

**Monograph on**  
***Toona hexandra* (Wall.) M. Roem.**

**Prepared by:**  
**Dr. Monoranjan Chowdhury**  
**Head & Associate Professor**

**Research Scholars Contributed**  
**Dr. Sujit Mondal, RA**  
**Mr. Aaratik Pal, UGC NET-JRF**  
**Mr. Dipak Barman, UGC-NET**

**Taxonomy of Angiosperm & Biosystematics Laboratory,**  
**Department of Botany**

**University of North Bengal**

**Raja Rammohunpur – 734013**

**Darjeeling, West Bengal**

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**Directorate of Forest,**  
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**Siliguri – 734001, Darjeeling, WB**

**January 2022**

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**Date: 1<sup>st</sup> JANUARY, 2022**

**INTRODUCTION:**

*Toona hexandra* (Wall.) M. Roem. is a huge, gigantic semi-deciduous forested tree belong to the family Meliaceae and its native range of origin is extended from Asia to Australia (Fig. 1, 2). The genus *Toona* M. Roem. has only 6 accepted species and all are native to SE Asia to Australia. *Toona hexandra* (Wall.) M. Roem. is one of the most important indigenous species among other three (*Toona calantas* Merr. & Rolfe, *Toona sureni* (Bl.) Merr., and *Toona sinensis* (Juss.) M. Roem.) species of *Toona* grown in India. This tree species was first time scientifically described by Dr. Nathaniel Wolff Wallich, a Danish surgeon and botanist (worked under Danish East India Company later British East India Company) in 1824 as *Cedrela hexandra* Wall, in the book *Flora Indica* was written by William Roxburgh and edited by William Carey, D.D., to which was added descriptions of plants more recently discovered by Nathaniel Wolff Wallich, Serampore, West Bengal, India in page number 425 of volume II. Later on, the name was rejected due to lack of information and as it was not validly published and treat as invalid. Max Joseph Roemer (1791-1849) was German botanist who worked in Weimar city in the federal state of Thuringia, Central Germany, re-published the species as *Toona hexandra* (Wall.) M. Roem. in the book entitled '*Familiarum Naturalium Regni Vegetabilis... Vimarieae [Weimar]*' in page no. 139 of Volume I in the year of 1846. After critical investigation of morphological characters, Max Joseph Roemer had change the generic rank of the taxon and shifted it from *Cedrela* to newly described genera *Toona* based on the characteristic featured as better matched with present generic name. Various author published it as different in species rank or varietal rank from various parts of the world in different years due to some noticeable character variations. But after critical investigation it was decided that the *Toona hexandra* is correct name and rest 69 are the accepted synonyms (POWO, 2021) and it is one of the higher synonym bearing angiosperm species.

The round and scattered canopy and excellent wood quality of *Toona hexandra* have largely been introduced elsewhere as a shade tree and highly valued red timber and fast-growing aspect. The tree is nicely grown in subtropical climate and can also well adopted in moist localities of riverine, streams and even swamps sides. It is also noticed that the species is grows best in Fire-protected savannah, abandoned cultivation and in small gaps in forest whereas, does not prefer dry soil condition (Wagner et al., 1999). *Toona hexandra* (Wall.) M. Roem. is mostly grown for its versatile reddish-brown timber, which is quite popular for building houses, ships, boats, high-value furniture's, musical instruments, carvings etc. The seeds, leaves, and stems of *Toona hexandra* are widely used in traditional Chinese and Indian medicine system for the treatment of various ailments like diarrhoea, dysentery and

