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Research Article

Seed and seedling morphology of some medicinal plants of family Malvaceae in Tripura, North-east India

Rashmi Rani* & B K Datta

Plant Taxonomy and Biodiversity Laboratory, Department of Botany, Tripura University, Surayamminagar 799 022, Tripura

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Abstract

Plants in their juvenile stage possess some important characters which are very important and promising from the taxonomic as well as evolutionary point of view. Seed and Seedling morphology of ten species of Malvaceae has been investigated on the basis of their germination pattern, position of cotyledon, hypocotyl, epicotyl and paracotyledon and eophylls development. An artificial key has been constructed for easier identification of plants in their juvenile stage. Phenogram has been made by using UPGMA analysis to investigate the correlation between the investigated taxa.

Keywords: Seedling Morphology; UPGMA; Taxonomy

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*Correspondence

Rashmi Rani
✉ rashmi.botany@tripurauniv.in

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Introduction

The term *seedling* can be used loosely to cover very young individuals (1). Critical examination of correlation between group of characters of both the adult as well as the juvenile plant has repeatedly shown results in better understanding of taxonomically difficult taxa (2). The study of seedling morphology, which had been a less explored field in flowering plants, particularly in angiosperms, has now emerged as an essential discipline for taxonomic research at present. Moreover, the world-wide loss of biodiversity is a symptom of indiscriminate human exploitation of natural resources and developing land for human use (3). So, proper studies on seedling and their

morphology will be helpful for their early identification and conservation of natural resources which in turn shall help in safe guarding the biodiversity.

In this study ten medicinal plants of family Malvaceae has been selected for the seed and seedling morphological study. These are *Abroma augusta* (L.) L., *Abutilon indicum* (L.) Sweet, *Hibiscus surattensis* L., *Melochia corchorifolia* L., *Sida acuta* Burm.f., *Sida cordata* (Burm.f.) Borss., *Sida cordifolia* L., *Sida rhombifolia* L., *Triumfetta rhomboidea* Jacq. and *Urena lobata* L. which are variously used as medicine in different treatments. The key prepared in the present study is completely a new initiative for the early identification and

conservation of the studied taxa. The phenogram presented in this study is the first report of implication of seedling morphological character in phenetic analysis of the members of the family Malvaceae found in Tripura.

Hibiscus surattensis, *Melochia corchorifolia*. *Sida acuta*, *Sida cordata*, *Sida cordifolia*, *Sida rhombifolia*, *Triumfetta rhomboidea* and *Urena lobata* were collected from different localities of Tripura. The specimens were photographed and



Plate 1. *Abroma augusta*. (1a: Fruit, 1b: Seed, 2a: Paracotyledon, 2b: mature seedling). *Abutilon indicum* (1c: Fruit, 1d: Seed, 2c: Paracotyledon, 2d: mature seedling). *Hibiscus surattensis* (1e: Fruit, 1f: Seed, 2e: Paracotyledon, 2f: mature seedling). *Melochia corchorifolia* (1g: Fruit, 1h: Seed, 2g: Paracotyledon, 2h: mature seedling). *Sida acuta* (1i: Fruit, 1j: Seed, 2i: Paracotyledon, 2j: mature seedling). *Sida cordata* (1k: Fruit, 1l: Seed, 2k: Paracotyledon, 2l: mature seedling). *Sida cordifolia* (1m: Fruit, 1n: Seed, 2m: Paracotyledon, 2n: mature seedling). *Sida rhombifolia* (1o: Fruit, 1p: Seed, 2o: Paracotyledon, 2p: mature seedling). *Triumfetta rhomboidea* (1q: Fruit, 1r: Seed, 2q: Paracotyledon, 2r: mature seedling). *Urena lobata* (1s: Fruit, 1t: Seed, 2s: Paracotyledon, 2t: mature seedling).

