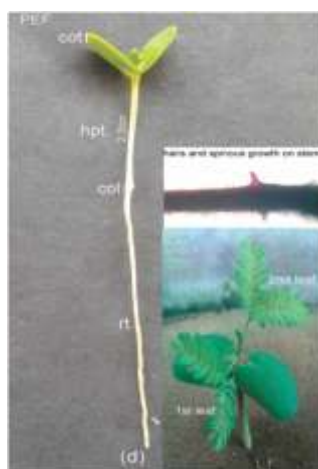


Photo (4) Seedling stage of *Acacia catechu*. Seedling germination period 25-30 for 5th and 6th stages. Seed source: from identified adult plant and seeds (rt. root, col. collet, hpt. hypocotyl, cotl. cotyledon, ep. eophyll, PEF. Phanerocotylar epigeal foliaceous seedlings.)

Table 1: Seedling characters of taxa

Taxa Species characters	A. nilotica ssp. Indica	A. raddiana	A. senegal	A. catechu
Seedling type	epigeal, phanerocotylar	epigeal, phanerocotylar	epigeal, phanerocotylar	epigeal, phanerocotylar
Root	tap root	tap root	tap root	tap root
Hypocotyl	glabrous	glabrous	glabrous	glabrous
Cotyledonphyllotaxy	opposite	opposite	opposite	opposite
Shape	elliptic	elliptic & ovate	rounded	rounded
Top	rounded	obtuse	rounded	rounded
Base	cordate or arrow shape, auriculate	cordate or arrow shape, auriculate	cordate or arrow shape, auriculate	cordate or arrow shape, auriculate
Petioles	petiolate	petiolate	petiolate	petiolate
Surface	glabrous	glabrous	glabrous	glabrous
Color	above dark green, beneath light green	above dark green, beneath light green	above dark green, beneath light green	above dark green, beneath light green
Epicotyl	very short, length 3mm	very short 4mm	short, epicotyls length 5 mm	reduced 2mm
Stem	erect, green	erect, green	erect, green	erect, green
Phyllotaxy, 1st and 2nd leaves	pinnate: pinnate opposite, unipinnate or paripinnate	pinnate: bipinnate alternate unipinnate or paripinnate	pinnate: pinnate opposite, unipinnate or paripinnate	bipinnate: bipinnate alternate, biparipinnate
3 rd leaf phyllotaxy	alternate, biparipinnate	alternate, biparipinnate	alternate, biparipinnate	alternate, biparipinnate
4 th leaf phyllotaxy	alternate, biparipinnate	alternate, biparipinnate	alternate, biparipinnate	alternate, biparipinnate
Leaves	petiolate	petiolate	petiolate	petiolate
Petiolate/sessile				
Stipules	stipulate	stipulate	stipulate	stipulate
Stipule shape	spinous	spinous, white in color	leafy	small, 1 leafy or needle shape, very short
Rachis	glabrous	glabrous	hairy or trichomatous	hairy or trichomatous
Leaflet pairs	8	5-6	8	9-10
Leaflet shape	oblong	oblong	oblong	oblong
Margin	entire	entire	entire	entire, hairy
Surface	glabrous	glabrous	glabrous	hairy
Apex	mucronet	mucronet	oblong	oblong
Base	rounded	rounded	rounded	rounded
Base asymmetrical /symmetrical	asymmetrical	asymmetrical	asymmetrical	asymmetrical

CONCLUSIONS

The present study shows that seedling of genus *Acacia* show great differential morphological characters that help in their identification at seedling stage. *Acacia nilotica* ssp. *indica* seedlings have ovate shape cotyledons and spinous stipules which give distinguishing feature to this species seedling. *Acacia senegal* seedlings are identified by their

big thick rounded cotyledons and show short 5mm epicotyl. *Acacia raddiana* display dark green appearance with long spinous stipules that grow in height ascendingly. *Acacia catechu* seedlings distinguish by densely haired epicotyls (very short), stem, rachis and bipinnate: bipinnate phyllotaxy. Therefore we can conclude that seedling stage of *Acacia* show very unique pattern of characters that distinguish them to

other species seedlings. But as a genus, *Acacia* seedlings have some common characteristic features such as disk shape collet, cotyledon epigeous, blade cordately based, phyllotaxy spiral but 1st two leaves sometimes opposite, leaves stipulate, stipules whether or not spinous, 1 pair of pinna, leaflets opposite, shortly or very shortly petiolulate. This investigation of *Acacia* seedling clearly show that we can resolve the identification and classification problem related to juvenile stage by studying seedling morphology (Miller and Miller 2011) and also determine their actual position in taxonomic classes

ACKNOWLEDGEMENT

The authors are grateful to Head, Department of Botany (UOR) Jaipur, India for providing necessary facilities and also to UGC (New Delhi) for providing grant.

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