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RESEARCH ARTICLE

Morpho-Taxonomic Approaches of Indian Date (*Tamarindus indica* L.) Seedling - A Multipurpose Tree

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Abstract

The aims of the present study are to characterize seedling taxonomy and morphology, and seed germination process in *Tamarindus indica*. Seed germination was Sloanea type. The development of seedlings are recorded for 23 days up to 5th leaf stage. Hypoctyl and epicotyl are angular and terete in cross section respectively and epicotyl with zig-zag growth pattern. Paracotyledons are opposite, phanerocotylar, isocotylar, fleshy and persist up to 4th to 5th leaf stages. First leaf was opposite but second and subsequent leaves were alternate. Date of sowing, Date of germination, Date of appearance of Paracotyledons and different leaves, Total Observation Period, and Root : Shoot length ratio (RS value) have also been recorded. Results are found useful for the identification and differentiation of *Tamarindus indiaca* L. at seedling stage.

Introduction

Tamarindus L. is a monotypic, diploid (2n=24), hermaphrodite, out crossing genus of the family Fabaceae (subfamily Caesalpinoideae, tribe Amherstiaeae) (Nyadoi et al., 2010). It is thought that Linnaeus gave the specific epithet *indicus* because the name Tamarind itself was derived from Arabic which combined *Tamar* meaning 'date' with *Hindi* meaning 'of India'. The full Arabic name was *Tamar-u'l-Hind* and the word date included because of the brown appearance of tamarind pulp.

The geographical distribution of Tamarind has been documented about 16 years back (Salim et al., 1998). In 16th century, *Tamarindus indica* L. was introduced to Mexico and South America and to the tropics in recent years. The capital of Senegal, Dakar, was named after the local word Dakar for Tamarind. *T. indica* is found in semiarid areas of tropics up to 1500 m above sea level where annual rainfall is more than 1500 mm and can grow well on poor soil especially in degraded areas (Azad et al., 2014).

The fruit, wood and other products, shade and soil fertility enhancement services of *Tamarindus indica* L. are utilized worldwide and exported in countries like India and Thailand (El-Siddig et al., 2006). The most important product of *T. indica* is the pulp of the fruit, and this species is well accepted for its soft, juicy, appetizing, tasty, delicious fruit because of its brown, sticky, sour-sweet pulp, generally used as an ingredient in curries, chutneys, preserves, pickles, sherbets, and beverages in a variety of dishes and drinks in household as well as in confectionery. Its fruits and seeds are also processed for non-food uses. The fruits of this species contain high levels of protein, carbohydrate, minerals (potassium, phosphorus, and calcium), and iron with low amount of water content. Tamarind is also documented as a fodder species. The seeds and the leaves can be used for the nourishment of household animal. The leaves, bark, seeds, and roots of tamarind are also documented as a source of allelopathic substance for the weed crops. The roots of tamarind have allele-chemical capability and, thus, contribute significantly to a weed free environment around the tamarind tree. By the application of powder of leaves, barks, and seeds of this species to the agricultural field, farmer can reduce nutrient and water competition to the plants. *T. indica* can play an important role in mitigating the fuel wood crisis as it has high calorific value. It also plays roles in erosion control through cultivating in degraded land. Home gardeners and tree planters in some parts of tropics and subtropics have already planted this species and have proved as a successful tree species because of its growth and specially its ability to thrive in poor soil. As an attractive, valuable, and useful tree, this species can be considered for massive plantation because of potential nitrogen fixation ability, tolerance to infertile, acid, alkaline, saline, or seasonally waterlogged soil. It is very much imperative to introduce this species in homestead and in fallow lands to overcome scarcity of timber and fuel wood. *T. indica* can be an alternative to meet the requirements of fuel wood, poles, and timber (Azad et al., 2014). This multipurpose tree is important for sustainable development of wasteland due to its hardy nature and adaptability to various agroclimatic conditions and is widely grown as a subsistence crop for meeting local demands.