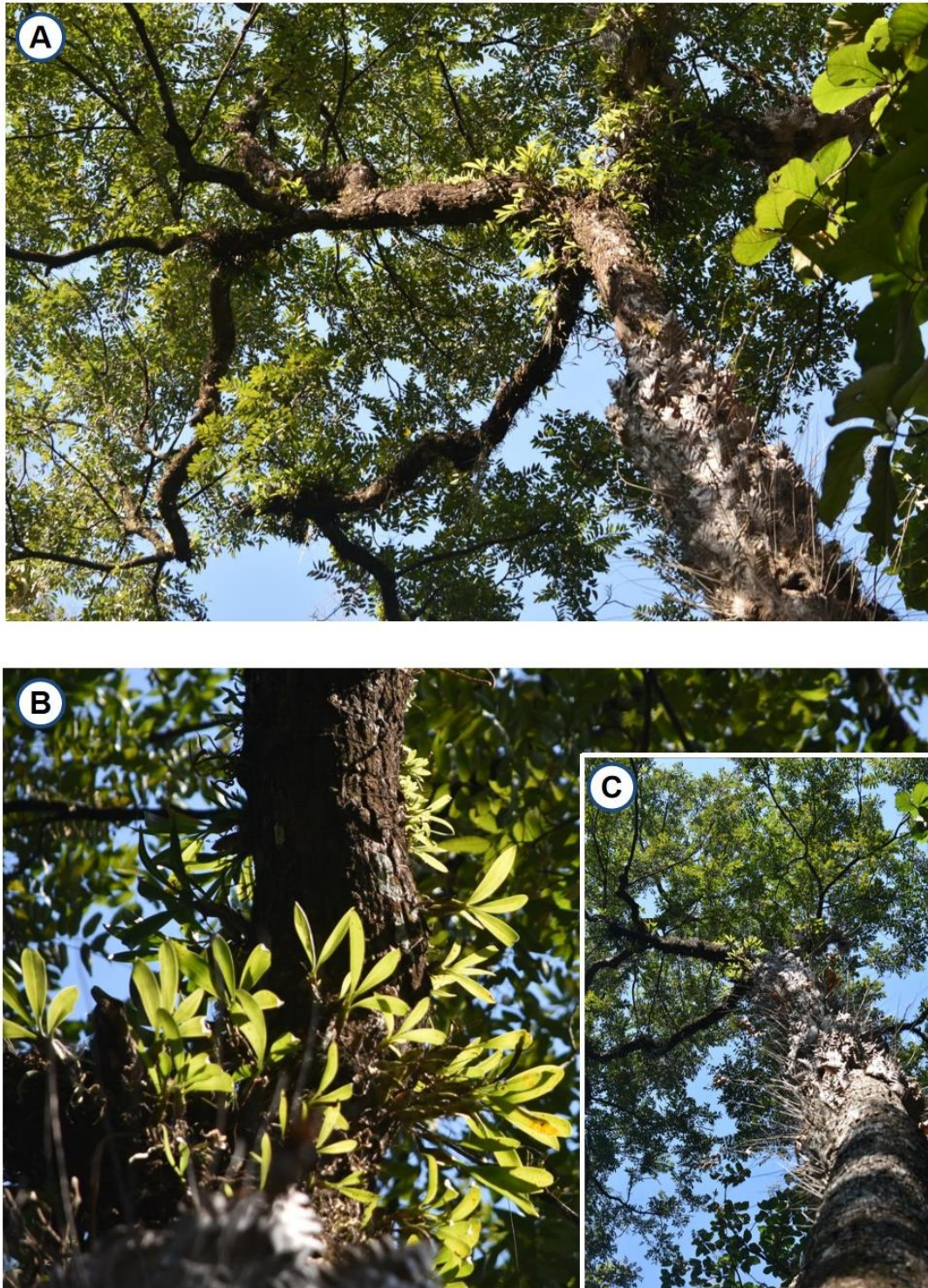


Fig. 1: *Toona hexandra* from Kalijhora, Darjeeling. A) Tree canopy from below, B) Epiphyte orchids on branches, C) *Drynaria sp.* inhabiting the tree trunk.

ringworm. Traditionally plants parts are also used to treat various ailments by many ethnic communities' lives in forested villages of terai, duars and Darjeeling Himalaya. The flowers are functionally unisexual but usually with well-formed vestiges of the opposite sex present. *T. hexandra* is reported to bear ripe fruit throughout the year. The samara types of seeds are released from the longitudinally ruptured capsules at an interval. Seeds are samara type with light weight and dispersed through wind to long distance seed dispersal.

## SCIENTIFIC CLASSIFICATION (APG IV, 2016)

Kingdom: Plantae

Clade: Tracheophytes

Clade: Angiosperms

Clade: Mesangiospermae

Clade: Eudicots

Clade: Rosids

Orders: Sapindales

Family: Meliaceae

Genus: *Toona*

Species: *T. hexandra*

## TAXONOMY

**Synonyms:** (69 Accepted; POWO, 2021)

*Toona ciliata* M.Roem., Fam. Nat. Syn. Monogr. 1: 139 (1846).

*Dracontomelon multijugum* Radlk. ex C.DC.

*Cedrela australis* Mudie

*Cedrela australis* F.Muell.

*Cedrela brevipetiolulata* Haines

*Cedrela febrifuga* Forsten  
*Cedrela hainesii* C.DC.  
*Cedrela hexandra* Wall.  
*Cedrela kingii* C.DC.  
*Cedrela mannii* C.DC.  
*Cedrela microcarpa* C.DC.  
*Cedrela mollis* Hand.-Mazz.  
*Cedrela multijuga* Kurz  
*Cedrelas errulata* Miq.  
*Cedrela teysmannii* Hassk.  
*Cedrela toona* Roxb. ex Rottler & Willd.  
*Cedrela toona* var. *australis* (Kuntze) C.DC.  
*Cedrela toona* var. *grandiflora* C.DC.  
*Cedrela toona* var. *parviflora* Benth.  
*Cedrela toona* var. *pubescens* Franch.  
*Cedrela toona* var. *vestita* C.T.White  
*Cedrela tuna* Oken  
*Cedrela velutina* DC.  
*Surenus australis* Kuntze  
*Surenus microcarpa* Kuntze  
*Surenus serrulata* (Miq.) Kuntze  
*Surenus teysmannii* (Hassk.) Kuntze  
*Surenus toona* (Roxb. ex Rottler & Willd.) Kuntze  
*Toona australis* (Kuntze) Harms  
*Toona ciliate* M.Roem.  
*Toona ciliata* var. *australis* (Kuntze) Bahadur  
*Toona ciliata* var. *brevipetiolum* (Haines) S.C.Mishra & Panigrahi  
*Toona ciliata* var. *hainesii* (C.DC.) Panigrahi & S.C.Mishra  
*Toona ciliata* var. *haslettii* (Haines) Bahadur  
*Toona ciliata* var. *hexandra* (Wall.) Bahadur  
*Toona ciliata* var. *kingii* (C.DC.) Bahadur  
*Toona ciliata* var. *latifolia* (C.DC.) Chandrab.  
*Toona ciliata* var. *listeri* (C.DC.) Bahadur  
*Toona ciliata* var. *mollis* (Hand.-Mazz.) Bahadur

