

TAXONOMIC IMPORTANCE OF SEEDLING MORPHOLOGICAL DATA**NABEELA MAHMOOD¹, SAHAR ZAIDI^{1*}, MOHAMMAD IMRAN² AND MUNIZA RIAZ¹**¹*Department of Botany, Federal Urdu University of Arts, Science and Technology, Gulshan-e-Iqbal Campus, Karachi, Pakistan*
*Department of Botany, Government Degree Boys College, Gulzar-e-Hijri, Karachi, Pakistan***Corresponding author's email: sahar.zaidi@fuuast.edu.pk***Abstract**

In the present work, morphological features of 16 plant species of 14 genera belonging to 6 families collected from different localities of Murad Memon Goth (Gadap town) Karachi, Pakistan were recorded. The study included the initial stages of seedlings just after their germination up to 3-4 leaves stage. Dichotomous key was constructed for the recognition of these taxa. All the taxa showed great diversity in their seedling morphological characters. These attributes may provide considerable data for the identification and classification of these taxa at the seedling stage.

Key words: Cotyledons, Seedlings, Germination, Hypocotyl, Morphological characters.**Introduction**

Seedling, an immature life stage in the development of plants and its morphological features has proved to be beneficial in the field of taxonomy (Muller, 1978; Garwood, 1996; Tillich, 2000; Paria & Bose, 2017). Morphological characterization of young plant stage is acquired by examining the features of hypocotyl or epicotyl, cotyledons, first two leaves and subsequent leaves. These attribute show variations and can give significant data for identification of plant species (Karmakar, 2012). An extensive study was carried out to reveal and justify the taxonomic value of seedling morphology of many plants species by Duke (1969), Burger (1972), Vogel (1980) and Nemoto & Ohashi (1993). In the recent years, seedling morphology emerged as an important gadget in plant systematics. This study is important in preservation as well as reforestation and also provide analytic tool for the identification of weed and wild seedlings in such areas where species composition is diversified (Paria, 2014; Khan *et al.*, 2015). Hu *et al.*, (2016) was of the view that seedling morphology being diversified was found helpful to grasp genetic association between the species of the same genus. The morphological characterization of seedling can be used in the identification and description of taxa as well as to conserve them from extinction (Bose *et al.*, 2017). Mehmood *et al.*, (2018) reported that seedling morphology provide significant information in the recognition of species.

Study area: The present study was carried out at Murad Memon Goth (Gadap town), Karachi to reveal the taxonomic implication of seedling morphology of some species collected from the area. Memon Goth is the biggest suburban area of Gadap town. It has dry and hot climate, like the other parts of Sindh. Basically it is an agricultural land but also consists of a number of wild plant species, which also occur as weed plant with the crops. The number of wild plant species showed a fast decline within the past few years. The decline is due to some natural and anthropogenic activities. These actions including increase in human population, clearing of land for the construction of different housing schemes, commercialization, salinity, low rainfall, long term summer season and rising temperature.

Materials and Methods

The mature seeds of 16 species of 14 genera belonging to 6 families of angiosperms were collected from 3 different localities of Murad Memon Goth (Gadap town). Majority of specimens were collected from cultivated fields as these wild plants were found as weeds in these fields. More than 10 voucher specimens were collected in each case for correct identification. In the laboratory, the seeds were rubbed with sand paper and soaked in water for 4-5 hours. Then 15 seeds of each plant were placed in their respective pots and after germination, morphology of their cotyledons and initial leaves was studied. The studied morphological characters were from cotyledons up to 3 to 4 leaf stages including shape of cotyledon, color, division of lamina, phyllotaxy, presence or absence of stipule, petiolate or sessile (if petiolate then all characters of petiole are studied like shape, color, size, indumentum), and leaf, base, apex, margin, surface, venation. The terminology followed here is that of Jackson (1928), Duke (1965), Burger (1972), Vogel (1980) and Ahammed & Paria (1996). The studied characters were matched with the voucher specimens collected from study area along with seeds. Photographs of each seedling were also taken with the help of Nikon D3200 (Figs. 1-25).