Materials and Methods

Study area: Tripura is a state in North-East India and considered as a biodiversity hotspot (4). It borders Bangladesh, Mizoram and Assam. Tripura is surrounded by Bangladesh on its north, south and west: the length of its international border is 856 km (84% of its total border). The state lies between 22° 56' to 24° 32' North latitudes and 91° 09' to 92° 20' East longitudes with an aerial extent of 10,491.69 sq. km. The mature seed and seedling specimens of *Abroma augusta*, *Abutilon indicum*,

documented in the form of herbarium sheets. They were compared and identified with the help of seedling raised from identified seeds. At least eight to ten specimens of each growth form were studied from various habitats. Morphological observed and description of seedlings were done according to Duke (5), Burger (1), Bokdam (2), Vogel (6) and Paria (7). Artificial keys were prepared for the identification of investigated taxa in juvenile stage. Phenogram were prepared based on UPGMA method in PAST software.

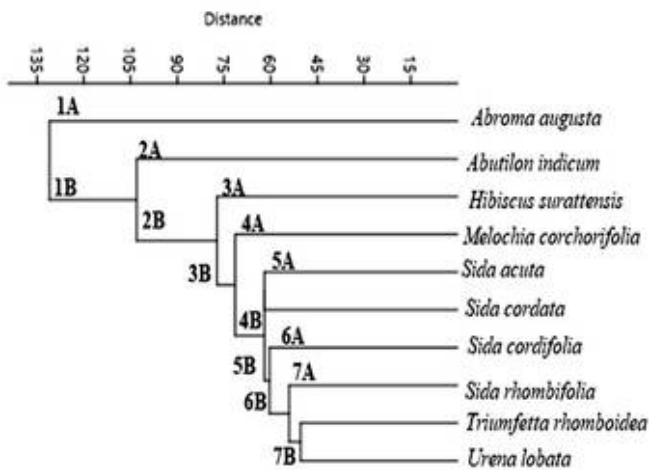


Fig. 1. Phenogram of investigated taxa using UPGMA analysis

Results

Diagnoses and key to the identification of investigated taxa

***Abroma augusta* (L.) L. Suppl. Pl. 341.1782. (Plate 1).**

Seed morphology: Seeds ovate, $\pm 0.25 - 0.32 \times \pm 0.15-0.2$ cm, weight $\pm 0.55- 0.65$ g, apex rounded, base acute, rough, black, hilum basal, hilum cream, length/ breadth 1.62, number of seeds per fruit many.

Seedling Morphology: (Up to 10th leaf stage)

Epigeal, phanerocotylar. *Roots* tap, shortly elongating, unbranched. *Hypocotyl* epigeous, shortly elongating, soft. *Paracotyledon* opposite, petiolate, leaf oblong, apex rounded, margin entire, base truncate, venation palmate, primary vein number 1, bronchiodromous, soft, glabrous, lamina balance symmetric, glabrous both surfaces. (Plate 1). *Epicotyl* green, soft, angular. *Eophylls* simple, alternate, soft/ membranous, stipulate, petiolate, leaf ovate, cordate, acuminate, base balance symmetric, margin serrate, venation pattern palmate, primary vein number 5, semi craspedodromous, veins distinct, glabrous. *Next leaves* simple, ovate, stipulate, petiolate, terete and knee bent, hairy, alternate, ovate, cordate, acuminate, symmetric, serrate, palmate, 5 semi craspedodromous, glabrous, other characters more or less same as that of first two leaves except measurements.

***Abutilon indicum* (L.) Sweet, Hort. Brit. 1: 54. 1826. (Plate 1).**

Seed morphology: Seeds reniform, $\pm 0.2-0.3 \times \pm 0.2-0.25$, weight 0.005-0.012 g, apex acuminate, base rounded, rough, black, hilum lateral, hilum black, length/ breadth 1.11, number of seeds per fruits many.