The medicinal value of Tamarind is mentioned in traditional Sanskrit literature. The laxative properties of the pulp and the diuretic properties of the leaf sap have been confirmed by modern medical science (Bueso, 1980). Tamarind fruits were well known in Europe for their medicinal properties, having been introduced by Arab traders from India (Rama Rao, 1975). Several medicinal properties are claimed for preparations containing tamarind pulp, leaves, flowers, bark and roots (Bueso, 1980; Rimbau et al., 1999). Medicinal value of Tamarind is also found to reduce fever and to cure intestinal ailments. It is used as a popular ingredient of cardiac and blood sugar reducing medicines. Anti-fungal, Anti-inflammatory, Anti-microbial, Anti-oxidant, and Anti-snake venom properties have been documented in many research reports. It is also found useful against scurvy (Azad et al., 2014).

In fact Tamarind trees appear to grow unattended in backyards, roadsides or on wastelands and hence it did not become a priority for focused development by governments. Tamarind remains underexploited even though its potential is widely recognised; it will remain so if traditional practices continue to result in poor tree management due to lack of skills in pruning, harvesting and processing of products (El-Siddig et al., 2006).

Traditional knowledge of vegetative and floral organs are found insufficient to resolve taxonomic and phylogenetic problems of the family Fabaceae. Thus, it is necessary to study seedlings not only for taxonomic, phylogenetic and ecological purposes, but also as contributions to the systematic knowledge. The identification of plants in the juvenile stage contributes to a better understanding of the biology of species, extends the taxonomic studies and assists in ecological survey work (Salles, 1987). The recognition of plants from seedlings is a task that is hardly completed, since the external characters in early development stages may be different from those observed in adults or plant species and allied genera. Typically, individuals of this stage have similarities that hinder their identification. The study of seedlings and plants is essential for obtaining data relevant to studies of natural regeneration (Pinheiro et al., 1989).The morpho-taxonomic observations on seedlings may be useful in recognition and management at early stages of the species concerned.

The objectives of this study are to highlight morph-taxonomic approaches of *Tamarindus indica* L. seedlings.

1 Materials and Method

Seeds of *Tamarindus indica* L. were collected from trees growing wild in Varanasi district (25^0 10′ - 25^0 37′ N & 82^0 11′ – 83^0 1′ E), Uttar Pradesh, India and sown in garden soil in upward direction of hilum, 1 cm below soil surface, during September, 2014, in the Botanic Garden of the Department of Botany, Udai Pratap College (Autonomous), Varanasi, India. The average maximum and minimum temperature during observation period were 35.5^0 C ± 1.0 and 26.5^0 C ± 1.0 respectively. The different stages of seedling development were considered up to 5^{th} leaf stage for complete description of seedlings, out of ten individuals. The seedlings were photographed at different leaf stages and documented in the form of herbarium sheets, which have been deposited in the Herbarium (28. 09. 2014, AKS 087), Department of Botany, Udai Pratap College (Autonomous), Varanasi, India. The methods and the terms employed are according to Vogel (1980) and Singh (2015). Stereomicroscope (Olympus-Magnus-MSZ Bi) is used for observation and measurements were made by digital Calliper with 0.05 mm accuracy. Root : Shoot length ratio (RS value) at different leaf stages (Table-1) and Date of sowing, Date of germination, Date of appearance of paracotyledons and different leaves and Total Observation Period (Table-2) up to 5^{th} leaf stage were also recorded.

2 Results

Tamarindus indica L. Sp. Pl. 34. 1753; Baker in Hook. f. Fl. Brit. India 2: 273. 1878.

