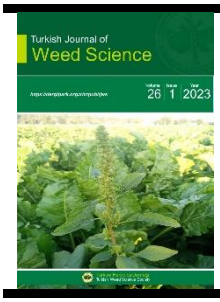

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Araştırma Makalesi/Research Article

Seedling morphological traits of some dicotyledonous invasive alien plant species (IAPS) of West Bengal, India: A case study for identification

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Abstract

Morphological traits of seedlings of 65 invasive alien species of 55 genera under 26 families of dicotyledonous have been studied from West Bengal, India. The juvenile vegetative characters are often ignored or less emphasized for the classification of higher plants, still, in reality, they are as valid as floral characters for the delimitation of families and genera (Tomlinson, 1984). The investigated phanerocotylar seedlings have been categorized into six seedling types (types I to VI). Seedling taxa are further grouped into families, genera and species within each type in the form of an artificial key. So, 65 seedling species are identified easily from natural habitats. The species mostly have ± positive value to our ecosystem and human health. Identified seedlings may be considered for conservation and cultivation. Juvenile phase is also important for weed management programmes in crop fields.

Keywords: Invasive Alien Plant Species (IAPS), West Bengal, artificial key, juvenile traits, heteroblasty, health issue

1. INTRODUCTION

Invasive alien plant species (IAPS) are substantial threat to local and global biodiversity (IUCN Council, 2002; Langmaier and Lapin, 2000), human health (Stone et al., 2018; Rai and Singh, 2020); agronomy (Paini et al., 2016), forestry (Langmaier and Lapin, 2020) and hotspot modelling (Adhikari et al., 2015), in both short and long term (Elgersma et al., 2011). The species invasion has a significant influence on the habitat they invade, affecting nutrient recycling (Teixeira et al., 2020), the richness of native species and the productivity of the encroaching ecosystem (Dogra et al., 2010) and finally, the world's flora or fauna becoming homogenized (Lockwood et al., 2007). Many threatened and endangered species are considered to be at risk because of continuous competition and pressures by nonindigenous species (Pimentel et al., 2005). The impacts of IAPS are complicated, and alter community dynamics (Holway et al., 2002; Carlton, 2003) permanently and conjointly genetic diversity (Ellstrand and Schierenbeck, 2000). Along with the different adverse effects, some invasive alien plant species may be beneficial to local communities and are frequently cultivated for ethnomedicinal, health issue purposes e.g. pulmonary, cardiovascular, digestive, skin and even dreaded cancer (Rai and Lalramnghinghlova, 2011; Rai and Singh, 2020). In India, the total number of 173 species, indicating 1% of the Indian flora was identified as IASP, distributed 117 genera under 44 families (Reddy et al., 2008). Habit indicates herbs which makeup 151 species and accounts for 87.3% of all species, are most prevalent, followed by shrubs (14), climbers (5), and trees (3) (Reddy et al., 2008). There is no accurate data on the number of alien species in West Bengal.

Many research organizations have started to chronicle exotic alien plant species and their effects on various ecosystems in India. Different studies also focus on floristic and faunistic surveys, documentation, ethnobiological studies, mapping and eco-physiological and genetic studies (Adhikari et al., 2015, Sandilyan, 2018). In this article, we have investigated the juvenile behavior of seedlings of invasive alien species. The juvenile features of taxa are evaluated qualitatively and quantitatively for identification purposes before the blooming and fruiting stages. The emergence and

establishment of seedlings are the most crucial in early development phase of the plant life cycle (Angevine and Chabot, 1979; Silvertown et al., 1993; Manri´quez et al., 2001). Seedling stage possesses many constant and conservative phenotypic traits that lead to proper identification too. The juvenile period i.e. the early phase of plant growth after seed germination, which comes before flowering and fruiting, is exceptionally ideal for controlling the establishment (Das and Kamilya, 2020; Mandal et al., 2022) of invasive alien weed taxa. IAPS having positive effects on local communities may be considered for conservation. In these domains, characterization and identification of IAPS are significant.

2. MATERIAL VE METHOD

Intensive field trips were conducted (2018-2021) in various natural habitats i.e., forests, agricultural fields, roadsides, railway tracks, wastelands, protected areas etc., for collection of seeds and seedlings in different parts of West Bengal (Figure1). West Bengal is a state in the western region of India having 88,752 km^2 area geographically lies between 22º.0' N and 26º.0' N latitude and 86º.0' E and 90º.0' E longitude. This state comprises diversified flora and fauna. Five to ten individuals of a species from various habitats are examined to avoid the questions of phenotypic plasticity and to assess conservative traits. In order to develop seedlings, collected mature seeds are thoroughly air-dried, and germinated in separate seedbeds measuring 1 m x 1 m in the experimental garden of Bejoy Narayan Mahavidyalaya with proper tagging. For accurate identification, the raised seedlings from the seed beds are also compared with collected ones from natural habitats. Herbarium sheets are made from seedlings collected from natural habitats and /or nursery grown, and are deposited at the herbarium section of B.N. Mahavidyalaya. Following literature sources i.e., Duke (1965, 1969), Burger (1972), Hickey (1973), Bokdam (1977), Muller (1978), de Vogel (1980), Paria and Kamilya (1999), Kamilya (2011), Dey et al. (2022) and Mandal et al. (2022) are considered as a reference for morphological attributes to describe seedlings. An artificial key has been prepared using conservative juvenile characters for identification. Different published literature/articles have been consulted to determine the nascence of plant species (Reddy et al., 2008, Sekar, 2011; Debnath and Debnath, 2017). The families of seedlings are arranged according to Takhtajan's (1997) classification system (Table 1). The species are listed under each family in alphabetical order, followed by the author's citation, nativity, habit, habitat, invasive status, Bejoy Narayan Mahavidyalaya (BNM) Herbarium sheet number, and route of introduction. Field photographs of each seedling have been represented in figures no 5, 6 & 7. Diverse traits of seedlings in abbreviated form and figure number are presented in table 2, following table 1. The character states from table 2 are considered for the construction of an artificial key.

3. DISCUSSION

All studied species belonging to 55 genera under 26 families were collected from different districts of West Bengal. The nativity of 65 investigated species suggests their 14 other phytogeographical locations. About 86 % of these come from five major geographic areas, viz.; Tropical America (36 species); South America (15 species); Tropical Africa (6 species); Central America (3 species) and Europe (3 species). The remaining about 14 % of species are contributed by Central Asia, Brazil, West Indies, Tropical East Africa, the Mediterranean, and Tropical South America. Life forms of the studied species indicate 42 annuals and 23 perennials representing 64.61% and 35.38% respectively. Most dominant taxa include 74% (48 taxa) herbs, whereas 12% (8 taxa) shrubs, 6% undershrub (4 taxa), and 6% (4 taxa) climbers (Figure 2). *Leucaena leucocephala* is the only tree species that encounters about 2% under the study. The Asteraceae is the dominant family having 15 species, followed by Fabaceae and Solanaceae (7 species each); Malvaceae (5 species), Euphorbiaceae, and Convolvulaceae (4 species each) contribute 64.615% of alien species (Figure 3).

Different constant and conservative juvenile traits are very significant attributes for their early identification and management in their natural habitats. Many invasive alien species, like *Parthenium hysterophorus*, *Lantana camara*, *Ageratum conyzoides*, *Chromolaena odorata*, *Mikania micrantha*, etc., are very harmful to humankind by triggering several symptoms i.e. skin inflammation, allergic reactions, dermatitis, eczema, burning and blisters around eyes. The rapid invasion and propagation of these species are responsible for the imbalance of our native flora (Debnath and Debnath, 2017). They are one of the significant threats to the global agricultural field, since many of them are annual and complete their life cycle within a few months e.g. *Cardamine hirsuta*, *Portulaca oleracea*, *Ludwigia* spp., *Croton bonplandianus*, *Xanthium strumarium*, *Mecardonia procumbens*, etc. They produce massive no. of viable seeds germinating rapidly for the next season. Therefore, rapid and accurate identification of these species leads to a successful weed management program (Parkinson et al., 2013). The alien weed species are effectively controlled at their juvenile stage as it is identified at the seedlings stage (Chomas et al., 2001). In

the crop fields of West Bengal, some dominant alien species like *Argemone mexicana*, *Croton bonplandianus*, *Euphorbia hirta*, *Oxalis corniculata*, *Ageratum* spp., *Grangea maderaspatana*, *Gnaphalium polycaulon*, *Nicotiana plumbaginifolia*, *Physalis minima*, *Evolvulus nummularius*, *Mecardonia procumbens*, *Xanthium strumarium*, etc. interact with crops variously for nutrient uptake. The majority of the taxa have medicinal value e.g., *Eclipta prostrata*, *Calotropis gigantea*, *Mimosa pudica*, *Solanum viarum*, *Datura* spp., *Argemone mexicana*, *Senna* spp.; some ornamental plants like *Impatiens balsamina*, *Euphorbia heterophylla*, *Ipomoea quamoclit*, etc.; timber yielding like *Leucaena leucocephala* and few having hallucinogenic property e.g., *Cannabis sativa*. Hardly few have ± harmful effects on the ecosystem and humans e.g., *Parthenium hysterophorus*, *Lantana camara*, *Mikania micrantha*, etc. Most of them are naturalized among our indigenous taxa.