List of investigated taxa

The list of studied taxa is given below:

- 1. Family Amaranthaceae**
 - a) *Achyranthus aspera* L.
 - b) *Aerva javanica* (Burm. f) Juss. ex Schult.
- 2. Family Asteraceae**
 - a) *Eclipta prostrata* (L.) L.
 - b) *Conyza bonariensis* (L.) Cronquist
 - c) *Sonchus asper* (L.) Hill
- 3. Family Boraginaceae**
 - a) *Heliotropium curassavicum* L.
 - b) *Heliotropium europaeum* L.
- 4. Family Mimosaceae**
 - a) *Acacia nilotica* Mill.
 - b) *Pithecellobium dulce* (Roxb.) Benth.
 - c) *Prosopis juliflora* (Swartz) DC.

5. Family Poaceae

- a) *Cenchrus biflorus* Roxb.
- b) *Panicum turgidium* Forssk.

6. Family Solanaceae

- a) *Datura fastoussa* L.
- b) *Solanum nigrum* L.
- c) *Solanum surrattense* Burm.f.
- d) *Withania somnifera* L.

Observations

1. Family Amaranthaceae

- a) *Achyranthus aspera* Linn.

Germination type: Epigeal, Phanerocotylar.

Hypocotyl: green, round, glabrous, size is about 1 cm to 1.7 cm. **Paracotyledons** two, opposite, horizontal, green, exstipulate, sessile, shape oblong, apex obtuse, base cuneate, margins entire, glabrous and glossy, midrib indistinct. **Internodes** yellowish green, soft, circular, pubescent, internode distance about 1 cm to 1.5 cm. **First two leaves** simple, opposite, shape obovate, light green, horizontal, exstipulate, petiolate (white, round, soft, pubescent, size is about 1 cm), apex obtuse, base cuneate, margins entire, shiny surface with pubescent indumentum, distinct midrib, pinnate opposite venation. **Subsequent leaves** simple, opposite, obovate-orbicular, light green, horizontal, exstipulate, petiolate (white, round, soft, pubescent, size is about 1 cm), apex obtuse, base obtuse, margins entire, shiny surface with pubescent, midrib distinct, pinnate opposite venation.

- b) *Aerva javanica* (Burm. f) Juss. ex Schult.

Germination type: Epigeal, Phanerocotylar.

Hypocotyl: light green, round, glabrous, size is about 2 cm to 3 cm. **Paracotyledons** two, opposite, horizontal, light green, narrow-elliptic, exstipulate, petiolate (yellowish green, flat, horizontal, pubescent), apex obtuse, base cuneate, margins entire, glabrous and shiny surface, midrib distinct. **Internodes** green, round, glabrous, internode distance 0.2 cm to 0.5 cm. **The first two leaves** simple, opposite, broad elliptic, green, horizontal, exstipulate, petiolate (green vertical, pubescent, flat, size is about 1 cm), apex acute, base obtuse, margins entire, pubescent, midrib distinct, pinnate alternate venation. **Subsequent leaves** simple, whitish green, alternate, narrow-elliptic, vertical, shortly petiolate or sub-sessile, exstipulate, apex acute-mucronate, base attenuate, margins undulate, pubescent, midrib distinct, pinnate alternate venation.

Family asteraceae

- a) *Conyza bonariensis* (L.) Cronquist.

Germination type: Epigeal, Phanerocotylar.

Hypocotyl: whitish, straight, soft, round, glabrous, size is about 0.3 cm to 0.5 cm. **Paracotyledons** two,

opposite, orbicular, horizontal, olive green in color, exstipulate, sessile, apex obtuse, base obtuse, margins entire, glabrous, midrib indistinct. **Internodes** green, erect, hard, strigose, internode distance 0.5 cm to 0.8cm. **First two leaves** simple, alternate, ovate-obovate, green, horizontal, exstipulate, sessile, apex obtuse, base obtuse, margins entire, strigose, midrib distinct, reticulate venation. **3rd and 4th leaves** simple, alternate, obovate-oblong lanceolate green, horizontal, exstipulate, sessile, apex obtuse, base attenuate, margins serrate, two-lobed, strigose, midrib distinct, reticulate venation. **Subsequent leaves** simple, alternate, oblong-lanceolate, green, horizontal, exstipulate, sessile, whorled, apex acute, base attenuate, margins serrate, 6 to 7 lobed, strigose, midrib distinct, reticulate venation.

- b) *Eclipta prostrata* (L.) L.

Germination type: Epigeal, Phanerocotylar.