Seedling morphology (Fig. 1, Fig. 2):

Seedling Sloanea type (in the sense of Vogel, 1980). The embryonic axle is axial and is inserted into cotyledons with 6 to 9 pairs of small leaflets (Fig. 2B). Primary root non-fibrous, tap root, less branched, less developed than shoot, rusty brown, warty and scabrous, terete in cross section with distinct circular root scars, 6.3 cm long at paracotyledon stage, and 6.7, 7.1, 8.0, 11.0, and 13.0 cm long at 1^{st}, 2^{nd}, 3^{rd}, 4^{th}, and at 5^{th} leaf stages respectively; secondary roots thin, short, tender, cylindrical and of same colour of primary root. (Fig. 1C, Fig. $D_{1,}$ Fig. 2A, Fig. 2C). Collet distinct, white, glabrous and slightly swollen (Fig. 1E, Fig. 2C). Hypocotyl light green below and green above in early stage, pubescent; hairs unicellular, base broad, apex acute, < 0.1 cm long (Fig. 1K); angular in cross section, 3.0 cm long at paracotyledon stage, and 8.0 cm long at 1^{st}, 2^{nd}, 3^{rd}, 4^{th}, and at 5^{th} leaf stages (Fig. 1F, Fig. 2D). Paracotyledons two, opposite, phanerocotylar, isocotylar, fleshy, persistant up to 4^{th} or 5^{th} leaf stage, exstipulate and sessile. Blade ovate, 1.7 x 1.1 cm, mean length : width ratio (L/W) 1.6, plano-convex in cross section, base truncate-rounded, apex obtuse, margins entire, both surface green and glabrous. Venation not distinct (Fig. 1A, Fig. 1I, Fig. 2A, Fig. 2B). Epicotyl green, villose; hairs as on hypocotyl (Fig. 1K) but 0.15 cm long; terete in cross section, 4.2, 5.0, 7.4, 9.0, and 10.3 cm long at 1^{st}, 2^{nd}, 3^{rd}, 4^{th}, and at 5^{th} leaf stages respectively (Fig. 1C, Fig. 1G). Internodes (at 5^{th} leaf stage): First one 5.0, second one 2.0, third one 1.5, fourth one 1.0 and fifth one 0.7 cm long and zig-zag (Fig. 2D). First leaves two, opposite, compound, peripinnate, stipulate and petiolate. Stipules 2, free lateral, obovate, 1.1 x 0.5 cm, mean L/W 2.2, base truncate, apex obtuse, margins entire, both surface green and hairy; hairs as on epicotyl (Fig. 1H). Petiole green, villose; hairs as on epicotyl; terete and channeled in cross section, 0.5 cm long. Rachis same as petiole and prolonged into mucro. Leaflets many, opposite, simple, exstipelate and sessile. Blade oblong, 0.9-1.8 x 0.4-0.7 cm, mean L/W 2.5, base oblique-rounded, apex obtuse-mucronate, margins entire**,** both surface green and sparsely hairy; hairs as on epicotyl. Venation brochidodromous; unicostate reticulate, single primary vein distinct, reaches to blade apex, 10 secondary veins distinct, 5 on each side of primary vein, looped at margins. Second and subsequent leaves alternate, other features same as that of first leaves.

Leaflets show nyctitropic movement.