For species having useful to human health, the first protocol is to identify them from natural habitats. There are some recent floristic literatures on identification of useful species at flowering-fruiting or adult morphological stages are West Bengal Flora Vol. I-V (Hajra, 1997; Paul et al., 2015; Ranjan et al., 2016; Lakshminarasimhan et. al., 2019). However, to identify them at the seedling stage there are no separate floristic works in our state, although their conservation, collection and peculiar juvenile behavior that differ from the adult stage, and management are important.

Early workers attempted to classify seedlings of both cryptocotylar and phanerocotylar modes of germination into several types are Klebs (1885), Leonard (1957), Vogel (1980), Ye (1983) and Das (Ph. D thesis, 2022). However, Das and Kamilya (2020) and Mandal et al. (2022) classified only phanerocotylar seedlings into a few types. Accordingly, we categorized phanerocotylar taxa into I-VI seedlings types (Figure 4). The families, genera, and species are again distinguished in the form of keys in each type. However, due to consideration of only juvenile vegetative traits, there are deviations of placement of some families uniquely in a single type e.g., Euphorbiaceae within type II, III, and V; Asteraceae within type III, V and VI; Solanaceae and Malvaceae with type V. Many species of different families are showing heteroblastic development e.g., *Sesbania aculeata*, *Parthenium hysterophorus*, *Euphorbia heterophylla*, *Malvastrum coromandelianum*, *Argemone mexicana*, etc. Such heteroblastic behavior indicating juvenile peculiarity is hardly recorded in different species.

The artificial key of the investigated taxa:

Key to the seedlings types

1a. First two leaves opposite……...…….2

1b. First two leaves alternate.....…….4

2a. Leaves simple.....…..3

2b. Leaves compound……type I

3a. Hypocotyl elongating (2.5-10 cm)…… type II

3a. Hypocotyl shortly elongating (0.5-2.5 cm)…….....Type III

4a. Leaves simple……..……5

4b. Leaves compound……...Type IV

5a. Hypocotyl elongating (2.5-10 cm).....…...V

5b. Hypocotyl shortly elongating (0.5-2.5 cm)…….…….……VI

Key to families, genera, and species under each type:

Type I

Capparaceae

Genus- *Cleome*

1a. Hypocotyl purplish, glabrous; paracotyledons narrowly oblong, base cuneate; subsequent leaves 3-foliolate always…….…… *C. rutidosperma*

1b. Hypocotyl green, pubescent; paracotyledons ± oblong, base cuneate; subsequent leaves 3-5 foliolate…….....*C. viscosa*

Type II

Key to the families

1a. First two leaves with margin entire to minutely wavy.....…..2

1b. First two leaves with margin serrate……....6

2a. Paracotyledons with apex retuse to emerginate……...3

2b. Paracotyledons with apex obtuse…….…….4

3a. Hypocotyl oblate; paracotyledons subreniform (35-48 mm × 25-32 mm), base truncate, primary vein 3, venation actinodromous……..……Nyctaginaceae (*Mirabilis jalapa*).

3b. Hypocotyl rounded; paracotyledons widely-ovate (13-15mm × 10-13 mm), base obtuse, primary vein 1, venation camptodromous…….…..……Acanthaceae (*Ruellia tuberosa*).

4a. Seedlings prostrate (after 6-8 leaves stage), terrestrial……....5

4b. Seedlings erect, semi-aquatic……...……Onagraceae

5a. Hypocotyl scabrous; paracotyledons narrowly lanceolate, base attenuate…....Amaranthaceae (*Alternanthera paronychioides*)

5b. Hypocotyl glabrous; paracotyledons widely elliptic, base sub truncate….Urticaceae (*Pilea microphylla*)

6a. Paracotyledons anisocotylar……....Cannabaceae (*Cannabis sativa*)

6b. Paracotyledons isocotylar……....7

7a. Paracotyledons with apex acute……....Euphorbiaceae (*Chrozophora rottleri*)

7b. Paracotyledons with apex retuse to emarginate…….…….…….8

8a. Hypocotyl quadrangular, hispid; paracotyledons widely-ovate (8-11mm × 9-13 mm)……...Lamiaceae (*Hyptis suaveolens*)

8b. Hypocotyl terete, glabrous; paracotyledons widely-elliptic (13-14 mm × 14-16 mm) .....…..Balsaminaceae (*Impatiens balsamina*)

Onagraceae

Genus-*Ludwigia*

1a. Paracotyledons elliptic, base obtuse; first internode angular, hirsute…….…..*L. octovalvis*

1b. Paracotyledons ovate, base cuneate; first internode rounded, glabrous……*L. perennis*

Type III

Key to the *families*

1a. Seedlings with milky latex……Euphorbiaceae (*Euphorbia hirta*)

1b. Seedlings without milky latex…….....2

2a. First two leaves and subsequent leaves sessile……...Primulaceae (*Lysimachia arvensis*)

2b. First two leaves and subsequent leaves petiolate…….....3

3a. First two leaves and subsequent leaves stipulate (interpetiolar)……Rubiaceae (*Spermacoce hispida*)

3b. First two leaves and subsequent leaves exstipulate…….....4

4a. Eophylls with primary veins 3-5…….....Asteraceae

4b. Eophylls with primary vein one …….....5

5a. First two leaves coriaceous with white cottony tomentose hair……Apocynaceae (*Calotropis gigantea*)

5b. First two leaves herbaceous with minutely pubescent to hirsute hair…….....…….6

6a. First two leaves and subsequent leave with margin entire……...… Portulacaceae (*Portulaca oleracea*)

6b. First two leaves and subsequent leave with margin serrate to dentate…….....7

7a. Hypocotyl glabrous; paracotyledons ovate to elliptic; first two leaves widely ovate to rhombic ovate, margin dentate; first internode angular, glabrous……..Scrophulariaceae

7b. Hypocotyl pubescent; paracotyledons suborbicular; first two leaves widely ovate, margin serrate; first internode rounded, hirsute ……Verbenaceae (*Lantana camara*)

Asteraceae

Key to the genera

1a. First two leaves with venation acrodromous…….....2

1b. First two leaves with venation actinodromous to camptodromous…….……4

2a. Hypocotyl ± hard; first two leaves with margin distantly dentate…….*Chromolaena* (*C. odorata*)

2b. Hypocotyl herbaceous; first two leaves with margin serrate to serrulate…….3

3a. Eophylls ovate to widely elliptic; first internode (8-12 mm) with densely hirsute hair…….....*Ageratum*

3b. Eophylls ovate to lance-ovate; first internode (3-8 mm) with densely strigose hair……..…….……*Eclipta* (*E. prostrata*)

4a. First two leaves with primary veins 1, venation camptodromous……..*Tridax* (*T. procumbens*)

4b. First two leaves with primary veins 3, venation actinodromous……..……5

5a. Paracotyledons with apex retuse; first two leaves lance-ovate, margin entire…….. *Lagascea* (*L. mollis*)

5b. Paracotyledons with apex rounded; first two leaves ovate, margin dentate to serrate……..…..……6

6a. Seedling pubescent; paracotyledon widely elliptic; first two leaves with base subcordate; first internode angular; subsequent leaves cordate……. *Mikania* (*M. micrantha*)

6b. Seedling densely hispid; paracotyledon elliptic; first two leaves with base cuneate; first internode rounded; subsequent leaves lance-ovate…… *Synedrella* (*S. nodiflora*)

Genus-*Ageratum*

Key to the species

1a. Paracotyledon glabrous, widely elliptic, base obtuse, apex obtuse……. *A. conyzoides*

1b. Paracotyledon scabrous; elliptic, base cuneate, apex retuse……..… *A. houstonianum*

Scrophulariaceae

Key to the species

1a. Hypocotyl purplish; paracotyledons ovate (2-3 mm× 2-2.5 mm), base cuneate, apex obtuse; first two leaves widely ovate (4-6 mm × 3-5 mm)…..…….… *Mecardonia* (*M. procumbens*)

1b. Hypocotyl light green, paracotyledons elliptic (2-3 mm × 1-2 mm), base obtuse, apex acute; first two leaves rhomboid-ovate to lanceolate (5-8 mm × 4-6 mm)…..... *Scoparia* (*S. dulcis*).