Hypocotyl: light green, straight, circular, glabrous, size is about 1 cm to 1.5 cm. **Paracotyledons** two, opposite, horizontal, oblanceolate, light green in color, exstipulate, sub-sessile, apex obtuse, base attenuate, margins entire, glabrous, midrib indistinct. **Internodes** reddish green, circular, strigose, internode distance about 1 cm. **The first two leaves** simple, opposite, green, narrow-elliptic, horizontal, erect, exstipulate, sessile, apex acute, base attenuate, margins serrate, strigose, midrib distinct, pinnate alternate venation. **3rd and 4th leaves** simple, opposite, narrow-elliptic, green, horizontal, erect, exstipulate, sessile, apex acute, base attenuate, margin serrulate, surface strigose, distinct midrib, pinnate alternate venation. **Subsequent leaves** simple, opposite, green, horizontal, exstipulate, sessile, shape lanceolate, apex acute, base attenuate, margins serrulate, pubescent, midrib distinct, pinnate venation.

- c) *Sonchus asper* (L.) Hill

Germination type: Epigeal, Phanerocotylar.

Hypocotyl: reddish green, round, delicate, glabrous, size is about 0.5 cm to 0.7 cm. **Paracotyledons** two, opposite, lanceolate, horizontal, green in color, exstipulate, petiolate (green, soft, pubescent, size is about 0.2 cm to 0.5 cm), apex acute-obtuse, base obtuse, margins entire, pubescent, midrib indistinct. **Internodes** rosettelike. **First two leaves** simple, opposite, spatulate, green, sub-horizontal, exstipulate, petiolate (green, soft, pubescent, size is about 0.3 cm to 0.5 cm), apex obtuse, base attenuate, margins entire, pubescent, midrib distinct. **Subsequent leaves** simple, opposite, spatulate, green, vertical, exstipulate, petiolate (green, flat, pubescent, size is about 0.6 cm to 0.8 cm), apex acute, base attenuate, margins lobed, pubescent, midrib distinct, pinnate opposite venation.

3. Family Boraginaceae

- a) *Heliotropium curassavicum* L.

Germination type: Epigeal, Phanerocotylar.

Hypocotyl: light green, round, thick, glabrous surface, size is about 0.5 cm to 1 cm. **Paracotyledons** two, opposite, oblanceolate, thick, horizontal, light green, exstipulate, petiolate (green, flat, glabrous, size is about 0.2 cm to 0.4 cm), apex obtuse, base attenuate, margins entire, glabrous, midrib indistinct. **Internodes:** internodal distance is indistinct. **First two leaves** simple, opposite, spatulate, green, horizontal, exstipulate, succulent, petiolate (small, flat, green, size is about 0.2 cm to 0.5 cm), apex obtuse, base attenuate, margins entire, glabrous, midrib indistinct. **Subsequent leaves** simple, opposite, oblanceolate, green, horizontal, rosette form, exstipulate, succulent, petiolate (small, flat, green, size is about 0.4 cm to 0.6 cm), apex obtuse, base attenuate, margins entire, glabrous, midrib distinct.

b) *Heliotropium europaeum* L.

Germination type: Epigeal, Phanerocotylar.

Hypocotyl: light green, round, thick, pubescent, size is about 0.5 cm to 0.7 cm. **Paracotyledons** two, opposite, broad elliptic, horizontal, light green in color, exstipulate, petiolate (light green, round, soft, pubescent, internodal distance about 0.4 cm to 0.6 cm), apex obtuse, base obtuse, margins entire, strigose hairs present, midrib and veins distinct. **Internodes** green, hard, straight, strigose, internode distance about 0.5 cm to 2.5 cm. **First two leaves** simple, opposite, ovate, light green, horizontal, exstipulate, petiolate (light green, round, soft, pubescent, size is about 1 cm), apex acute, base obtuse, margins entire, strigose surface, midrib distinct, pinnate opposite venation. **Subsequent leaves** simple, opposite, ovate-lanceolate, light green, horizontal, exstipulate, petiolate (light green, round, pubescent, size is about 1 cm), apex acute, base obtuse, margins entire, pubescent, midrib distinct.

4. Family Mimosaceae

a) *Acacia nilotica* Mill.

Germination type: Epigeal, Cryptocotylar.