*Toona ciliata* var. *multijuga* (Kurz) Panigrahi & S.C.Mishra  
*Toona ciliata* subsp. *nepalensis* (C.DC.) Panigrahi  
*Toona ciliata* var. *parviflora* (Benth.) Bahadur  
*Toona ciliata* var. *pilipetala* (C.DC.) N.C.Nair & Kumari  
*Toona ciliata* var. *pubescens* (Franch.) Hand.-Mazz.  
*Toona ciliata* var. *pubinervis* (C.DC.) Bahadur  
*Toona ciliata* var. *sublaxiflora* (C.DC.) C.Y.Wu  
*Toona ciliata* var. *vestita* (C.T.White) Bahadur  
*Toona ciliata* var. *yunnanensis* (C.DC.) C.Y.Wu  
*Toona hainesii* (C.DC.) Harms  
*Toona hexandra* var. *gamblei* (C.DC.) S.M.Almeida & M.R.Almeida  
*Toona hexandra* var. *griffithiana* (Pierre) S.M.Almeida & M.R.Almeida  
*Toona hexandra* var. *haslettii* (Haines) S.M.Almeida & M.R.Almeida  
*Toona hexandra* var. *kingii* (C.DC.) S.M.Almeida & M.R.Almeida  
*Toona hexandra* var. *listeri* (C.DC.) S.M.Almeida & M.R.Almeida  
*Toona hexandra* var. *mollis* (Hand.-Mazz.) S.M.Almeida & M.R.Almeida  
*Toona hexandra* var. *parviflora* (Benth.) S.M.Almeida & M.R.Almeida  
*Toona hexandra* var. *pubinervis* (C.DC.) S.M.Almeida & M.R.Almeida  
*Toona hexandra* subsp. *velutina* (DC.) S.M.Almeida & M.R.Almeida  
*Toona kingii* (C.DC.) Harms  
*Toona mannii* (C.DC.) Harms  
*Toona microcarpa* (C.DC.) Harms  
*Toona microcarpa* var. *pilipetala* (C.DC.) Bahadur  
*Toona mollis* (Hand.-Mazz.) A.Chev.  
*Toona serrulata* (Miq.) Harms  
*Toona sureni* var. *cochinchinensis* (Pierre) Bahadur  
*Toona sureni* var. *teysmannii* (Hassk.) Bahadur  
*Toona ternatensis* (Miq.) Bahadur

**Common Names:** Tun (*Bengali*); Indian Mahagony, Australian redcedar, Sandal neem(*English*), Pama, Poma, LalPoma (*Assamese*);Tairel (*Manipuri*);Kacchapah, Nandi (*Sanskrit*);Nandi, Nandik, Tun, Tunna (*Hindi*); Drab, Drawi, TUni (*Kashmiri*); GandaGarike, KempuGandagiri, Belamdi (*Kannada*); Akil, Aranamaram, Chuvannaakil, Devadaram, Ekana

(*Malayalam*); Nandurki, Tunna, Thunnam (*Marathi*); Mahalimbo (*Oriya*); Tunumaram, SanthanaVembu, TheraTharam (*Tamil*); Nandivrikshamu (*Telegu*); Nandi, Tunna (*Urdu*).

**Distribution:** The native range of distribution of *Toona hexandra* is reported from Eastern India, Southern China to Tropical Asian countries that includes Pakistan, North East India, Nepal, Bangladesh, China, Myanmar, Java, Laos, Malaysia, Philippines, Thailand, Vietnam and New Guinea (Fig. 2).

This species is also introduced in various countries for its good quality woods and canopy sizes. It was introduced in various countries of America (Hawaiian Islands), Africa and Asia (Afghanistan, Indo-Myanmar; cultivated in Sri Lanka,) and during the course of time in some parts of those countries it is naturalized. Due to good quality wood and canopy magnitude this species is highly popular as avenue tree, ornamental, fuel and experimental forestry and extensively planted and naturalized in different countries of Eastern Africa (Malawi), southern Africa, western Africa (Madagascar, Mauritius). It was recorded from Zambia and Zimbabwe as early as the beginning of the 20<sup>th</sup> century. The species has become extensively naturalized in various tropical climates of Asia and Australia.

*Toona hexandra* is also introduced in different other African and American counties like Cuba, Gulf of Guinea Island, Kenya, Kwa Zulu-Natal, Malawi, Uganda, Tanzania, Trinidad-Tobago, Maryland, Hawaii, Northern Provinces, Puerto Rico, St. Helena.

Indian territories especially eastern and North Eastern parts (Sub-Himalaya, Assam) are the native range of *Toona hexandra*. Apart from this it is commonly planted and naturally grown in tropical and sub-tropical climates of West Bengal, Sikkim, Assam, Meghalaya, Arunachal Pradesh, and Tripura of eastern India. It is also nicely grown in Northern India and Western Ghats of Southern India that includes the tropical climates of the states of Punjab, Himachal Pradesh, Utterakhand, Madhya Pradesh, Orissa, Maharashtra, Kerala and Kerala.