TYPE IV

Key to the families

1a. First two leaves and subsequent leaves exstipulate……...…Oxalidaceae (*Oxalis corniculata*)

1b. First two leaves and subsequent leaves stipulate (free lateral)…….....Fabaceae

Fabaceae

Key to the genera

1a. First two leaves trifoliolate……..……*Crotalaria* (*C. pallida*)

1b. First two leaves pinnately compound…….....2

2a. Paracotyledons with primary vein one, venation hyphodromous……....3

2a. Paracotyledons with primary veins 3-5, venation palinactnodromous…….....4

3a. Hypocotyl terete; paracotyledons ± orbicular, base reniform, margin retuse; leaflets oblance-ovate, margin ciliate, venation actinodromous; first internode with hirsute…….*Mimosa* (*M. pudica*)

3b. Hypocotyl fistulose; paracotyledons narrowly oblong, base reniform, margin retuse; leaflets ovate, margin entire, venation camptodromous; first internode with glabrous…....*Sesbania* (*S. bispinosus*)

4a. First leaf paripinnate, leaflets 8-10 pairs, second leaf geminate-pinnate…….. *Leucaena* (*L. leucocephala*)

4b. First two leaves paripinnate, leaflets 1-3 pairs…….……....*Senna*

Genus-*Senna*

1a. Paracotyledons with apex retuse; leaflet surface of first two leaves strigulose, margin emarginate, venation semi-craspidodromous to brochidodromous……..……....2

1b. Paracotyledons with apex rounded; leaflets surface of first two leaves pubescent, margin obtuse, venation camptodromous……...……...…….*S. tora*

2a. Paracotyledons widely elliptic, base subauriculate; petiolule yellowish; leaflets oblong or obovate-oblong, gland absent at base…….....*S. alata*

2b. Paracotyledons suborbicular, base subcordate; petiolule green; leaflets ovate to ovate oblong, big ovoid gland present at base……..……*S. occidentalis*

Type V

Key to families

1a. Paracotyledons bilobed…….…....Convolvulaceae

1b. Paracotyledons not bilobed……...2

2a. Seedlings with watery or milky latex…….…....Euphorbiaceae

2b. Seedlings without latex…….....3

3a. First two leaves with primary vein 3-7…….....4

3b. First two leaves with primary vein 1…….……..…..……Solanaceae

4a. Paracotyledons thin, herbaceous, petiole ± rounded, without sheathing……Malvaceae

4b. Paracotyledons thick, coriaceous, petiole flattened, ± sheathing…….…Asteraceae (*Xanthium strumarium*)

Convolvulaceae

Genus-*Ipomoea*

1a. Hypocotyl strigulose; paracotyledons with primary veins 5, venation actinodromous; first two leaves trilobed, densely hispid; first internode rounded with densely hirsute……...……..... *I. pes-tigridis*

1b. Hypocotyl strigulose; paracotyledons with primary veins 4, venation acrodromous; first two leaves pinnatisect, minutely pubescent; first internode angular with pubescent hair……..……..... *I. quamoclit*

Euphorbiaceae

Key to the genera

1a. Seedlings with watery latex; hypocotyl terete; paracotyledons oblong, base rounded; no. of primary veins 1, venation hyphodromous; first two leaves obovate……*Croton* (*C. bonplandianuus*)

1b. Seedlings with milky latex; hypocotyl fistulose; paracotyledons narrowly elliptic, base cuneate; no. of primary veins 3, venation acrodromous; first two leaves lanceolate……..*Euphorbia* (*E. heterophylla*)

Solanaceae

Key to the genera

1a. Hypocotyl glabrous; paracotyledons with apex obtuse……..…….…….2

1b. Hypocotyl pubescent; paracotyledons with apex acute.....……....*Physalis* (*P. minima*)

2a. Hypocotyl purplish, paracotyledons narrowly lanceolate……..……*Datura*

2b. Hypocotyl greenish, paracotyledons lance-ovate to widely lanceolate……...….*Solanum*

Key to the species

Genus-*Datura*

1a. Paracotyledons pale green with purplish tinge on the ventral surface, base cuneate; first two leaves with margin entire…….…….…….*D. innoxia*

1b. Paracotyledons green, base obtuse; first two leaves with margin undulate…….....*D. metel*

Genus-*Solanum*

1a. Paracotyledons lance-ovate; first two leaves ovate to pinnately lobed, upper surface densely hairy with prickles……..…….…….*S. sisymbriifolium*

1b. Paracotyledons lanceolate; first two leaves ovate to widely elliptic, upper surface hairy without prickles……....2

2a. First two leaves widely elliptic (17-22.5 mm × 15.5-21 mm), base obtuse; first internode rounded ……..……...……..*S. viarum*

2b. First two leaves widely ovate (40-80 mm × 30-55.5 mm), base cuneate; first internode angular……..……..……*S. americanum*

Malvaceae

Key to the genera

1a. Paracotyledons ovate to widely ovate, base reniform, apex retuse to emerginate……..…2

1b. Paracotyledons elliptic, base subtruncate, apex rounded……..……*Malachra* (*M. capitata*)

2a. Hypocotyl pubescent, paracotyledons widely ovate, venation acrodromous; first two leaves orbicular, apex mucronate…….....*Malvastrum* (*M. coromandelianum*)

2b. Hypocotyl scabrous, paracotyledons ovate, venation actinodromous; first two leaves elliptic to ± trilobed…….....*Urena* (*U. lobata*)

Type VI

Key to the families

1a. Seedlings rosette form/ rosulate……...2

1b. Seedlings without rosette form/ rosulate…….…….…….…...5

2a. First two leaves and subsequent leaves subsessile to sessile (1-2 mm)…….....3

2b. First two leaves and subsequent leaves petiolate (except *Blumea lacera*)……..……4

3a. Paracotyledons linear (16-30 mm × 1.5-2 mm), base attenuate, first two leaves oblanceolate to oblance-ovate, margin spinescent……Papaveraceae (*Argemone mexicana*)

3b. Paracotyledons elliptic (1-2 mm ×1-1.5 mm), base cuneate, first two leaves ovate-elliptic (5-10 mm × 3-6 mm), margin entire……..…Solanaceae (*Nicotiana plumbaginifolia*)

4a. First two leaves with margin entire to wavy ……...Brassicaceae (*Cardamine hirsuta*)

4b. First two leaves with margin serrate to dentate; subsequent leaves pinnatisect.....Asteraceae

5a. First two leaves with margin entire…….....6

5a. First two leaves with margin serrate to dentate…….…...7

6a. Hypocotyl angular, translucent; paracotyledons with apex obtuse; first internode angular, glabrous……Piperaceae (*Peperomia pellucida*)

6b. Hypocotyl rounded, green; paracotyledons with apex retuse to bilobed; the first internode rounded, pubescent……..…..……Convolvulaceae

7a. Paracotyledons with primary veins one, venation hyphodromous; first two leaves with margin dentate…….....Tiliaceae (*Triumfetta rhomboidea*)

7b. Paracotyledons with primary veins 3, venation actinodromous; first two leaves with margin serrate…….....Malvaceae

Asteraceae

Key to the genera

1a. First two leaves with primary vein one……....2

1a. First two leaves with primary veins 3-5…….....5

2a. First two leaves with margin serrate to serrulate…….....3

2b. First two leaves with margin entire……....…….……4

3a. Paracotyledons widely elliptic; eophylls subsessile to sessile, blade widely elliptic……..……*Blumea* (*B. lacera*)

3b. Paracotyledons suborbicular; eophylls with petiole winged, blade spathulate to lance-ovate.....…...*Youngia* (*Y. japonica*)

4a. Seedlings with hirsute hair; paracotyledons ovate to elliptic, apex subrounded; first two leaves obovate to oblanceolate (4-5mm × 2-3mm); subsequent leaves pinnatifid ……..……....……. *Grangea* (*G. maderaspatana*)

4b. Seedlings with densely white tomentose hair; paracotyledons suborbicular, apex rounded; first two leaves obovate to oblong; subsequent leaves spathulate to oblanceolate-oblong……....…….. *Gnaphalium* (*G. polycaulon*)

5a. Seedlings with densely scaberulous; paracotyledons with base cuneate, apex obtuse; first two leaves ovate to simple trilobed to pinnately lobed……. *Parthenium* (*P. hysterophorus*)

5b. Seedlings with glabrous; paracotyledons with base obtuse, apex rounded; first two leaves suborbicular……....*Sonchus* (*S. oleraceus*)

Malvaceae

Key to the species

1a. Paracotyledons widely elliptic, base obtuse, no. of primary veins 3, venation acrodromous; first two leaves ovate, base rounded to reniform……. *Corchorus* (*C. aestuans*)

1b. Paracotyledons suborbicular, base rounded, no. of primary vein 5, venation actinodromous; first two leaves suborbicular, base subrounded……. *Melochia* (*M. corchorifolia)*

Convolvulaceae

Key to the species

1a. Hypocotyl green; paracotyledons oblong, base obtuse, apex retuse, no. of primary vein one, venation camptodromous ……...……..…….……*Evolvulus* (*E. nummularius*)

1b. Hypocotyl purplish green; paracotyledons bilobed, base subcordate, each lobe apex acute, no. of primary vein 5, venation actinodromous…….……*Ipomoea* (*I. eriocarpa*)

4. CONCLUSION

A strategy for identifying of invasive alien species at the juvenile stage has been demonstrated by constructing an artificial key. The young developmental variations may fulfill our knowledge on the life cycle of angiosperms. The typical immature behavior is gradually changed towards the adult stage, where a large number of literatures are available for identification. But, the literatures on the identification of seedlings are rare. Many species may be advised for *ex-situ* conservation following different strategies. Some alien weed species may be taken into consideration for eradication at the early stages of their growth from crop fields following appropriate control measures. Thus, seedling stage identification has many folds importance.