Hypocotyl light green, erect, round, glabrous, size 2 cm to 3 cm. **Cotyledons** two, opposite, obovate, horizontal, green, exstipulate, petiolate (green, round, thick, glabrous, size 0.2 cm to 0.5 cm), apex truncate-obtuse, base sagittate, margins entire, glabrous, midrib indistinct. **Internodes** green, round, glabrous, erect, internode distance 2 cm to 4.5 cm. **First two leaves** compound, paripinnate, opposite, green, horizontal, stipulate (free-lateral), petiolate (green, round, glabrous, size is about 1 cm). **Leaflets** green, opposite, oblong, sessile, glabrous, apex obtuse, base obtuse, margins entire, glabrous, 6 to 7 paired, midrib indistinct. **Subsequent leaves** compound, paripinnate, opposite, green, vertical, stipulate (free-lateral), petiolate (green, round, glabrous, size is about 2 cm to 3 cm). **Leaflets** green, opposite, oblong, sessile, glabrous, apex obtuse, base obtuse, margins entire, glabrous, 10 to 11 paired, midrib indistinct.

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

Germination type: Epigeal, Cryptocotylar.

Hypocotyl whitish green, round, soft, erect, glabrous, size is about 2.5 cm to 3 cm. **Cotyledons** two, opposite, obovate, horizontal, light green, exstipulate, sub-sessile, apex obtuse, base cuneate-obtuse, margins entire, glabrous, midrib indistinct. **Internodes** green, round, thin, narrow, glabrous, internode distance 0.2 cm to 0.5 cm. **First two leaves** simple, opposite, obovate, green, horizontal, stipulate, stipules free-lateral, sub-sessile, apex truncate, base cuneate, margins entire, midrib distinct. **Subsequent leaves** compound, bipinnate, 2 to 3 in number, obovate, green, vertical, stipulate, sub-sessile to shortly petiolate, apex truncate, base cuneate, margins entire, midrib distinct, pinnate opposite venation.

c) *Prosopis juliflora* (Swartz) DC.

Germination type: Epigeal, Cryptocotylar.

Hypocotyl light green, round, erect, glabrous, size is about 0.5 cm. **Cotyledons** two, opposite, orbicular, horizontal, green, exstipulate, sub-sessile, apex slightly retuse, base obtuse, margins entire, glabrous, midrib distinct with pinnate venation. **Internodes** green, round, angled, glabrous, internode distance about 1 cm. **The first two leaves** green, compound, bipinnate, opposite, vertical, stipulate (free-lateral), petiolate (green, glabrous, soft, size is about 0.2 cm to 0.5 cm). **Leaflets** green, opposite, oblong, glabrous, sessile, apex obtuse, base obtuse, margins entire, 5-7 pairs, midrib distinct. **Subsequent leaves** green, compound, bipinnate, glabrous, vertical, stipulate (free-lateral), petiolate (green, glabrous, soft, size is about 0.5 cm to 1 cm). **Leaflets** green, opposite, oblong, glabrous, sessile, apex obtuse, base obtuse, margins entire, 8-10 pairs, midrib distinct.

5. Family Poaceae

a) *Cenchrus biflorus* Roxb.

Germination type: Hypogeal, Cryptocotylar.

Epicotyl: whitish, erect, glabrous, size is about 1 cm to 1.7 cm. **Cotyledon** single, green, linear, vertical, exstipulate, apex acute, sheathing leaf base, margins entire, glabrous, midrib indistinct. **Internodes** green, circular, straight, glabrous, internode distance 2 cm to 3 cm. **First two leaves-subsequent leaves:** simple, alternate, oblong, green, vertical, flat, exstipulate, apex acute, sheathing leaf base, margins entire, pubescent, parallel venation.

b) *Panicum turgidium* Forssk.

Germination type: Hypogeal, Cryptocotylar.

Epicotyl: green, round, glabrous, size is about 0.8 cm to 1 cm. **Cotyledon** single, linear, green, vertical, exstipulate, apex acute, base sheathing, margins entire, glabrous,

parallel venation. **Internodes** olive green, circular, straight, glabrous, internode distance 1.5 cm to 2.5 cm. **First two leaves-subsequent leaves:** simple, alternate, linear, green, vertical, exstipulate, apex acute, base sheathing, margins entire, glabrous, parallel venation.

6. Family Solanaceae

a) *Datura fastulosa* L.

Germination type: Epigeal, Cryptocotylar.