Seedling Morphology: (Up to 10th leaf stage)

Epigeal, phanerocotylar. *Roots* tap, elongating, unbranched. *Hypocotyl* epigeous, green, terete,

hairy, elongating, soft. *Paracotyledon* opposite, petiolate, exstipulate, leaf ovate, apex acute, margin ciliate, base cordate/cuneate, venation pattern palmate, primary vein number 3, actinodromous, soft, green, lamina balance symmetric. (Plate 1). *Epicotyl* green, soft, terete, hairy. *Eophylls* simple, alternate, soft, exstipulate, petiolate, leaf ovate, base cordate, apex acute, base balance symmetric, margin serrate, venation pattern palmate, primary vein number 5 or 7, gross venation actinodromous, hairy. *Next leaves* simple, ovate, soft, exstipulate, petiolate, terete, hairy, alternate, ovate, cordate, acuminate, symmetric, serrate, palmate, actinodromous, distinct hairy both surface, other characters more or less same as that of first two leaves except measurements.

***Hibiscus surattensis* L., Sp. Pl. 2: 696. 1753. (Plate 1).**

Seed morphology: Seeds reniform, $\pm 0.3-0.4 \times \pm 0.25-0.3$ cm, weight $\pm 0.007-0.013$ g, apex obtuse, base rounded, sparsely strigose with white minute hairs, brown/black, hilum lateral, hilum brown, length/breadth 1.27, number of seeds per fruit many.

Seedling Morphology: (Up to 10th leaf stage)

Epigeal, phanerocotylar. *Roots* tap, elongating, unbranched. *Hypocotyl* epigeous, green, hairy, elongating, woody. *Paracotyledon* opposite, petiolate, stipulate, leaf elliptic, apex emarginate, margin entire, base cordate, venation pattern palmate, primary vein number 3, gross venation pattern bronchiodromous, soft, green, glabrous, lamina balance symmetric. (Plate 1). *Epicotyl* green, woody, hairy. *Eophylls* simple, alternate, soft, stipulate, petiolate, leaf elliptic, base cordate, apex acute/tridentate, base balance symmetric, margin dentate, venation pattern palmate, primary vein number 5, gross venation actinodromous, surface of blade hairy both surface and spiny. *Next leaves* simple, elliptic, soft, stipulate, petiolate, terete, hairy/spiny, alternate, elliptic, cordate, tridentate, symmetric, dentate, palmate, actinodromous, prominent hairy both surface and spiny, other characters more or less same as that of first two leaves except measurements.

***Melochia corchorifolia* L., Sp. Pl. 2: 675. 1753. (Plate 1).**

Seed morphology: Seeds ovoid, slightly triangular, $\pm 0.2-0.21 \times \pm 0.1-0.2$ cm, weight $\pm 0.0022-0.0031$ g, apex acute, base obtuse, rough, black/brown, hilum basal, hilum black, length/breadth 1.33, number of seeds per fruit 1 or 2 per cells.

Seedling Morphology: (Up to 10th leaf stage)

Epigeal, phanerocotylar. *Roots* tap, elongating, unbranched. *Hypocotyl* epigeous, hairy, elongating. *Paracotyledon* opposite, petiolate, stipulate, leaf oblong/reniform, apex rounded,

margin entire, base rounded/cordate, venation pattern palmate, primary vein number 3/5, gross venation actinodromous, glabrous lamina balance symmetric (Plate 1). *Epicotyl* green, soft, hairy. *Eophylls* simple, alternate, stipulate, petiolate, leaf oblong/ovate, base cordate, apex rounded/obtuse, margin serrate, venation pattern palmate, primary vein number 5, gross venation actinodromous, glabrous. *Next leaves* simple, ovate/oblong, soft, stipulate, petiolate, terete, hairy, alternate, oblong, cordate, acute, symmetric, serrate, palmate, actinodromous, glabrous, other characters more or less same as that of first two leaves except measurements.

***Sida acuta* Burm.f., Fl Indica. 147. 1768. (Plate 1).**

Seed morphology: Seeds ovate, trigonous, $\pm 0.3 - 0.5 \times \pm 0.2 - 0.3$ cm, weight $\pm 0.0021 - 0.0030$ g, apex acute, base rounded, glabrous except around hilum, brown, hilum basal, hilum brown, length/breadth 1.6, number of seeds per fruit 5-8.