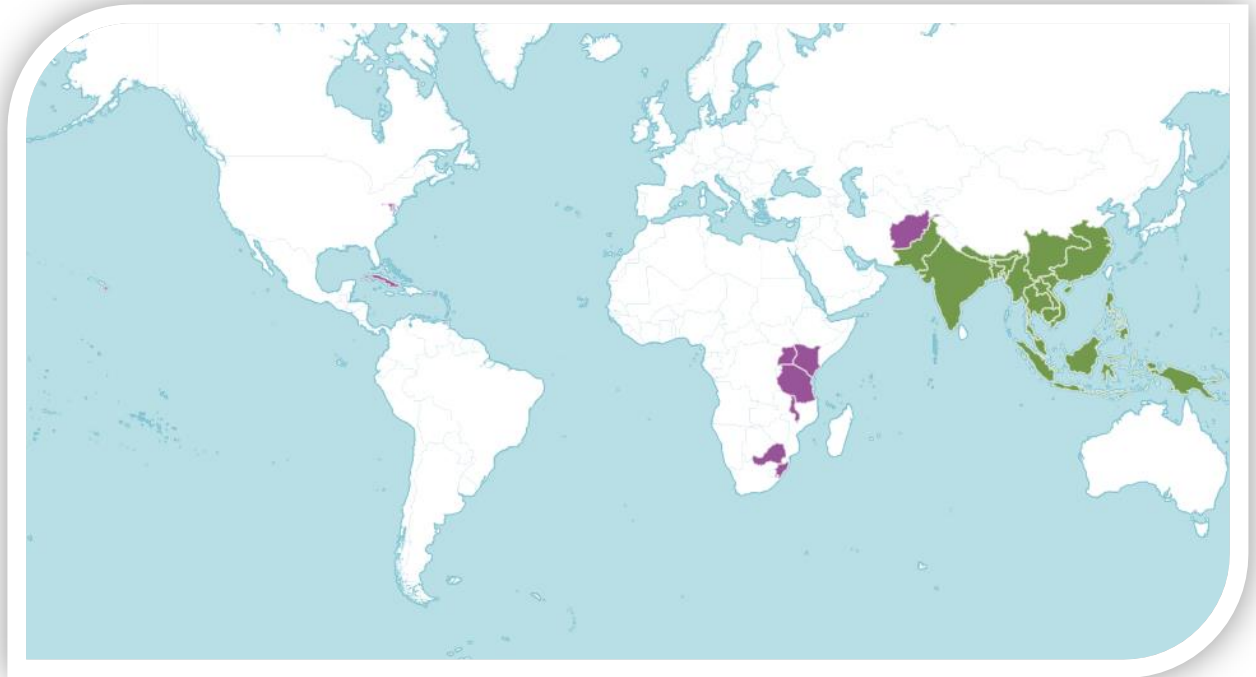


Fig 1: Distribution map of *Toona hexandra* (Green=Native Range & Violet=Introduced)  
[[www.powo.org](http://www.powo.org)]

**Biophysical Limits:** *Toona hexandra* is easily grown in tropical to sub-tropical climate with mean temperature 16-41°C with mean Mean annual rainfall 750-4000 mm. It is grown in plains and can found at an altitude upto 1150 m in Himalayas. For the better growth this species prefers well-drained, deep, fertile soils with or without humus, bhabar soil with small sand, humus and bolder of terai and duars are also found great environment for their luxurious growth.

**Habitats:** In the sub-Himalayan tract of India, *T. hexandra* is found mostly in moist areas, in sheltered ravines, along the small streams and even in swamp forest (Troup, 1921), whereas in the Western Ghats, it is quite common in wet evergreen forests and in scattered form found in moist deciduous forests (Rai, 1985).

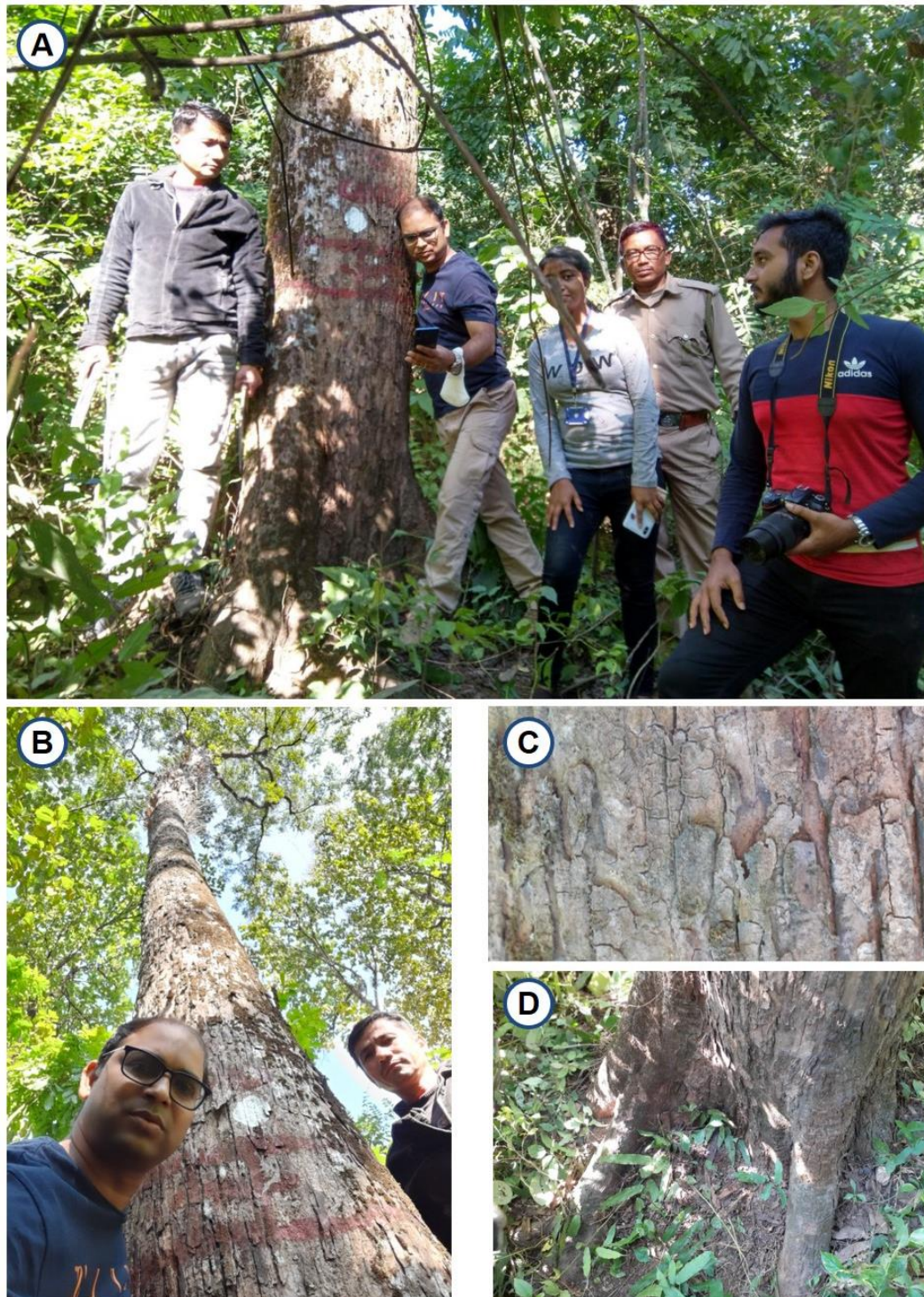
In India, the climate of the natural habitat comprises rainfall from 1100–4000 mm per year and temperatures range from about 0–35°C and can tolerate some frosts, but is somewhat sensitive to drought (Streets, 1962).