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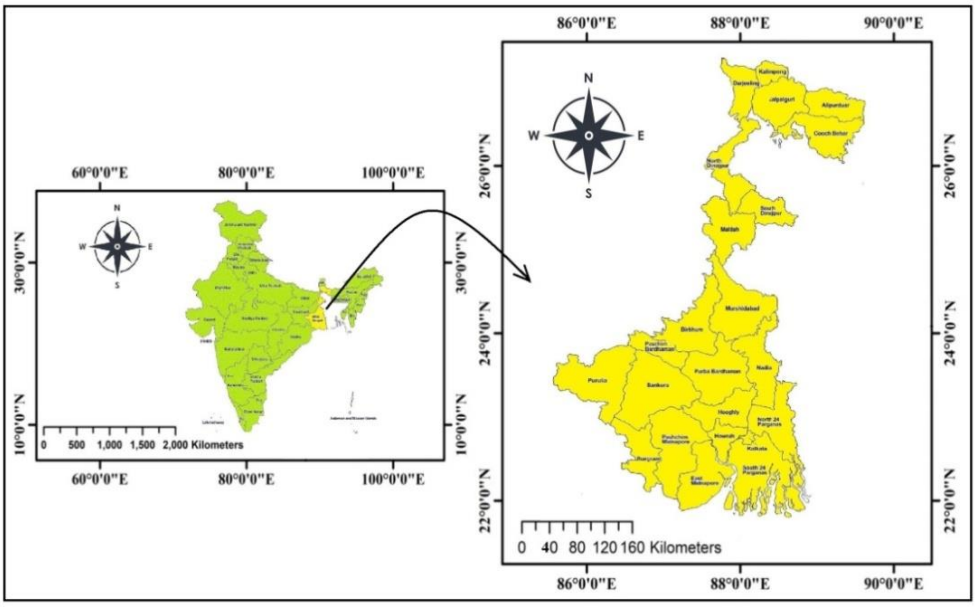

Figure 1. Location map of study area (West Bengal)

Table1. List of studied invasive alien taxa

SN	Name of the species	Family	Nativity	HA	HT	LF	IS	MI
1	*Peperomia pellucida* (L.) Kunth [BNM 69, 156]	Piperaceae	S. America	H	W, R, Cf	A	NT	Ui
2	*Argemone mexicana* L. [BNM 147, 184]	Papaveraceae	S. America	H	W	A	NT	Ui
3	*Mirabilis jalapa* L. [BNM 121]	Nyctaginaceae	Peru	H	W, G	A	CL	O
4	*Portulaca oleracea* L. [BNM 19]	Portulacaceae	S. America	H	W, R, Cf	A	IN	Fd
5	*Alternanthera paronychioides* A.St.-Hil. [BNM 132, 181]	Amaranthaceae	T. America	H	W, R,	A	IN	Ui
6	*Lysimachia arvensis* (L.) U. Manns & Anderb. [BNM 89]	Primulaceae	Europe	H	Cf	A	NT	Ui
7	*Cleome rutidosperma* DC.	Capparaceae	T. America	H	W, Cf	A	NT	Ui
8	*Cleome viscosa* L. [BNM 17, 52]	Capparaceae	T. America	H	W, Cf	A	NT	Ui
9	*Cardamine hirsuta* L. [BNM 76]	Brassicaceae	T. America	H	W	P	NT	Ui
10	*Triumfetta rhomboidea* Jacq. [BNM 217]	Tiliaceae	T. America	H	W, R	P	NT	Ui
11	*Corchorus aestuans* L. [BNM 53, 87]	Malvaceae	T. America	H	W, R	A	NT	Ui
12	*Malachra capitata* L. [BNM 89,158]	Malvaceae	T. America	H	W, R, Cf	P	NT	Ui
13	*Malvastrum coromandelianum* (L.) Garcke [BNM 211,125]	Malvaceae	T. America	H	W, R.	A	NT	Ui
14	*Melochia corchorifolia* L. [BNM 174, 156]	Malvaceae	T. America	H	W, R	P	NT	Ui
15	*Urena lobata* L. [BNM 92, 103]	Malvaceae	T. Africa	S	W, R	P	IN	Ui
16	*Cannabis sativa* L. [BNM 93]	Cannabaceae	C. Asia	H	W	P	NT	Ui
17	*Pilea microphylla* (L.) Liebm. [BNM 72, 249]	Urticaceae	S. America	H	W	A	NT	Ui
18	*Chrozophora rottleri* (Geiseler) Spreng. [BNM 32, 157]	Euphorbiaceae	T. Africa	H	W, R, Cf	A	IN	Ui

19	*Croton bonplandianus* Baill. [BNM 122, 247]	Euphorbiaceae	S. America	H	W, R, Cf	P	IN	Ui
20	*Euphorbia heterophylla* L. [BNM 254, 126]	Euphorbiaceae	T. America	H	W, R	A	CL	Ui
21	*Euphorbia hirta* L. [BNM 41]	Euphorbiaceae	T. America	H	W, R, Cf	A	IN	
22	*Ludwigia octovalvis* (Jacq.) P.H.Raven [BNM 54, 91]	Onagraceae	T. Africa	H	A	A	IN	Ui
23	*Ludwigia perennis* L. [BNM 51]	Onagraceae	T. Africa	H	A	A	NT	Ui
24	*Crotalaria pallida* Aiton [BNM 25, 75]	Fabaceae	T. America	US	R, G	P	IN	Ui
25	*Leucaena leucocephala* (Lam.) de Wit [BNM 75, 139]	Fabaceae	T. America	T	R, F	P	NT	I
26	*Mimosa pudica* L. [BNM 84, 71]	Fabaceae	Brazil	H	W, R	P	IN	Ui
27	*Sesbania aculeata* (Schreb.) Pers. [BNM 23, 46]	Fabaceae	T. America	S	W, Cf	A	NT	Ui
28	*Senna alata* (L.) Roxb. [BNM 94]	Fabaceae	S. America	S	W, R	*P*	IN	O
29	*Senna occidentalis* (L.) Link [BNM 86, 256]	Fabaceae	S. America	S	W, R	P	IN	I
30	*Senna tora* (L.) Roxb. [BNM 85]	Fabaceae	S. America	S	W, R, Cf	P	IN	Ui
31	*Oxalis corniculata* L. [BNM 94]	Oxalidaceae	Europe	H	W, Cf	A	NT	Ui
32	*Impatiens balsamina* L. [BNM 44, 142]	Balsaminaceae	T. America	H	G	A	CL	O
33	*Ageratum conyzoides* L. [BNM 129, 257]	Asteraceae	T. America	H	W, Cf	A	IN	Ui
34	*Ageratum houstonianum* Mill. [BNM 148, 184]	Asteraceae	T. America	H	W, Cf	A	IN	Ui
35	*Blumea lacera* (Burm.f.) DC. [BNM 78, 152]	Asteraceae	T. America	H	W, F	A	IN	Ui
36	*Chromolaena odorata* (L.) R.M.King & H. Rob. [BNM 56]	Asteraceae	T. America	S	W, R, F	P	IN	Ui
37	*Eclipta prostrata* (L.) L. [BNM	Asteraceae	T. America	H	W, Cf	A	IN	Ui
38	*Grangea maderaspatana* (L.) Poir. [BNM 237, 141]	Asteraceae	T. South America	H	W, Cf	A	NT	Ui
39	*Gnaphalium polycaulon* Pers. [BNM 172, 149]	Asteraceae	T. America	H	W, Cf	A	IN	Ui
40	*Lagascea mollis* Cav. [BNM 183, 208]	Asteraceae	C. America	H	W, R	A	IN	Ui
41	*Mikania micrantha* Kunth [BNM 249, 123]	Asteraceae	T. America	C	W, R	A	IN	Ui
42	*Parthenium hysterophorus* L. [BNM 47, 263]	Asteraceae	N. America	H	W, R, Cf	A	IN	Ui
43	*Sonchus oleraceus* L. [BNM 138, 258]	Asteraceae	Mediterranean	H	W, R	A	IN	Ui
44	*Synedrella nodiflora* (L.) Gaertn. [BNM 128, 234]	Asteraceae	West Indies	H	W, R	A	IN	Ui
45	*Tridax procumbens* L. [BNM 159, 209]	Asteraceae	C. America	H	W, R	A	IN	Ui
46	*Xanthium strumarium* L. [BNM 84]	Asteraceae	T. America	H	W, R, Cf	A	IN	Ui
47	*Youngia japonica* (L.) DC. [BNM 96, 219]	Asteraceae	S. America	H	W, R	A	IN	Ui
48	*Spermacoce hispida* L. [BNM 27]	Rubiaceae	T. America	H	W, R	P	NT	Ui
49	*Calotropis gigantea* (L.) Dryand. [BNM 153, 212]	Apocynaceae	T. Africa	S	W, R	P	NT	Ui
50	*Datura innoxia* Mill. [BNM 29]	Solanaceae	T. America	S	W, R, G	P	NT	Ui
51	*Datura metel* L. [BNM 31, 213]	Solanaceae	T. America	S	W, R, G	P	NT	Ui