Hypocotyl: whitish, straight, round, pubescent, size is about 1.3 cm to 1.7 cm. **Cotyledons** two, opposite, lanceolate, horizontal, green, exstipulate, petiolate (green, soft, pubescent, size 0.3 cm to 0.6 cm), apex acute-slightly obtuse, base obtuse, margins entire, pubescent, midrib distinct. **Internodes** pinkish green, erect, thick, fleshy, hirsute, internode distance about 1 cm. **The first two leaves** simple, sub-opposite, ovate, green, horizontal, exstipulate, petiolate (green, soft, hirsute, size 1.5 cm to 2 cm), apex acute, base obtuse, margins entire, pubescent, midrib distinct, pinnate alternate venation. **Subsequent leaves** simple, sub-opposite, ovate-broad elliptic, green, horizontal-vertical, exstipulate, petiolate (green, soft, hirsute, size 2 cm to 3 cm), apex acute, base cuneate or oblique, margins undulate-dentate, pubescent, midrib distinct, pinnate alternate venation.

b) *Solanum nigrum* L.

Germination type: Epigeal, Cryptocotylar.

Hypocotyl: green, round, pubescent, fleshy, size is about 2 cm. **Cotyledons** two, opposite, broadly elliptic-ovate, horizontal, green, exstipulate, petiolate (green, angled, flat, pubescent, size 1 cm to 2 cm), apex acute, base obtuse, margins entire, pubescent, midrib distinct. **Internodes** reddish green, round, hard, erect, pubescent, internode distance 1 cm to 2.5 cm. **First two leaves** simple, alternate, ovate, olive green, horizontal, exstipulate, petiolate (red, round, angled, pubescent, size is about 1.2 cm – 1.5 cm), apex acute, base obtuse, margins entire to irregularly dentate, pubescent, midrib distinct, pinnate venation. **Subsequent leaves** simple, alternate, ovate, olive green, horizontal, exstipulate, petiolate (reddish green, round, pubescent, size is about 2

cm to 3 cm), apex acute, base obtuse, margins undulate to irregularly dentate, glabrous, midrib distinct midrib, pinnate opposite venation.

c) *Solanum surrattense* Burm.f.

Germination type: Epigeal, Cryptocotylar.

Hypocotyl: green, slightly curved, glabrous, size is about 1.5 cm to 2 cm. **Cotyledons** two, opposite, lanceolate-narrow elliptic, horizontal, green, exstipulate, sessile, apex slightly acute-obtuse, base cuneate, margins entire, glabrous, midrib indistinct. **Internodes** green, angled, pubescent, internode distance 0.6 cm to 1 cm. **First, two leaves** simple, opposite-sub-opposite, ovate-broad elliptic, green, horizontal, exstipulate, petiolate (green, round, angled, fleshy, pubescent, spiny, size is about 0.5 cm – 0.7 cm), apex acute, base obtuse, margins undulate, pubescent, midrib distinct, pinnate venation. **Subsequent leaves** simple, opposite-sub-opposite, ovate-broad elliptic, green, horizontal, exstipulate, petiolate (green, round, glabrous, spiny, size is about 1 cm), apex obtuse, base truncate, incision of lamina fid-partite, lobed, lobes unequal, margins undulate, glabrous, midrib distinct, pinnate alternate venation with spines.

c) *Withania somnifera* L.

Germination type: Epigeal, Phanerocotylar.

Hypocotyl green, straight, circular, fleshy, glabrous, size is about 0.3 cm to 0.6 cm. **Paracotyledons** two, opposite, cordate, horizontal, green, estipulate, petiolate (yellowish green, circular, fleshy, size 0.3 cm to 0.4 cm), apex obtuse, base cordate, margins entire, strigose, midrib distinct. **Internodes** green, circular, fleshy, pubescent, internode distance 0.7 cm to 1.3 cm. **First, two leaves** simple, sub-opposite, ovate-broad elliptic, green, horizontal, exstipulate, petiolate (green, round, pubescent, size is about 0.6-1cm), apex acute, base cuneate-obtuse, margins entire, pubescent, midrib distinct, pinnate venation. **Subsequent leaves** simple, alternate, broad elliptic, green, asymmetrical, horizontal, estipulate, petiolate (green, round, soft, pubescent, size 1 cm to 1.5 cm), apex obtuse, base cuneate, margins entire-ciliate, pubescent, midrib distinct, pinnate opposite venation.