In China, it occurs at altitudes upto 1600 m, typically on open hillsides and more rarely in ravines and forested areas (Hua and Edmonds, 2008). In Australia, *T. Hexandra* is occurs from plains and upto the elevation to 1100 m where the annual rainfall of 1200–3800 mm is reported. The species is grown there in the tolerable mean maximum temperature of the hottest month is 26–31°C and the mean minimum of the coldest month 5–10°C (Boland et al., 2006). The individual of the this tree species are quite common and abundant in shady or open habitats of forests of terai and duars, hill slopes, valleys, ravines forests, thickets, of Himalayan and sub-Himalayan habitats upto 1150 meter. Population size and growth of individual tree are found quite significant.

### **Taxonomic Description:**

#### **Macroscopic Characters:**

**Habit:** Semi-deciduous, Medium to Large sized, gigantic trees, grows upto 30 m high. **Stem:** Main trunk 18-24 m tall, mostly straight, girth ranges 1.5 m-3.2 m d.b.h.. **Root** buttresses prominent in mature trees (upto 4.5 m); bark 12-15 mm thick, reddish, rough, exfoliating in large flakes, fibrous; blaze pink red with white streaks and strong smell; canopy mostly round, spreading, large, dense; sap-wood white, pink, or red, smelling strongly of cedar when cut. Twigs pilose to glabrescent, inconspicuously lenticellate with small lenticels. **Leaves:** Leaves paripinnate, alternate, clustered at the tips of branchlets, estipulate; rachis 13-90 cm long, slender, grooved above, glabrous, swollen at base; leaflets 12-30, opposite or subopposite, estipellate; petiolules 2-20 mm, slender, grooved above, glabrescent, rarely pilose to velutinous; petiolule 7-20 mm long; leaflet lamina 7-16 x 2-7 cm, ovate, ovate-lanceolate or oblong-lanceolate, base oblique, apex acuminate, margin entire or serrate, chartaceous, glossy above, pale beneath; lateral nerves 10-15 pairs, pinnate, slender, prominent, intercostae reticulate, faint. **Inflorescence:** Inflorescences to 55 cm, pendent; rachis pilose to pilose-villous with short to long spreading or appressed trichomes. **Flowers:** Flowers bisexual, 8 mm across, white, in terminal or axillary drooping panicles; peduncle to 2 cm; pedicel to 2 mm long; Pedicel 0.5-1 mm, usually pilose to occasionally villous. lobes imbricate; sepals spatulate, 0.7-1 × 0.6-1.3 mm, margins shortly ciliate. **Calyx** 0.7-1.3 mm, outside usually glabrescent, lobes 5, ovate, tomentose, margin ciliate; **Corolla** creamy white, 5, 5 x 3 mm, usually glabrescent, occasionally outside pilose, margin shortly ciliate, oblong, spreading, ciliate, imbricate; Androgynophore 3-5 mm; filaments 1.2-2.5 mm (male flowers), 0.7-1.8 mm (female flowers), glabrous to pilose/villous; anthers of male



**Fig. 3:** *Toona hexandra*. A) Stem diameter, B) Stem height, C) Portion of the stem-bark, D) Root along with the herb association.



**Fig. 4:** *Toona hexandra* in NBU campus, Darjeeling. A) Compound leaves, B) Stem showing red-wood, C) Diameter of the trunk, D) Single compound leaf, E) *Pholidota sp.* growing on stem.

flowers 0.6-1.1 × 0.4-0.9 mm, apex usually apiculate, appendage long; antherodes of female flowers usually sagittate, 0.5-0.9 × 0.3-0.6 mm, often with a long apiculate appendage. Disk reddish orange, 1.2-2.5 mm in diam., densely pilose. Ovary 1.2-1.8 mm in diam., ovary superior, moderately pilose, ovules 8-12 per cell, pendulous; style 1.2-3 × 0.2-0.4 mm (male), 0.3-1.5 × 0.3-0.5 mm (female), glabrous; style head 0.7-1.3 mm in diam. Fruits: Capsule 1.5-2.25 cm; columella 1.5-2 × 0.5-0.7 cm, concave with apical scarring; valves reddish brown, smooth to lenticellate with 0.1-0.5 mm in diam. scattered lenticels. Seeds: Seeds many, oblong, 1.1-2 cm × 2.5-4 mm, winged at both ends; wings unequal, apex narrowly obtuse; seed body 5-7 × 1.2-3 mm. (Fig. 3 & 4)

### Microscopic Characters:

**Stem:** Stem terete, pubescent, and covered with about 2 mm greyish hairs.

**Petiole:** Petiole is pubescent and densely covered with straight, upright, uniseriate, nodulus, non – glandular, whitish hairs, 0.5 – 1 mm in length.