52	*Nicotiana plumbaginifolia* Viv. [BNM 207, 218]	Solanaceae	T. America	H	W, R	A	NT	Ui
53	*Physalis minima* L. [BNM 279]	Solanaceae	T. America	H	W, Cf	A	IN	Ui
54	*Solanum americanum* Mill. [BNM 39, 203]	Solanaceae	T. America	H	W, Cf	A	IN	Ui
55	*Solanum sisymbriifolium* Lam. [BNM 202, 204]	Solanaceae	S. America	US	W, R	P	IN	Ui
56	*Solanum viarum* Dunal [BNM 70, 117]	Solanaceae	T. America	H	W, R	P	IN	Ui
57	*Evolvulus nummularius* (L.) L.	Convolvulaceae	T. America	H	W, R	P	IN	Ui
58	*Ipomoea eriocarpa* R. Br. [BNM 161, 189]	Convolvulaceae	T. Africa	C	W, R,Cf	A	CL	O
59	*Ipomoea pes-tigridis* L. [BNM 87, 82]	Convolvulaceae	T. E. Africa	C	W, R, F	A	IN	Ui
60	*Ipomoea quamoclit* L. [BNM, 154, 181]	Convolvulaceae	T. America	C	G, R	A	CL	O
61	*Mecardonia procumbens* (Mill.) Small [BNM 77, 308]	Scrophulariaceae	T.N America	H	W, Cf	A	CL	Ui
62	*Scoparia dulcis* L. [BNM 72, 86]	Scrophulariaceae	T. America	H	W, R, Cf	P	IN	Ui
63	*Ruellia tuberosa* L. [BNM 3,78]	Acanthaceae	T. America	H	W, R	A	NT	Ui
64	*Lantana camara* L. [BNM 62]	Verbenaceae	T. America	S	W, R, F	P	IN	Ui
65	*Hyptis suaveolens* (L.) Poit. [BNM 143, 187]	Lamiaceae	T. America	H	W, R	A	IN	Ui

Abbreviations: SN- Serial Number; HA (Habit): H-Herb; US-Undershrub; C-Climber; S-Shrub; T-Tree; HT (Habitat): Cf - Crop field; W- Wasteland; R-Roadside; F-Forest; A-Aquatic; G-Garden; LF (Life From): A-Annual; P-Perennial; IS (Invasive Status): CS-Casual; CL-Cultivated; NT-Naturalized; IN-Invasive; MI (Mode of Introduction): O-Ornamental; Af- Agroforestry; Fd-Food; Ui-Unintentional; Nativity: T-Tropical; T.N-Tropical North; T.E-Tropical East; S-South; C-Central

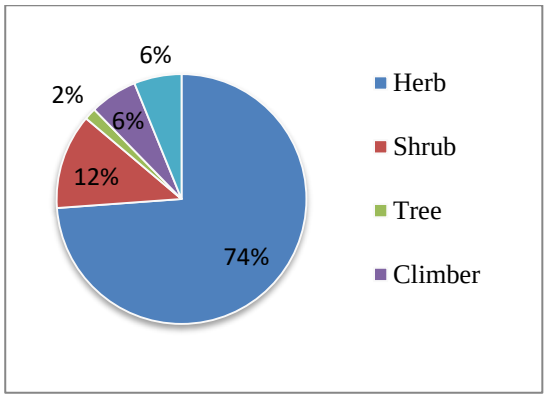

Figure 2. Habits of IAPS

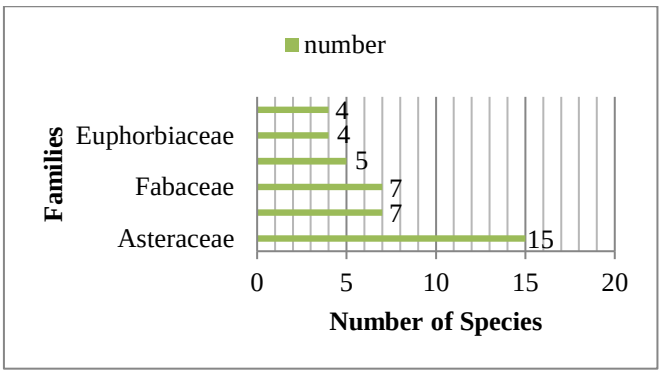

Figure 3. Six dominant families of IAPS Seedlings

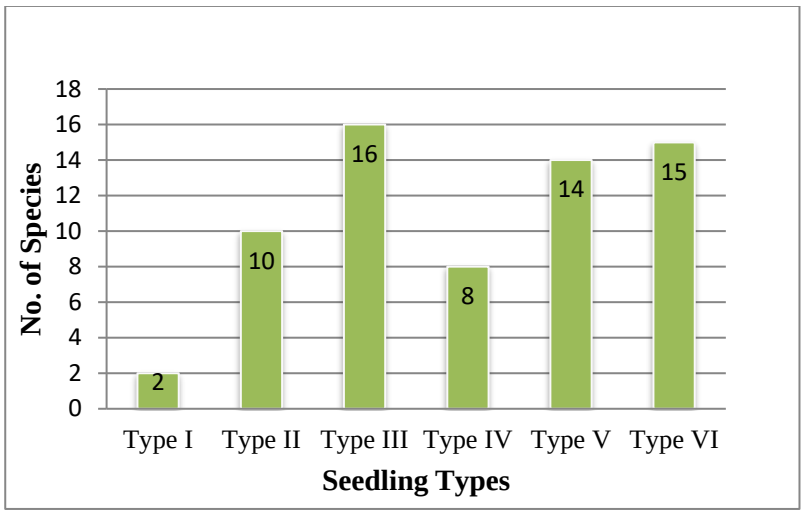

Figure 4. Seedling types (I to VI) of investigated taxa

Table 2. Abbreviations of different seedlings traits and figure number of studied species

Name of the species with figure no.	HPT		PCD									FTL												FI	
	Shape	Surface	Texture	Surface	Petiole	Shape	Base	Apex	Margin	Pri. veins	Venation	Phyllotaxy	Nature	Texture	Surface	Petiole	Stipule	Shape	Base	Apex	Margin	Pri. veins	Venation	Shape	Surface
Peperomia pellucida (Fig. 5A)	a	gb	hb	gb	1	wo	ob.r	ob	et	3	act	al	smp	hb	gb	1	0	wo-co	co	ob	et	3-5	act	a	gb
Argemone mexicana (Fig. 5B)	r	gb	hb	gb	1	lin	an	ac	et	1	hyp	al	smp	hb	gb	0	0	oc-oo	n.cn	ac	sp	1	cra	r	gb
Mirabilis jalapa (Fig. 5C)	obl	pb	hb	pb	1	w-el	tr	ema	et	1	act	op	smp	hb	str	1	0	o	sr	ac	wv	1	cam	a	stg
Portulaca oleracea (Fig. 5D)	r	gb	hb	gb	1	lc	cn	ob	et	1	hyp	op	smp	hb	gb	1	0	ov	cn	ob-r	et	1	hyp	r	gb
Alternanthera paronychioides (Fig. 5E)	r	sca	hb	gb	1	n-lc	an	ac	et	1	hyp	op	smp	hb	gb	1	0	olc	an	ac	et	1	cam	r	gb
Lysimachia arvensis (Fig. 5F)	r	gb	hb	gb	1	n-rb	an	ac	et	1	hyp	op	smp	hb	gb	0	0	o-el	sr	ac-ob	et	3	acr	a	gb
Cleome rutidosperma (Fig. 5G)	r	gb	hb	gb	1	n-ol	cn	ob	et	1	hyp	op	cmp	hb	gb	1	0	el-olc	cn	ob	se	1	cam	r	gb
Cleome viscosa (Fig. 5H)	r	pb	hb	gb	1	ol	ob	ob	et	1	hyp	op	cmp	hb	g.ha	1	0	rb-o	cn	ac	et	1	cam	r	g.ha
Cardamine hirsuta (Fig. 5I)	r	gb	hb	gb	1	w-el	ob	re	et	1	hyp	op	smp	hb	gb	1	0	sl.tri	ren	re	et	3	act	r	gb
Triumfetta rhomboidea (Fig. 5J)	r	gb	hb	gb	1	ov	cn	r	et	1	hyp	al	smp	hb	ha	1	1	rb	sr	ac	dn	3	act	r	ha
Corchorus aestuans (Fig. 5K)	r	str	hb	pb	1	w-el	ob	ob.r	et	3	acr	al	smp	hb	pb	1	1	o	r-ren	ac-ob	se	3	acr	r	dn.st
Malachra capitata (Fig. 5L)	r	pb	hb	pb	1	el	sbtr	r	et	3	act	al	smp	hb	pb	1	1	orb	co	r	i.se	5-7	act	r	st.ha
Malvastrum coromandelianum (Fig. 5M)	r	pb	hb	pb	1	wo	ren	re	et	3	acr	al	smp	hb	st-ha	1	1	orb	ren	muc	cre	5	act	r	st.ha