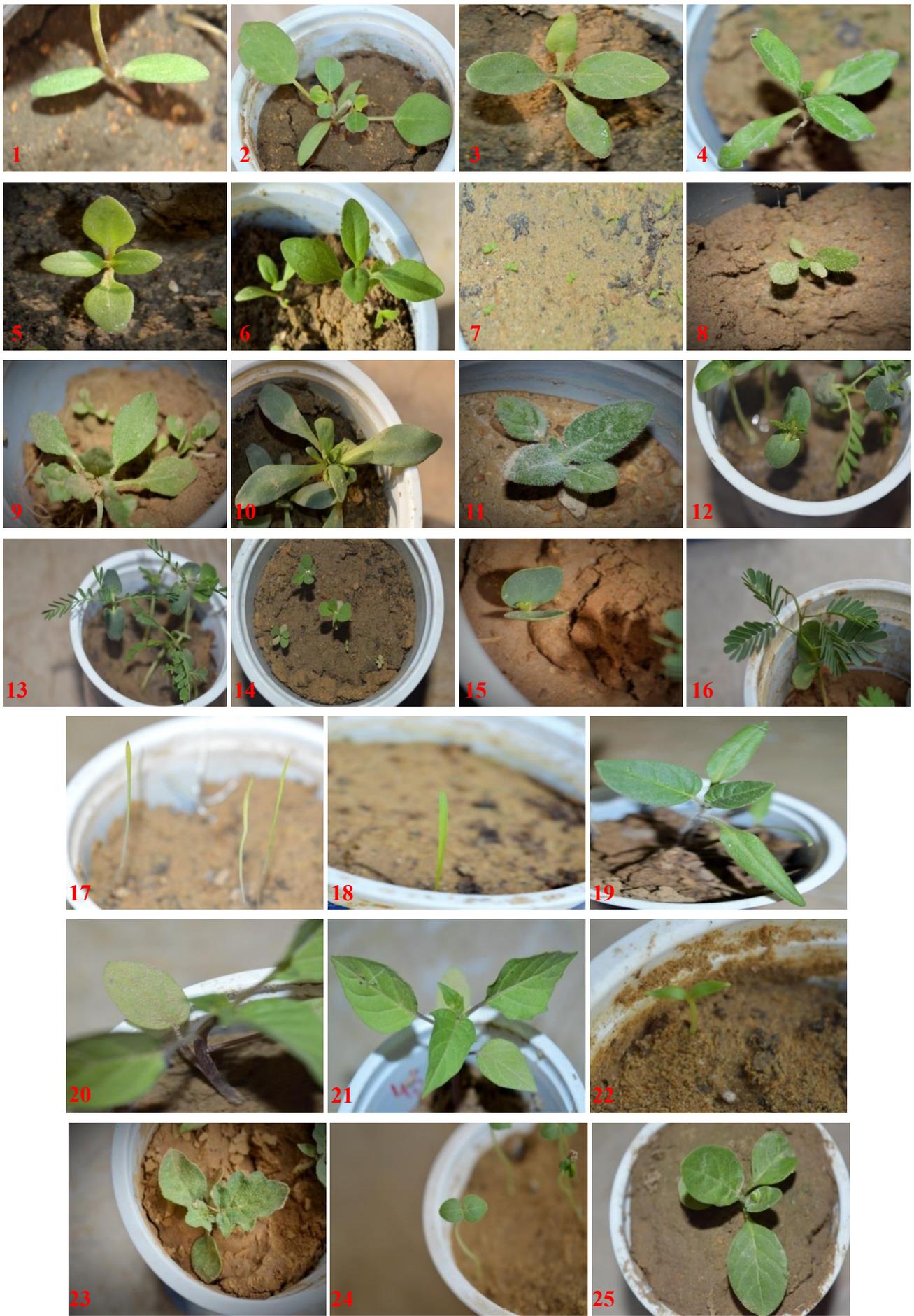
The present work comprise of few species therefore the present key comprise of only those taxa which we study.