Seedling Morphology: (Up to 6th leaf stage)

Epigeal, phanerocotylar. *Roots* tap, elongating. *Hypocotyl* epigeous, elongating, soft. *Paracotyledon* opposite, petiolate, leaf elliptic, apex obtuse, margin entire, base obtuse, venation pattern pinnate, primary vein number 1, gross venation pattern eucamptodromous, glabrous (Plate 1). *Epicotyl* green, moderately woody. *Eophylls* simple, alternate, soft, exstipulate, petiolate, leaf ovate/elliptic, base cuneate, apex obtuse, base balance symmetric, margin serrate, venation pattern palmate, primary vein number 5, gross venation actinodromous. *Next leaves* simple, elliptic, soft, stipulate, petiolate, terete, hairy, alternate, ovate, cuneate, acute, symmetric, serrulate, palmate, actinodromous, hairy both surface, other characters more or less same as that of first two leaves except measurements.

***Sida cordata* (Burm.f.) Borss.Waalk., Blumea 14: 182. 1966. (Plate 1).**

Seed morphology: Seeds ovoid, $\pm 0.2 - 0.25 \times \pm 0.1 - 0.2$ cm, weight $\pm 0.0013 - 0.0018$ g, apex obtuse, base obtuse, glabrous, hilum basal, hilum brown, length/breadth 1.5, number of seeds per fruit 5, seeds 1 per mericarp.

Seedling Morphology: (Up to 6th leaf stage)

Epigeal, phanerocotylar. *Roots* tap, short elongating, branched. *Hypocotyl* epigeous, shortly elongating, woody. *Paracotyledon* opposite, petiolate, exstipulate, leaf ovate, apex acute, margin entire, base obtuse, venation palmate, primary vein number three, venation distinct, venation pattern of secondary veins actinodromous (Plate 1). *Epicotyl* green, woody. *Eophylls* simple, alternate, petiolate, leaf elliptic, base cordate, apex acute, base balance symmetric, margin of lamina serrate, venation palmate, veins distinct, primary vein 5, gross venation

actinodromous. *Next leaves* alternate, simple, elliptic, stipulate, cordate, acute, serrate, palmate, actinodromous, prominent, hairy both surface, other characters more or less same as that of first two leaves except measurements.

***Sida cordifolia* L., Sp. Pl. 2: 684. 1753. (Plate 1).**

Seed morphology: Seeds ovoid, $\pm 0.5 - 0.7 \times \pm 0.2 - 0.3$ cm, weight $\pm 0.0040 - 0.0045$ g, apex obtuse, base rounded, rough, brown, hilum basal, hilum brown, length/breadth 2.4, number of seeds per fruit 9-10.

Seedling Morphology: (Up to 6th leaf stage)

Epigeal, phanerocotylar. *Roots* tap, reduced, unbranched. *Hypocotyl* epigeous, elongating, soft. *Paracotyledon* opposite, petiolate, exstipulate, leaf ovate, apex acute, margin entire, base cordate, venation pattern palmate, primary vein number 3, acrodromous, hairy. (Plate 1). *Epicotyl* soft, hairy. *Eophylls* simple, alternate, exstipulate, petiolate, leaf ovate, base cordate, apex rounded, margin serrate, venation pattern palmate, primary vein number 5, gross venation actinodromous, hairy. *Next leaves* simple, ovate, soft, exstipulate, petiolate, terete, hairy, alternate, ovate, cordate, rounded, symmetric, serrate, palmate, actinodromous, distinct hairy both surface, other characters more or less same as that of first two leaves except measurements.

***Sida rhombifolia* L., Sp. Pl. 2: 684. 1753. (Plate 1).**

Seed morphology: Seeds reniform, $\pm 0.2 - 0.21 \times \pm 0.15 - 0.2$ cm, weight $\pm 0.020 - 0.025$ g, apex obtuse, base rounded, glabrous, black, hilum basal, hilum brown, length/breadth 1.14, number of seeds per fruit 6 to 7.