Melochia corchorifolia (Fig. 5N)	r	pb	hb	gb	1	s-orb	r	r	et	5	act	al	smp	hb	pb	1	1	s-orb	s-r	ob	se	3	act	r	pb
Urena lobata (Fig. 5O)	r	st-ha	hb	st-ha	1	o	ren	eme	et	3	act	al	smp	hb	st-ha	1	0	el-sl.tri	co	ob	i-se	5	act	r	sca
Cannabis sativa (Fig. 5P)	r	pb	th	pb	1	ol-ov	cn	ob	et	n-p	hyp	op	smp	hb	pb	1	0	el-ol	cn	ac	se	1	cas	r	pb
Pilea microphylla (Fig. 5Q)	r	gb	hb	gb	1	w-el	sb-tr	ob-s-r	et	1	hyp	op	smp	hb	gb	1	0	el-wo	ob	ob	et	1	cam	r	gb
Chrozophora rottleri (Fig. 5R)	r	sca	hb	sp-pb	1	el-ol	r	ob	et	1	hyp	op	smp	hb	sca	1	1	o	r	ac	et	1	d.se	r	sca
Croton bonplandianus (Fig. 5S)	r	st-ha	co	st-ha	1	ol	ob	r	et	1	hyp	al	smp	hb	st-ha	1	0	ov	cn-ob	ac	se	3	act	r	st-ha
Euphorbia heterophylla (Fig. 5T)	f	pb	hb	str	1	n-el	cn	ac	et	3	acr	al	smp	hb	str	1	0	lc	cn	n.ac	et	1	hyp	f	str
Euphorbia hirta (Fig. 5U)	obl	pb	hb	pb	1	el	ob	r	cr	1	hyp	op	smp	hb	pb	1	0	el	cn	s. ac	cr	1	act	obl	pb
Ludwigia octovalvis (Fig. 5V)	a	gb	hb	gb	1	el	ob	ac	et	1	hyp	op	smp	hb	gb	1	0	o	cn	ob	et	1	cam	a-4	hi
Ludwigia perennis (Fig.6A)	r	pb	hb	gb	1	o	cn	ac	et	1	hyp	op	smp	hb	gb	1	0	o	cn	ac	et	1	cam	r	gb
Crotalaria pallida (Fig. 6B)	r	ha	hb	gb	0	ol	sr	r	et	1	hyp	al	cmp	hb	gb	1	1	ol-ov	cn	ob	et	1	cam	r	pb
Leucaena leucocephala (Fig. 6C)	a	pb	hb	gb	1	w-el	aur	r	et	3-5	act	al	cmp	hb	gb	1	1	lf-ol	obq	ob	et	3	act	sr	pb
Mimosa pudica (Fig. 6D)	r	pb	hb	gb	1	orb	ren	ret	et	1	hyp	al	cmp	hb	hs	1	1	lf-olv-o	cn	ac-sr	cil	3	act	r	hs
Sesbania aculeata (Fig. 6E)	f	gb	hb	gb	1	n-ol	ob	r	et	1	hyp	al	smpcmp	hb	gb	1	1	ln-o	ob	r	et	1	cam	r	gb
Senna alata (Fig. 4F)	r	pb	th	gb	0	w-el	s-aur	ret	et	3-5	act	al	cmp	hb	stg	1	1	lf-ov	obq	ema	et	1	se-cas	r	gb

Senna occidentalis (Fig. 6G)	r	pb	th	gb	0	sorb	sco	ret	et	3	act	al	cmp	hb	stg	1	1	ov	obq	ema	et	1	bro	a	hi
Senna tora (Fig. 4H)	r	pb	th	gb	1	el-orb	aur	r	et	5	act	al	cmp	hb	pb	1	1	ov	obq	ob	et	1	cam	4an	pb
Oxalis corniculata (Fig. 6I)	r	pb	hb	pb	1	o	ob-r	ob	et	1	hyp	al	cmp	hb	pb	1	0	obc	cn	ema	et	1	yph	r	hi
Impatiens balsamina (Fig. 6J)	r	gb	th	gb	1	w-el	ob	eme	et	1	hyp	op	smp	hb	gb	1	0	o	cn	ac	se	1	cam	r	pb
Ageratum conyzoides (Fig. 6K)	r	gb	hb	gb	1	w-el	ob	ob	et	1	hyp	op	smp	hb	pb	1	0	w-el	ob	ac	se	3	acr	r	pb
Ageratum houstonianum (Fig. 6L)	r	sca	hb	sca	1	o	cn	ret	et	1	hyp	op	smp	hb	pb	1	0	o	b-cn	ob	se	3	acr	r	pb
Blumea lacera (Fig. 6M)	r	pb	hb	gb	0	w-el	ob	ob	et	1	hyp	al	smp	hb	pb	1	0	w-el	cn	ob	su	1	ecam	r	lan
Chromolaena odorata (Fig. 6N)	r	sca	hb	gb	1	ol	sr	r	et	1	hyp	op	smp	hb	pb	1	0	o	cn	ob	dn	1	acr	r	pb
Eclipta prostrata (Fig. 6O)	r	stg	hb	st	1	el-ol	cn	r	et	1	hyp	op	smp	hb	stg	1	0	ln-o	cn	ac	dn.se	3	acr	r	pb
Grangea maderaspatana (Fig. 6P)	r	gb	hb	gb	1	ov-el	an	sr	et	1	hyp	al	smp	hb	pb	1	0	ov-olc	an	ob	et	1	hyp	r	hi
Gnaphalium polycaulon (Fig. 6Q)	r	gb	hb	gb	1	s-orb	sr	r	et	1	hyp	al	smp	hb	tom	1	0	el	an	ob	et	1	hyp	r	tom
Lagascea mollis (Fig. 6R)	r	pb	hb	pb	1	el	ob	ret	et	1	hyp	op	smp	hb	pb	1	0	ln-o	ob	ac	et	3	act	r	hs
Mikania micrantha (Fig. 6S)	r	pb	hb	gb	1	w-el	ob	r	et	1	hyp	op	smp	hb	pb	1	0	o	sco	ac	dnt	3	act	a	pap
Parthenium hysterophorus (Fig. 6T)	r	gb	hb	pb	1	lc	cn	ob	et	1	hyp	al	smp	hb	sca	1	0	o-tri	cn	ac	et	3	cam	r	pb
Sonchus oleraceus (Fig. 6U)	r	gb	hb	gb	1	el	ob	r	et	1	hyp	al	smp	hb	gb	1	0	s-orb	ob	mun	se	3	scas	ind	gb
Synedrella nodiflora (Fig. 7A)	r	pap	hb	gb	1	el	ob	r	et	1	hyp	op	smp	hb	hs	1	0	o-lno	cn	ac	se	3	act	r	hs
Tridax procumbens (Fig. 7B)	r	hi	hb	pb	1	w-el	r	ret	et	1	hyp	op	smp	hb	hs	1	0	o-lc	an	ac	et	1	cam	r	pb

Xanthium strumarium (Fig. 7C)	r	hs	cor	hs	1	lc-lo	ob	ac	et	3	acr	al	smp	hb	hs	1	0	o	s.co	ob	i-se	3-5	act	r	hs
Youngia japonica (Fig. 7D)	r	gb	hb	gb	1	s-orb	an	sr	et	1	hyp	al	smp	hb	hs	1	0	b-el	b-cn	r	se	1	cam	r	hs
Spermacoce hispida (Fig. 7E)	r	pap	hb	gb	1	o-ol	cn	s-r	et	1	hyp	op	smp	hb	sca	1	1	lc	ob	ac	et	1	cam	4-a	hi
Calotropis gigantea (Fig. 7F)	r	m.pb	hb	m.pb	1	ol	cn	r	et	1	cam	op	smp	cor	pb	1	0	el	cn	sr	et	1	cam	r	pb
Datura innoxia (Fig. 7G)	r	pb	hb	m.pb	1	lc	cn	ac	et	1	hyp	al	smp	hb	pb	1	0	el	cn	ob	et	1	cam	r	pb
Datura metel (Fig. 7H)	r	pb	hb	pb	1	lc	ob	ac	et	1	hyp	al	smp	hb	pb	1	0	el	cn	ob	wv	1	cam	r	pb
Nicotiana plumbaginifolia (Fig. 7I)	r	m.pb	hb	pb	1	el	cn	ac	et	1	hyp	al	smp	hb	m.pb	1	0	o-el	cn	ac	et	1	cam	a	pb
Physalis minima (Fig. 7J)	r	gb	hb	pb	1	o	ob	ob	et	1	hyp	al	smp	hb	pb	1	0	o	r-sr	ob	et	1	cam	a	pb
Solanum americanum (Fig. 7K)	r	pb	hb	pb	1	lc	cn	ac	et	1	hyp	al	smp	hb	pb	1	0	o	un	ob	et	1	cam	a	pb
Solanum sisymbriifolium (Fig. 7L)	r	pb	hb	pb	1	ln-o	ob	ac	et	1	hyp	al	smp	hb	pb	1	0	o-pl	obq	ac	dn	1	cam	r	pb
Solanum viarum (Fig. 7M)	r	sp.pb	hb	pb	1	ln-o	cn	ac	et	1	hyp	al	smp	hb	hi	1	0	w-el	obq	ob	si-dn	1	cam	r	hi
Evolvulus nummularius (Fig. 7N)	r	gb	hb	gb	1	ol	ob	ret	et	1	cam	al	smp	hb	pb	1	0	el	sr	ret	et	1	cam	r	lan
Ipomoea eriocarpa (Fig. 7O)	fis	gb	hb	gb	1	bil	co	eme	et	5	act	al	smp	hb	stg	1	0	co	co	ac	et	5	cam	r	gb
Ipomoea pes-tigridis (Fig. 7P)	r	stg	hb	hs	1	bil	tr	lo-ob	et	5	act	al	smp	hb	dn-hs	1	0	pa-tri	co	ac	et	5	act	r	dn.hs
Ipomoea quamoclit (Fig. 7Q)	a	gb	hb	pb	1	bil	ren	lo-ac	et	4	acr	al	smp	hb	pbl	1	0	pis	tr	ac	etn	1	cam	a	pbl