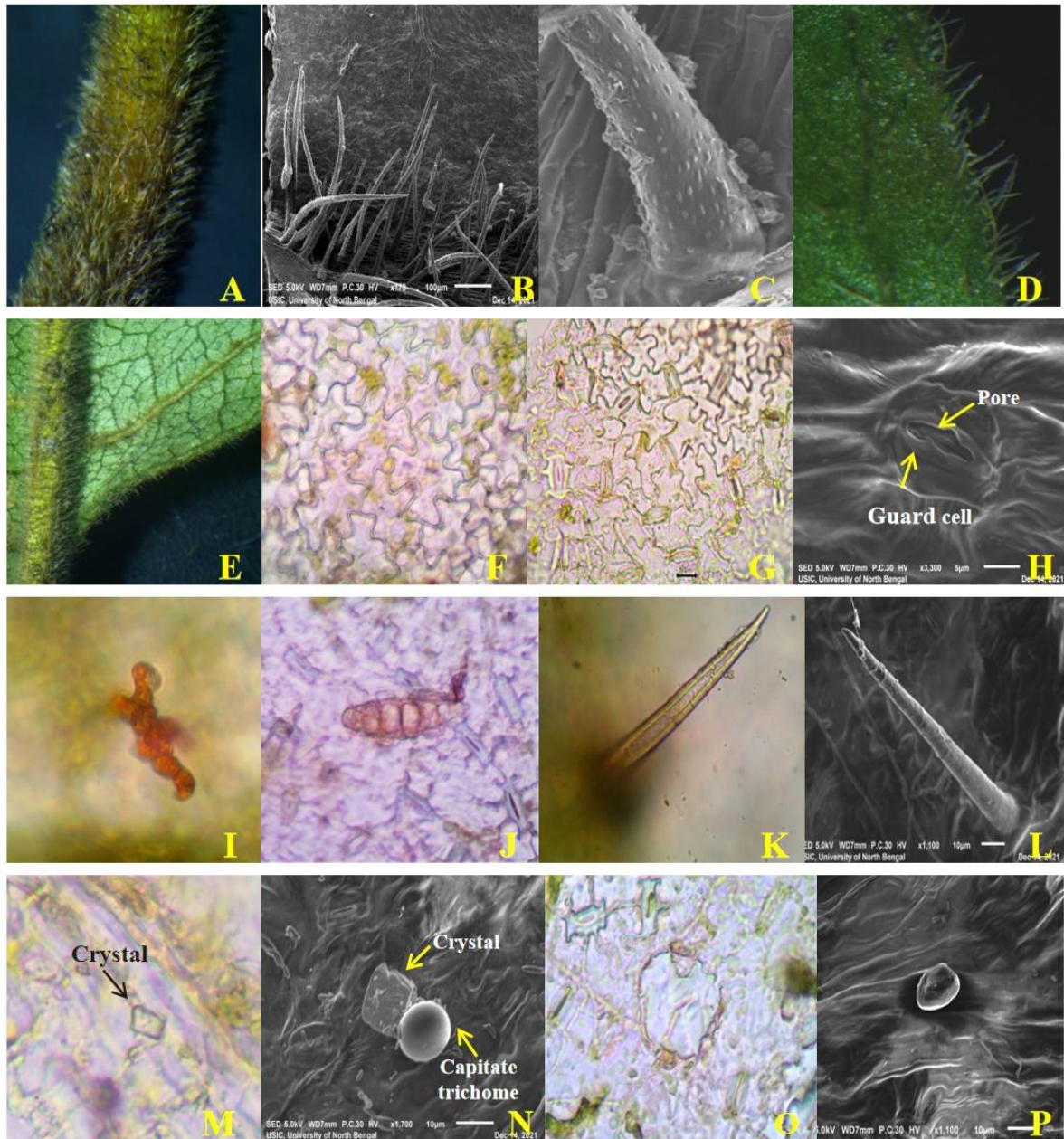
**Leaf:** Leaflets are pubescent in both surfaces. Greenish white hairs are present throughout lamina margin, mid vein and lateral vein areas. Epidermal cells are undulate with sinuous pattern. Both glandular and non-glandular trichomes are present in *T. hexandra*. Non glandular trichomes are 30 – 90 µm in length, uniseriate, multicellular type. Glandular hairs are peltate, capitate types. Leaflets are amphistomatic. Stomata are anomocytic type. Stomatal frequency ranges and stomatal index. Stomatal pore size are  $3.55 \pm 1.07$  mm<sup>2</sup>, Guard cell kidney shaped, length  $14.46 \pm 1.65$  mm, Breadth  $3.03 \pm 0.74$  mm. Stomatal frequency (SF) 5883.3 mm<sup>2</sup>, stomatal index (SI) 24.40.

Epidermal cell patterns of both surfaces are irregular and sinuous. During LM and SEM study, few prismatic crystals are found in abaxial surface. Crystal length is 5 – 11 µm and breadth 4 – 8 µm. (Fig: 5)

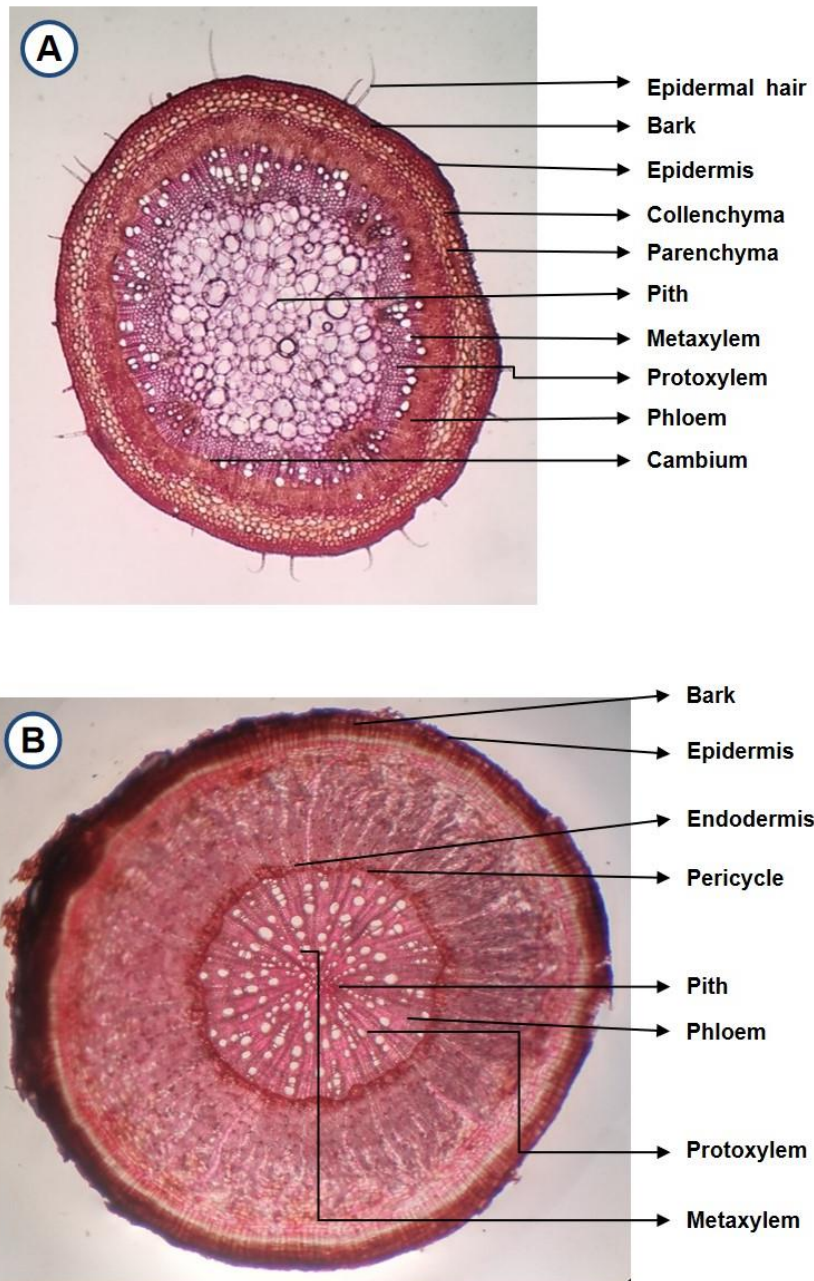
### Anatomy:

**Root: Epiblema or Epidermis:** It is the outermost single layer with several unicellular root hairs. It consists of thin walled, compactly arranged living parenchymatous cells. Epiblema is characterised by absence of stomata and cuticle. It provides protection to the roots due to presence of unicellular root hairs it also helps in absorption of water and minerals from soil.

**Cortex:** It is thin walled, multilayered region made from parenchymatous cells with usually intercellular spaces. The cortex is responsible for transportation of *water and salts* from the root hairs to the centre of the root. **Endodermis:** It is the innermost layer of cortex and covers



**Fig. 5:** *Toona hexandra*, leaf (D-M) and petiole (A-C) ultra-morphology. A) LM image of petiole trichome, B) SEM image of petiole trichome, C) a single petiole trichome, D) marginal hairs, E) abaxial hairs of midrib and lateral veins, F) sinuous epidermal cell pattern, G) LM image of stomata, H) SEM image of stomata, I) & J) glandular multicellular trichome of adaxial surface, K) & L) LM and SEM of non-glandular, uniseriate, multicellular trichome, M) LM image of crystal, N) SEM image of crystal and capitate trichome, O) LM of glandular, peltate trichome, & P) SEM of glandular, peltate trichome.



**Fig. 6:** *Toona hexandra*. A) T.S. of the stem, & B) T.S. of the root.

the stele. It composed of barrel shaped parenchymatous cells. These cells allow radial diffusion of water and minerals through the endodermis. **Pericycle:** It is the outermost layer of stele and composed of uniseriate layer of parenchymatous cells and it produces secondary cambium or phellogens. **Vascular bundles:** Several vascular bundle arranged in ring. Xylem and phloem bundles are separated from each other by parenchymatous cells. Xylem is exarch i.e. protoxylem towards the periphery and metaxylem towards the centre. Phloem forms oval masses beneath the pericycle, alternating with xylem bundles. **Pith:** Centrally located. It consists of thin walled, polygonal parenchyma cells with intercellular spaces. It helps in storage of food materials. (Fig: 5B)

**Stem: Epidermis:** Epidermis is the outermost and the single layer of cells. Epidermis is without intercellular spaces, cuticle present. **Hypodermis:** This is just below the epidermis and consists of 3 to 4 layers of collenchymatous cells. This layer contain chloroplasts. **Cortex:** This zone lies just beneath the hypodermis. The cells of this zone are parenchymatous and multilayered. **Endodermis:** This zone lies beneath the cortex and is made up of a single layer of barrel-shaped cells. It is the innermost layer of the cortex. **Pericycle:** It lies next to the endodermis. **Medullary rays:** It lies in between the vascular bundles and is made up of parenchymatous cells that constitute medullary rays. **Vascular bundles:** The vascular bundles are present in a ring form on the inside of the pericycle. Conjoint, collateral, endarch, and open. It is made up of xylem, phloem, and cambium. **Pith:** The pith holds the large central part of the stem. (Fig: 5A)

**Karyotype:** Chromosome number- $2n=52, 56, 78$

### **FLOWERING AND FRUITING:**

As the tree are semi-deciduous, complete leaf fall never occur during lifetime. The species remain sterile with many empty dehiscent fruits with old unhealthy leaves from December to Late January. Fertile stage observed with the flowering that starts blooming from first week of February with the appearance of new leaves. The trees are in full bloom with huge green dense canopy till the month of June. From June to October each branches bears cluster of dry blackish-brown fruits and fruits start dehiscing through longitudinal slits and winged samara light seeds are dispersed.



**SPECIMEN EXAMINED:** North Bengal Terai and Duars are good habitat for growth of *Toona hexendra* and habitat extended to the hilly slopes of Himalaya of Darjeeling and Kalimpong upto 1150 m. For details study about the species out of several trees of *Toona hexendra*, five mature individual two from lower hill slopes of Darjeeling Himalaya (Sevok Range of Mahananda Wildlife Sanctuary) and three individuals from University of North Bengal campus were considered. Details of sample coordinates, altitude, and locations for the studied specimens were as follows:

**SITE 1 (Hill Slopes):**Coordinates-26°94'78.53" & 88°43'33.88"; Altitude 336 M; CPT-1, Lower Kadung, Sevok Range, Birik Beat, Mahananda Wildlife Sactuary, (Probably 1940 plantation, age not determined).

**SITE 2 (Hill Slopes):**Coordinates-26°57'49.42577" & 88°25'52.30045"; Altitude 311 M; CPT-1, Lower Kadung, Sevok Range, Birik Beat, Mahananda Wildlife Sactuary, (Probably 1940 plantation, age not determined).

**SITE 3 (Plains):** Coordinates-26°42'37.31166" & 88°21'19.44238"; Altitude 31 M; Medicinal Plant Garden, University of North Bengal, Rajarammohunpur, Darjeeling (Age not determined).