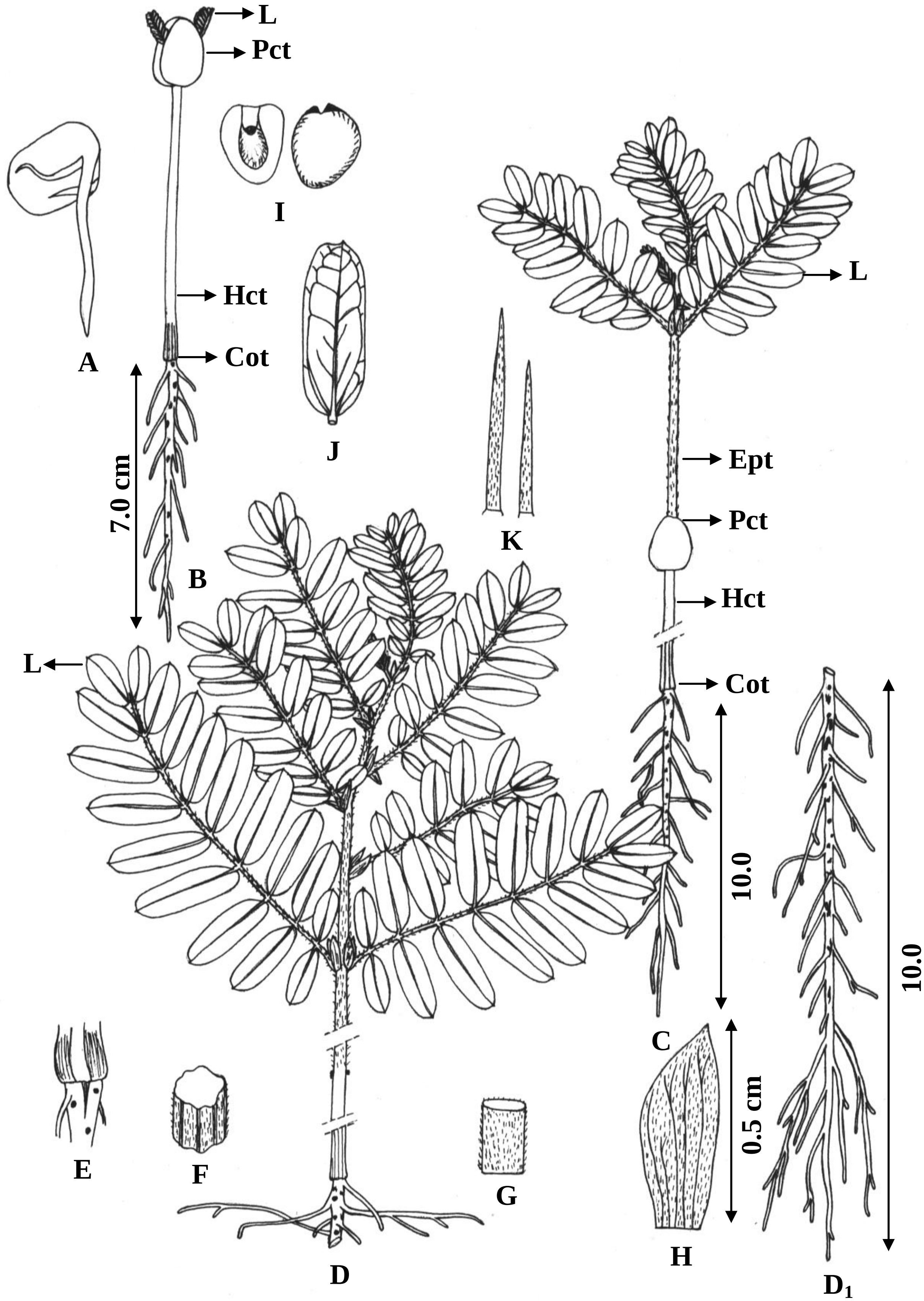
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Figure 1: *Tamirindus indica*-Seedling and its parts (A-L) : **A.** Germinating seed; **B.** First leaf stage; **C.** Third leaf stage; **D.** Sixth leaf stage; **D_1.** Part of root; **E.** Collet; **F.** Part of hypocotyl; **G.** Part of epicotyl; **H.** Stipule; **I.** Paracotyledons (adaxial and abaxial view); **J.** Single leaflet; **K.** Hairs; **Cot.** Collet; **Pct.** Paracotyledon; **Ept.** Epicotyl; **Hct.** Hypocotyl; **L.** First leaf.