Mecardonia procumbens (Fig. 7R)	r	gb	hb	gb	1	o	cn	ob	et	1	hyp	op	smp	hb	gb	1	0	b-o	b-cn	ob	et	1	cam	a	gb
Scoparia dulcis (Fig. 7S)	r	gb	hb	gb	1	el	ob	ac	et	1	hyp	op	smp	hb	gb	1	0	rh-o	cn	ac-ob	dn	1	cam	a	gb
Ruellia tuberosa (Fig. 7T)	r	pb	hb	gb	1	w.o	ob	ret	et	1	cam	op	smp	hb	gb	0	0	el-o	cn	sr	et	1	ecam	a	pb
Lantana camara (Fig. 7U)	r	hs	hb	gb	1	s-orb	ob	ret	et	1	hyp	op	smp	hb	hs	1	0	o	ob	ac	se	1	cas	r	hi
Hyptis suaveolens (Fig. 7V)	a	hi	hb	pb	1	w-o	tr	ret	et	1	cam	op	smp	hb	hi	1	0	o	r	ac	se	1	cam	a	hs

Abbreviations: HPT—Hypocotyl; PCD—Paracotyledons; FTL—First two leaves; FI—First internode; hb—herbaceous; gb—glabrous; pb—pubescent; str—strigose; dn-st—densely strigose; stg—strigulose; pbl—puberulent; st-ha—stellate hairy; sp.pb—sparsely pubescent; tom—tomentose; hi—hirsute; hs—hispid; sca—scabrous; m-pb—minutely pubescent; 0—absent; 1—present; o—ovate; wo—widely ovate; o-el—ovate-elliptic; w-el—widely elliptic; lin—linear; r—rounded; a—angular; sr—subrounded; rb-o—rhombic-ovate; obc—obcordate; ol-o-ov—oblong-ovate to obovate; orb—orbicular; ren—reniform; r-ren—rounded to reniform; b—broadly; b-o—broadly ovate; sr—sub-rounded; b-cn— broadly cuneate; ln-o—lance-ovate; n-el— narrowly elliptic; n-el— narrowly elliptic; s-orb—sub-orbicular; wo-co — widely ovate-cordate; ov—ovovate; n-rb—narrowly rhombic; el-sl.tri—elliptic–shallowly trilobed; bil—bilobed; o-tri—ovate–trilobed; o-pl—ovate–pinnately lobed; lf-ol—leaflets oblong; co—cordate; pa-tri—palmately trilobed; olv-o—oblance-ovate; oo—oblance-ovate; el-olc—elliptic–oblanceolate; ob-sr—obtuse-sub-rounded; lc—lanceolate; s-co—sub-cordate; el—elliptic; obl—oblate; ov—ovovate; oc—oblanceolate; cil—ciliate; ob-r —obtuse–rounded; ob—obtuse; ac—acute; sco—subcordate; ol—oblong; an—attenuate; n-ol—narrowly oblong; g-ha—glandular hairy; aur—auriculate; pap—papillate; cor—coriaceous; si-dn—sinutely dentate; tr—truncate; sb-tr—sub-truncate; i-se—irregularly serrate; re—retuse; muc—mucronulate; cre—crenate; se—serrate; eme—emerginate; n.p—not prominent; co—coriaceous; sp-pb—sparsely pubescent; d-se—distantly serrate; ret—retuse; lan—lanate; un—unequal; dn—dentate; fis—fistulose; ind—indistinguishable; cn—cuneate; et—entire; se—serrate; mun—mucronulate; dnt—denticulate; n-cn—narrowly cuneate; su—serrulate; pis—pinnatisect; an—attenuate; n.cn—narrowly cuneate; hyp—hyphodromous; cam—camptodromous; act—actinodromous; cas—caspedodromous; scas—semicraspedodomous; ecam—eucamtodrompus se-cas—ssemicraspedodromous; wv—weavy; f—fistulose; sp—spinecent; prl—parallel; smp—simple; cmp—compound; al—alternate; op—opposite; obq—oblique

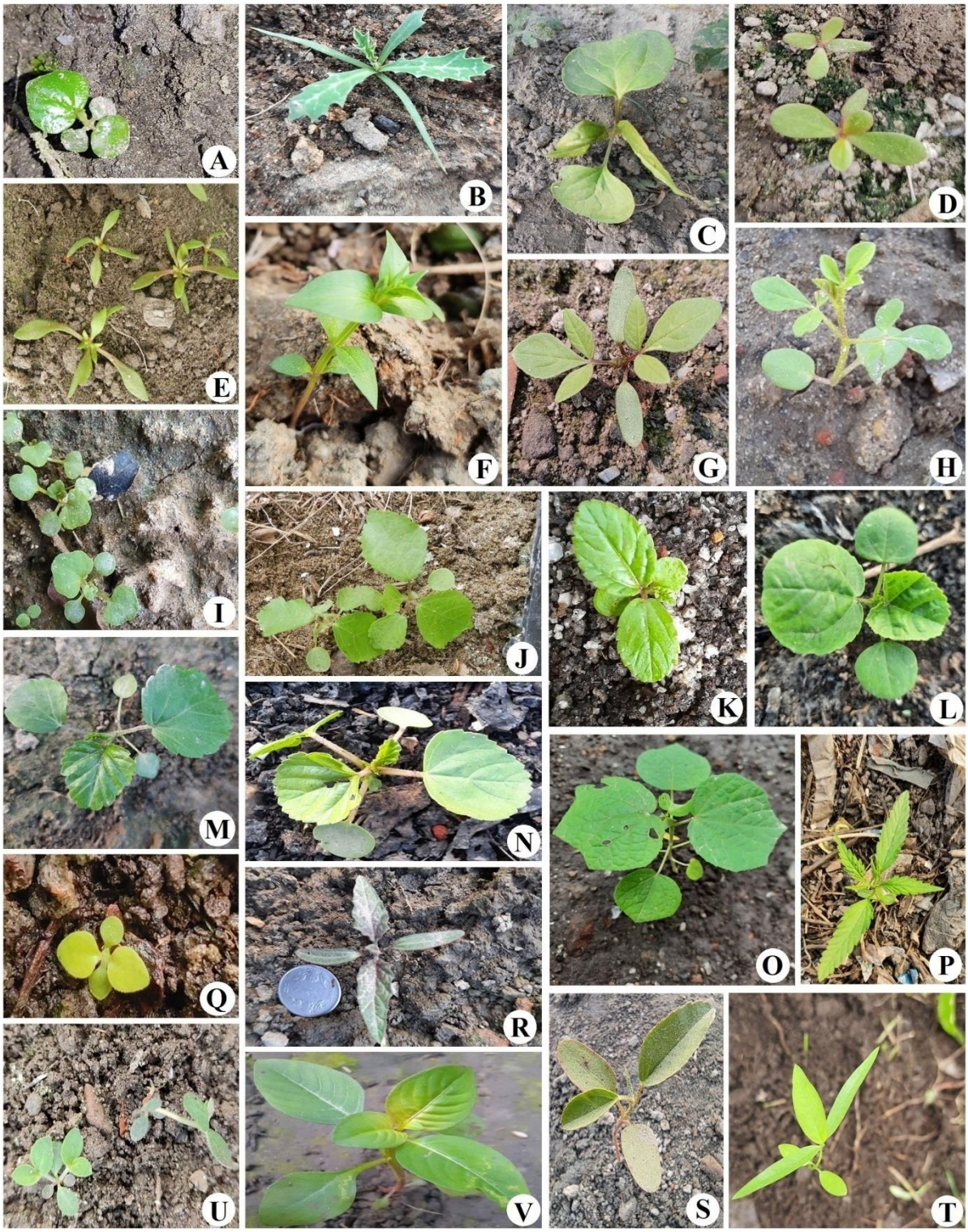

Figure 5. A. *Peperomia pellucida*; **B.** *Argemone mexicana*; C**.** *Mirabilis jalapa*; **D.** *Portulaca oleracea*; **E.** *Alternanthera paronychioides*; **F.** *Lysimachia arvensis*; **G.** *Cleome rutidosperma*; **H.** *C. viscosa*; **I.** *Cardamine hirsuta*; **J.** *Triumfetta rhomboidea*; **K.** *Corchorus aestuans*; **L.** *Malachra capitata;* **M.** *Malvastrum coromandelianum*; **N.** *Melochia corchorifolia*; **O.** *Urena lobata*; **P.** *Cannabis sativa*; **Q.** *Pilea microphylla*; **R.** *Chrozophora rottleri*; **S.** *Croton bonplandianus*; **T.** *Euphorbia heterophylla*; **U.** *E. hirta*; **V.** *Ludwigia octovalvis*