Seedling Morphology: (Up to 6th leaf stage)

Epigeal, phanerocotylar. *Roots* tap, short elongating, unbranched. *Hypocotyl* epigeous, hairy, reduced. *Paracotyledon* opposite, petiolate, exstipulate, leaf ovate, apex obtuse, margin entire, base obtuse, venation pattern pinnate, primary vein number 1, gross venation pattern craspedodromous, glabrous (Plate 1). *Epicotyl* soft, terete, hairy. *Eophylls* simple, alternate, exstipulate, petiolate, leaf elliptic/ rhomboidal, base obtuse, apex rounded, margin serrate, venation pattern pinnate, primary vein number 1, gross venation eucamptodromous, glabrous. *Next leaves* simple, elliptic/rhomboidal, soft, exstipulate, petiolate, terete, hairy, alternate. elliptic/ rhomboidal, obtuse, rounded, symmetric, serrate, pinnate, eucamptodromous, prominent, glabrous, other characters more or less same as that of first two leaves except measurements.

***Triumfetta rhomboidea* Jacq., Enum. Syst. Pl. 22. 1760. (Plate 1).**

Seed morphology: Seeds ovoid, trigonous, $\pm 0.2 - 0.3 \times \pm 0.1 - 0.2$ cm, weight $\pm 0.0020 - 0.0030$ g, apex acute, base rounded, glabrous, brown, hilum basal,

hilum brown, length/breadth 1.66, number of seeds per fruit 2-6.

Seedling Morphology: (Up to 6th leaf stage)

Epigeal, phanerocotylar. *Roots* tap, elongating, branched. *Hypocotyl* epigeous, hairy, elongating. *Paracotyledon* opposite, petiolate, leaf elliptic, apex rounded, margin entire, base obtuse, venation pattern palmate, primary vein number 3, gross venation pattern actinodromous, glabrous. (Plate 1). *Epicotyl* soft, hairy. *Eophylls* simple, alternate, stipulate, petiolate, leaf elliptic, base cordate, apex acute/ acuminate, margin serrate, venation pattern palmate, primary vein number 5, gross venation actinodromous, hairy. *Next leaves* simple, elliptic, soft, stipulate, petiolate, terete, hairy and red, alternate, elliptic, cordate, acute/ acuminate, symmetric, serrate, palmate, actinodromous, prominent hairy on both surface, other characters more or less same as that of first two leaves except measurements.

Urena lobata L., Sp. Pl. 2: 692. 1753. (Plate 1).

Seed morphology: Seeds ovoid, trigonous, $\pm 0.3-0.4 \times 0.2-0.3$ cm, weight $\pm 0.004-0.011$ g, apex acute, base rounded, glabrous, brown, hilum basal, hilum brown, length/breadth 1., number of seeds per fruit 3 to 4.

Seedling Morphology: (Up to 6th leaf stage)

Epigeal, phanerocotylar. *Roots* tap, elongating, unbranched. *Hypocotyl* epigeous, hairy, elongating. *Paracotyledon* opposite, petiolate, leaf oblong/orbicular, apex emarginate, margin entire, base obtuse, venation pattern palmate, primary vein number 3/5, gross venation pattern bronchiodromous, glabrous. (Plate 1). *Epicotyl* soft, hairy. *Eophylls* simple, alternate, stipulate, petiolate, leaf elliptic/orbicular, base rounded/cordate, apex lobed/acute, margin serrate, venation pattern palmate, primary vein number 3, gross venation semi craspedodromous/actinodromous, hairy. *Next leaves* simple, elliptic/orbicular, soft/membranous, stipulate, petiolate, angular, hairy, alternate, elliptic/orbicular, rounded/cordate, lobed, symmetric, serrate, palmate, actinodromous, hairy both surface, other characters more or less same as that of first two leaves except measurements.