Key to the species of Amaranthaceae

- 1 + Cotyledonary leaves sessile, oblong, internode pubescent, first two leaves obovate *Achyranthes* (*A. aspera*)
 1 - Cotyledonary leaves petiolate, narrow elliptic, internode glabrous, first two leaves broad elliptic *Aerva* (*A. javanica*)

Key to the species of Asteraceae

1. + Cotyledonary leaves sessile-sub-sessile, oblanceolate-orbicular 2
 1. - Cotyledonary leaves petiolate, lanceolate *Sonchus* (*S. asper*)
 2. + First two leaves opposite, narrow elliptic *Eclipta* (*E. prostrata*)
 2. - First two leaves alternate, ovate-obovate *Conyza* (*C. bonariensis*)



Key to the species of Boraginaceae

- 1 + Cotyledonary leaves oblanceolate, first two leaves succulent, spatulate *Heliotropium (H. curassavicum)*
 1 - Cotyledonary leaves elliptic, first two leaves non-succulent, ovate *Heliotropium (H. europaeum)*

Key to the species of Mimosaceae

- 1 + Cotyledonary leaves petiolate *Acacia (A. nilotica)*
 1 - Cotyledonary leaves sub-sessile 2
 2 + Cotyledonary leaves obovate, first two leaves simple, subsequent leaves bifoliolate *Pithecellobium (P. dulce)*
 2 - Cotyledonary leaves orbicular, first two leaves compound, subsequent leaves bipinnate *Prosopis (P. juliflora)*

Key to the species of Poaceae

- 1 + Hypocotyle whitish, internode green, surface pubescent *Cenchrus (C. biflorus)*
 1 - Hypocotyle green, internode olive green, surface glabrous *Panicum (P. turgidium)*

Key to the species of Solanaceae

- 1 + Cotyledonary leaves sessile, lanceolate-narrow elliptic, base cuneate, glabrous *Solanum (S. surrattense)*
 1 - Cotyledonary leaves petiolate, pubescent 2
 2 + First two leaves sub-opposite, subsequent leaves ovate-broad elliptic, base cuneate 3
 2 - First two leaves alternate, subsequent leaves ovate, base obtuse *Solanum (S. nigrum)*
 3 + Cotyledonary leaves lanceolate, base obtuse, subsequent leaves margin undulate- dentate ... *Datura (D. fastuosa)*
 3 - Cotyledonary leaves cordate, base cordate, subsequent leaves entire- ciliate *Withania (W. somnifera)*

Conclusion

The present work deals to enhance and promote the taxonomic and phylogenetic value of seedling stages of flowering plants. The morphological characters of seedling provide reliable data for advance taxonomic study. In this study, seedling morphology of 16 species of 14 genera belonging to 6 families collected from Murad Memon Goth was recorded. All the species showed great diversity among morphological features at their juvenile stages specially the leaf shapes found to be distinguishing. The members of family Poaceae were quite similar. The study on seedling morphology may prove to be significant in recognition of species and helpful in conservation of endangered and rare species.

Another important and useful aspect of this type of study is that it is found to be more useful in eradicating the weeds for the cultivated crops at the seedling stage. As mentioned above that most of the species were collected from the cultivated fields where they were found as wild plants or weeds. In many cases once the weeds are established and start producing fruits and seeds, then eradication is rather difficult and tedious. Therefore these seedlings can be identified at seedling stage and remove from the field as soon as they are identified.

Captions to Figures: 1. *Achyranthus aspera* (cotyledonary leaves), 2. *A. aspera* (early leaves), 3. *Aerva javanica* (cotyledonary leaves), 4. *A. javanica* (early leaves), 5. *Eclipta prostrata* (cotyledonary leaves), 6. *E. prostrata* (leaves), 7. *Conyza bonariensis* 8. *Sonchus asper* (cotyledonary leaves), 9. *S. asper* (leaves), 10. *Heliotropium curassavicum*, 11. *Heliotropium europaeum*, 12. *Acacia nilotica* (cotyledonary leaves), 13. *Acacia nilotica* (leaves), 14. *Pithecellobium dulce*, 15. *Prosopis*

juliflora (cotyledonary leaves), 16. *P. juliflora* (leaves), 17. *Cenchrus biflorus*, 18. *Panicum turgidium*, 19. *Datura festuosa* (cotyledonary leaves), 20. *Solanum nigrum* (cotyledonary leaves), 21. *S. nigrum* (leaves), 22. *Solanum surrattense* (cotyledonary leaves), 23. *S. surrattense* (leaves), 24. *Withania somnifera* (cotyledonary leaves), 25. *W. somnifera* (leaves).

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(Received for publication 6 June 2019)