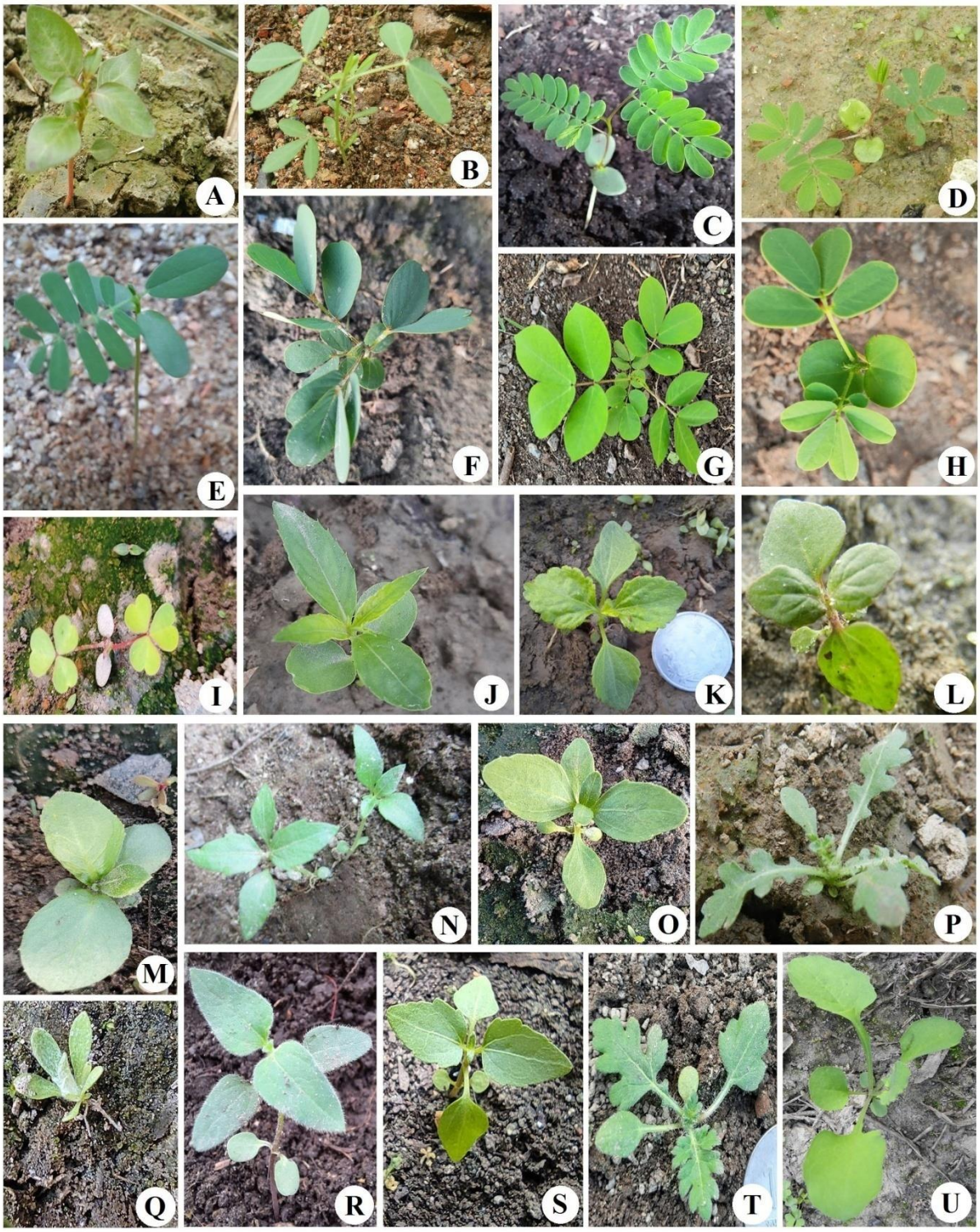

Figure 6. A. *Ludwigia perennis*; **B.** *Crotalaria pallida*; **C.** *Leucaena leucocephala*; **D.** *Mimosa pudica*; **E.** *Sesbania aculeata*; **F.** *Senna alata*; **G.** *S. occidentalis*; **H.** *S. tora*; **I.** *Oxalis corniculata*; **J.** *Impatiens balsamina*; **K.** *Ageratum conyzoides*; **L.** *Ageratum houstonianum*; **M.** *Blumea lacera*; **N.** *Chromolaena odorata*; **O.** *Eclipta prostrata*; **P.** *Grangea maderaspatana*; **Q.** *Gnaphalium polycaulon*; **R.** *Lagascea mollis*; **S.** *Mikania micrantha*; **T.** *Parthenium hysterophorus*; **U.** *Sonchus oleraceus*

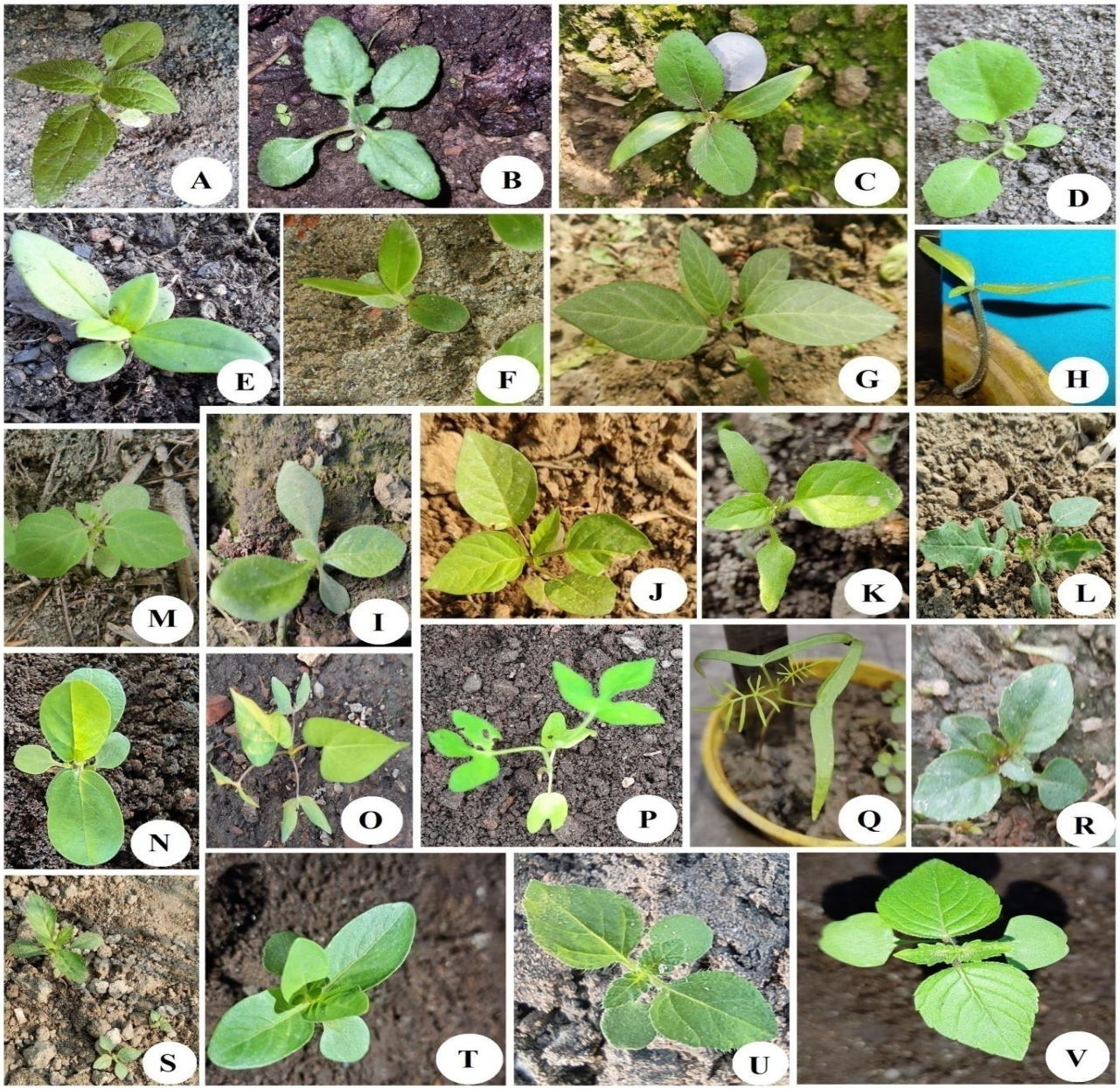

Figure 7. A. *Synedrella nodiflora*; **B.** *Tridax procumbens*; **C.** *Xanthium strumarium*; **D.** *Youngia japonica*; **E.** *Spermacoce hispida*; **F.** *Calotropis gigantea*; **G.** *Datura innoxia*; **H.** *Datura metel*; **I.** *Nicotiana plumbaginifolia*; **J.** *Physalis minima*; **K.** *Solanum americanum*; **L.** *S. sisymbriifolium*; **M.** *S. viarum*; **N.** *Evolvulus nummularius*; **O.** *Ipomoea eriocarpa*; **P.** *Ipomoea pes-tigridis*; **Q.** *Ipomoea quamoclit*; **R.** *Mecardonia procumbens*; **S.** *Scoparia dulcis*; **T.** *Ruellia tuberosa*; **U.** *Lantana camara*; **V.** *Hyptis suaveolens*

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