Key to the investigated taxa:

- | | | |
|-------|--|-------------------------------|
| 1. | Paracotyledon leaf shape oblong or orbicular | 2 |
| 1. | Paracotyledon leaf shape elliptic or ovate | 4 |
| 2(1). | Paracotyledon leaf shape orbicular | <i>Urena lobata</i> |
| 2. | Paracotyledon leaf shape oblong | 3 |
| 3(2). | Paracotyledon leaf base truncate | <i>Abroma augusta</i> |
| 3 | Paracotyledon leaf base cordate | <i>Melochia corchorifolia</i> |

- | | | |
|-------|--------------------------------------|------------------------------|
| 4(1). | Paracotyledon leaf shape elliptic | 5 |
| 4. | Paracotyledon leaf shape ovate | 7 |
| 5(4). | Hypocotyl woody | <i>Hibiscus surattensis</i> |
| 5. | Hypocotyl soft | 6 |
| 6(5). | Paracotyledon leaf apex rounded | <i>Triumfetta rhomboidea</i> |
| 6. | Paracotyledon leaf apex obtuse | <i>Sida acuta</i> |
| 7. | Hypocotyl reduced | <i>Sida rhombifolia</i> |
| 7(4). | Hypocotyl elongating | 8 |
| 8(7). | Paracotyledon base cordate | 9 |
| 8. | Paracotyledon leaf base obtuse | <i>Sida cordata</i> |
| 9(8). | Eophyll leaf apex acute or acuminate | <i>Abutilon indicum</i> |
| 9. | Eophyll leaf apex rounded | <i>Sida cordifolia</i> |

Discussion

The ten investigated species of family Malvaceae were characterized by some important seedling morphological features which can serve as marker characters for identified taxa. It was observed that all ten studied species showed Phanerocotylar Epigeal Foliaceous (PEF) type of germination. PEF type of germination is advantageous over other types in many ways. Seedling with PEF type of germination generally grow faster than seedling with other types when they were exposed to increases light (8). Multivariant phenetic analyses have been used in classifying many plants and interpreting results of taxonomic studies. (9). Seedling features are often distinctive at the species level and correlate well with the data from other source with regard to sectional and sub sectional placement of species with genus. (10). Seedling morphology of 14 species under 13 genera from 4 families of Malvales had been studied (11). The seedling features as exhibited by these taxa reveal that there exist relationships between them in juvenile vegetative characters and accordingly the families of the order may be identified. Seedling morphology of plants includes distinguished characters like germination pattern, nature of root, hypocotyl, shape, size, color, apex, base, margin of paracotyledons and eophylls. Root of *Sida cordifolia* is reduced while root of all nine plants are elongating. Germination is epigeal and phanerocotylar in all species. Hypocotyl of *Sida rhombifolia* is reduced, *Sida cordata* is shortly elongating and others have elongating hypocotyl. Paracotyledon of *Hibiscus surattensis*, *Sida acuta* and *Triumfetta rhomboidea* is elliptic, *Abutilon indicum*, *Sida cordata*, *Sida cordifolia* and *Sida rhombifolia* have ovate leaf, *Abroma augusta* and *Melochia corchorifolia* have oblong leaf and *Urena lobata* have orbicular leaf. On the basis of these seedling characters artificial key has been constructed for the easier identification of plants in their juvenile stage. A