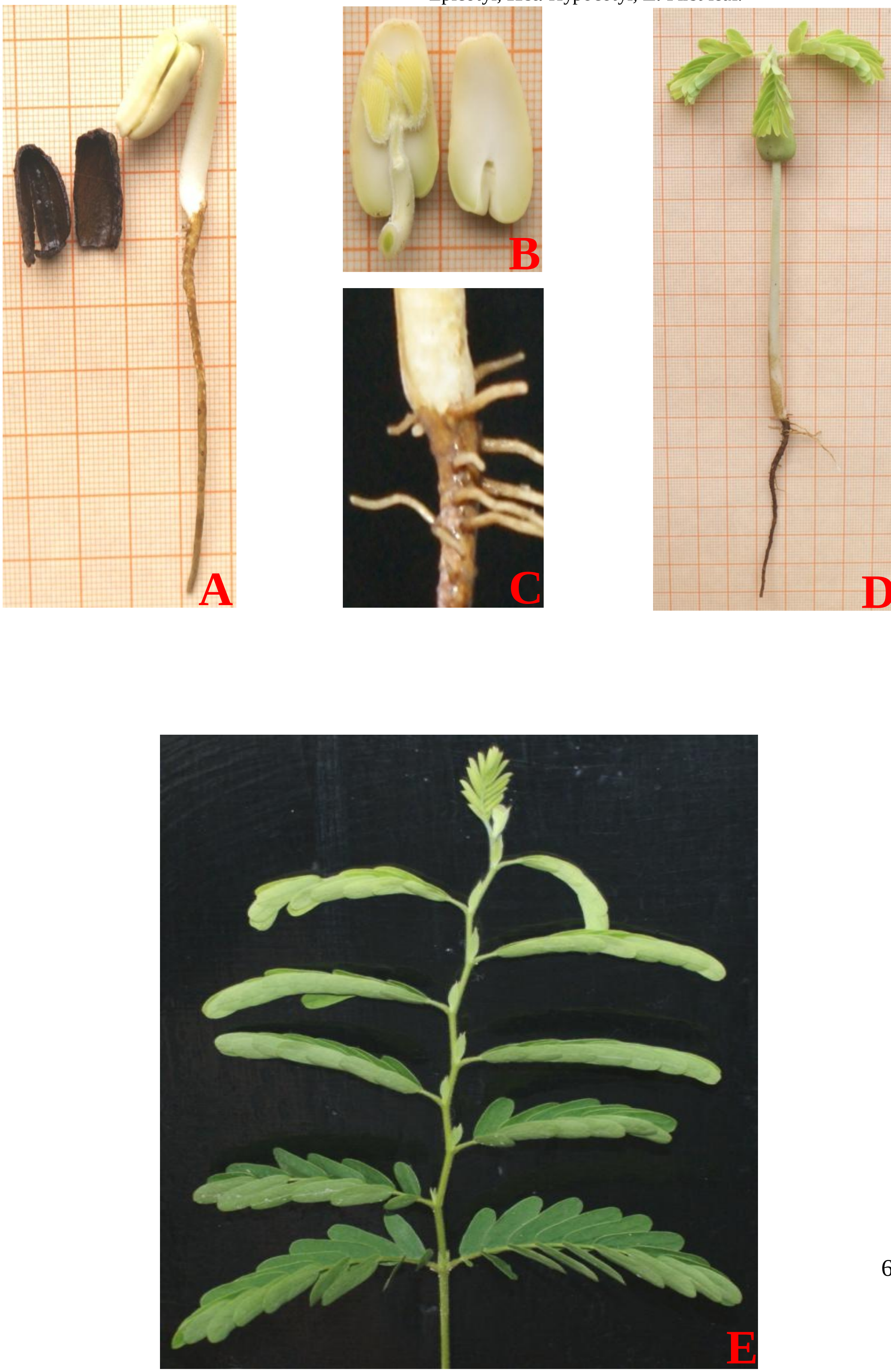

Figure 2: Seedling of *Tamarindus indica* and its parts: **A.** Seedling just after seed germination showing looped hypocotyl, exposed paracotyledons with detached seed coat and primary root; **B.** Paracotyledons with adaxial and abaxial views and protophylls; **C.** Enlarged Collet, primary and secondary roots; **D.** Seedling at third leaf stage; **E.** Seedling leaves up to 11th leaf stage.

Table 1: Root, Hypocotyl, Epicotyl length and RS values of the seedling of *Tamarindus indica* at Paracotyledon and at different leaf stages.