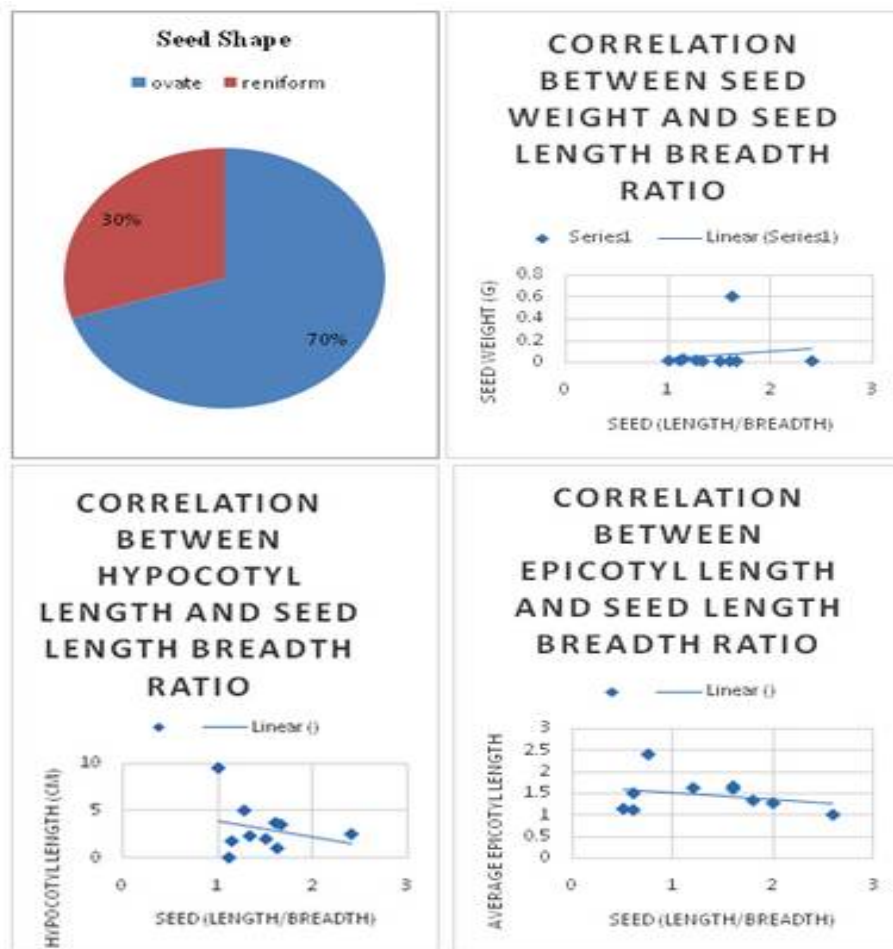


Fig. 2. (A). Pie chart showing seed shape. (B). Graph showing positive correlation between seed weight and seed length breadth ratio. (C). Graph showing negative correlation between average hypocotyl length and seed length breadth ratio. (D). Graph showing negative correlation between average epicotyl length and seed length breadth ratio.

phenogram has been constructed using UPGMA method. Phenogram includes two cluster 1A and 1B. Cluster 1A contains *Abroma augusta* and 1B contains two sub cluster 2A and 2B. 2A contains *Abutilon indicum* and 2B again sub clusters into 3A and 3B. 3A contains taxa *Hibiscus surattensis* and 3B sub clusters into 4A and 4B. 4A contains *Melochia corchorifolia* and 4B sub clusters into 5A and 5B. 5A contains *Sida acuta* and *Sida cordata*. 5B sub clusters into 6A and 6B. 6A contains *Sida cordifolia* and 6B sub clusters into 7A and 7B. 7A contains *Sida cordifolia* and 7B contains two taxa *Triumfetta rhomboidea* and *Urena lobata*. Thus, the phenogram shows the correlation between the taxa and is very similar to the correlation shown by adult taxa. Out of ten taxa seven have ovate seeds and 3 have reniform seed. There is a positive correlation between seed weight and seed length breadth ratio. (Fig. 2). Graph shows negative correlation between average hypocotyl length and seed length breadth ratio and between average epicotyl length and seed length breadth ratio.

Conclusion

Seedling characters of ten species of Malvaceae plants are related to each other and the artificial

key is very helpful for early identification and restoration of plants. Seedling morphological studies of medicinal plants help to restore the wild medicinal plants in very early stage of their life cycle. These types of study are very useful for safeguarding plants of medicinal importance and also to draw the evolutionary relationship among medicinal plants.

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Competing interest

The authors' do not have any competing interests to declare.

Authors' contribution

The first author collected the specimen, identified, analyse the field data and wrote the manuscript and the second author revised the final manuscript.

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