Sr. No.	Stage	Root (cm)	Hypocotyl (cm)	Epicotyl (cm)	RS values
1.	Paracotyledon	6.3	3.0	-	1 : 0.476
2.	First leaf	6.7	8.0	4.2	1 : 1.820
3.	Second leaf	7.1	8.0	5.0	1 : 1.830
4.	Third leaf	8.0	8.0	7.4	1 : 1.925
5.	Fourth leaf	11.0	8.0	9.0	1 : 1.545
6.	Fifth leaf	13.0	8.0	10.3	1 : 1.407

-Values are mean of ten replicates

Table 2: Date of sowing **(DS)**, Date of germination **(DG)**, Date of appearance of Paracotyledons **(Pct)**, Date of appearance of different leaves **(DAL)** and Total Observation Period **(TOP)**.

DS	DG	Pct	DAL					TOP
			1st leaf	2nd leaf	3rd leaf	4th leaf	5th leaf	23 days
08.07.2014	18.07.2014	21.07.2014	21.07.2014	23.07.2014	25.07.2014	27.07.2014	30.07.2014	

3 Discussion

The *Tamarind* seeds show epigeal germination, and seed coat adheres to the paracotyledons in the initial phase of germination. With rehydration of the seed, increase of its volume takes place. The paracotyledons of yellowish white colouring are exposed, and the root protrusion occurs near the hilum, on the eleventh day after sowing (Table-2). The radicle has yellowish white colour. The radicle swells and emerges from one end of the seed and descends rapidly. The hypocotyl looped in early stage of germination and straight later with yellowish white colouring, raises the cotyledons and shoot apex above the ground surface towards the light. The testa falls to the ground when the cotyledons expand. The plumule, a more or less developed bud, in which an internode and two juvenile leaves can be distinguished, is already present in the seed. During germination it develops after the first rest without a pause and forms a more or less long first internode, with two fully developed leaves (Fig. 1A, Fig. 1C, Fig. 2D). Further development is by growth of the terminal bud, which produces internodes and leaves. The cotyledons are then shed. In this newly formed stem the leaves are arranged in spiral, unlike first leaves which are opposite (Fig. 1D, Fig. 2E). Seedlings grow rapidly in the early stages and produce a long tap root (Fig. 1D$_1$).

The seedling of Tamarind represents Sloanea type in the sense of Vogel (1980). In Sloanea type seedlings the haustorial or food storing cotyledons become eventually exposed. During germination two resting periods occur: the first one with the cotyledons enclosed, the second one with the cotyledons exposed and the plumule developed in a first internode with two full-grown foliar leaves. The Sloanea subtype (2a) has the cotyledons borne above the soil on a long hypocotyl (evident in the present study), the Palaquium subtype (2b) has a short subterranean hypocotyl and the free cotyledons are borne at soil level.

After 13 or 14 days of sowing, the seed coat begins to detach the paracotyledons (Fig. 2A).

In addition to above observations, data pertaining to Root, Hypocotyl and Epicotyl length and RS values of the seedling of *Tamarindus indica* at Paracotyledon stage, and at different leaf stages, and date of sowing, date of germination, date of appearance of Paracotyledons and date of appearance of different leaves and total observation period have also been recorded (Table-1 and Table-2).

It is evident from Table-1 that root length almost twice than the shoot length with RS value 1 : 0.47 at paracotyledon stage, but at 5th leaf stage shoot was much longer than root with RS value 1 : 1.40. The hypocotyl length from 1st leaf stage to 5th leaf stage was same i.e. 8.0 cm (Table-1). The hypocotyl and epicotyl length was almost equal at 4th and 5th leaf stages.

Seeds germinated on 11th day and paracotyledons appear on 13th day after sowing. Seedling attained 5th leaf stage in 23 days. The gap between appearance of 1st and 5th leaf was 10 days (Table-2).

4 Conclusion

From observations of the present study it is evident that the seedlings of *T. indica* can be recognized on the basis some interesting morpho-taxonomic attributes viz. Rusty brown, warty, scabrous, terete tap root with distinct circular root scars and constant length 8.0 cm from 1st to 5th leaf stage; Collet distinct, white, glabrous and slightly swollen; Embryonic axle with small leaflets; Hypocotyl angular and pubiscent but Epicotyl terete and villose; First leaf opposite and subsequent leaves alternate, and show nyctitropic movement and Internodes zig-zag. The results justify the relevance, aims and objectives of the present study.

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