**SITE 4 (Plains):** Coordinates-26°42'33.05869" & 88°21'19.299331"; Altitude 31 M; Plant 1, Rabindra Bhanu Mancha, University of North Bengal, Rajarammohunpur, Darjeeling (Age not determined).

**SITE 5 (Plains):** Coordinates-26°42'33.24834" & 88°21'19.43716"; Altitude 31 M; Plant 2, Rabindra Bhanu Mancha, University of North Bengal, Rajarammohunpur, Darjeeling (Age not determined).

**ECOLOGICAL IMPORTANCE:** In natural forest *Toona hexandra* is significant components in primary as well as secondary forest. The species grown in plains and moist riverine and stream sides and occur up to 1500 m altitude in different part of the world and prefers average range of 800–1800 mm annual rainfall. The seeds are well germinated in shade but also well capable of regeneration in full sunlight. For the growth of the species mostly prefers well-drained landscapes, fertile soils whereas poorly grows in sandy localities. The mature tree can partially tolerates some extend of drought and frost for limited periods.

In subtropical climates, *T. hexandra* can able to grows in moist localities such as ravines, banks of streams, even swamps and grows best in fire-protected savannah, abandoned cultivation and in small gaps in forest, hilly slops.

**Association:** In Lower hills of Darjeeling Himalaya and Terai-Duars *Toona hexandra* grows with many other associated species and that includes *Mecaranga denticulata*, *Mecaranga peltata*, *Clerodenreum japonicum*, *C. infortunatum*, *Oplishmenus composiyus*, *Dalbergia stipulacea*, *Maesa indica*, *Leea indica*, *Leea asiatica*, *Piper peepuloides*, *Dioscorea prazeri*, *Carex sp*, *Tebarnemontana divericata*, *Coffea benghalensis*, *Bauhunia valli*, *Musanda roxburghi*, *Mellotus philipensis*, *Tunbergia grandiflora*, *Smilex zeylanika*, *Strobilanthus sp*, *Callicarpa arborea*, *Lepidagathis imbrecata*, *Panicum repens*, *Amoora wallichii*, *Artocarpus chaplasha*, *Pterygota alata*, *Atrocarpus lakocha*, *Tectona grandis*.

**Provide shelters epiphytes:** The berk of *Toona hexandra* is quite thick and can absorb and hold sufficient amount of moisture. The soft cork tissue of berk allows a good population of various epiphytic floras that includes unidentified mosses, lichens, pteridophytes like *Dryneria quercifolia*, *Pyrrrosia lanceolata*, *Microsorium punctatum* and angiosperms like species of *Raphidophora*, *Dendrodium*, *Pholidota*, *Bulbophyllum*, *Ceologyne sp*.

#### **MEDICINAL USE:**

*Toona hexandra* is the large tree mainly distributed in tropical and sub-tropical ranges of sub Himalayan territory. Traditionally the leaves and barks are used by various tribal communities to treat various ailments.

#### **Ethnic Uses:**

Bhatta (1999) reported ethnobotanical uses of *T. hexandra* in constructions and as fodder plants. Leaves are used in skin diseases and vomiting by Chothe tribe of Bishnupur district, Manipur (Sanglakpam *et al.* 2012). Prusti & Behera (2007) reported that the water extract of stem bark is given in fevers.

#### **Ayurveda System:**

Traditionally, the plant parts are used for the treatment of various ailments that includes chronic dysentery, leprosy, fever, headache, blood complaints, cardiogenic, aphrodisiac and ulcer. The species is traditionally used in menstrual disorders. Pharmacologically the plant has been investigated for its anti-ulcer activity, analgesic activity, antifungal activity,

antimicrobial activity and antitumor activity, gastro-protective and cytotoxic activity. Steroids of the species can be used medicinally as cardiogenic, growth promoter, anti-tumor, antifungal, hepatoprotective, anti-microbial, anti-tussive etc. Coumarins have a variety of bioactivities including dermal photosensitizing, anti-microbial, vasodilator, molluscicidal, antihelminthic, anticoagulant, estrogenic, sedative, hypnotic, analgesic and hypothermic activity. Tannins are astringent, bitter polyphenols may be employed medicinally as antidiarrheal, haemostatic, and antihemorrhoidal compounds, anti-viral, antibacterial, and antiparasitic effects. Flavonoids exhibit several biological effects such as anti-inflammatory, anti-ulcer, anti-hepatotoxic activity (Singh et al, 2012).

**Ayurvedic formulation:** Nyagrodhadi Kvatha Curna.

**Active Components:**

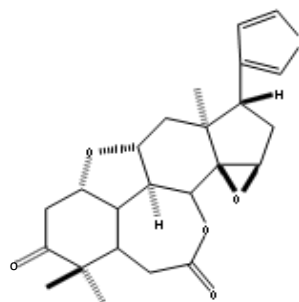
The key phytoconstituents present in the plants are triterpenoids, cedrelone, polyynes, limonoids, siderin, steroids etc. Coumarin, Phenolics & Polyphenols, Terpenes & Terpenoids, Steroids, Stigmasterol, Flavonoids, Limonoids & nor-limonoids, Polyynes, Tannins. Bark and heartwood yielded tetranortriterpenoids, including toonacilin. The phenolic compounds are divided into phenolic acids, flavonoids, lignans and stilbenes. The most phytochemically important parts of *Toona hexandra* are leaves and bark. The major phytoconstituents of both leaves and barks are give below.

**Leaves:** The *Toona hexandra* leaves are important source of some aromatic components like coumarin glycoside, siderin, tannins, Toonafolin, flavonoids, phenolic compounds, triterpenoids and steroids.

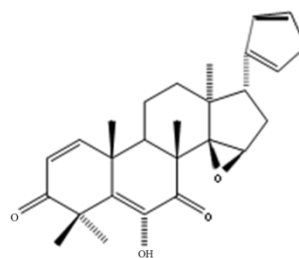
**Barks:** The bark of *Toona hexandra* is good source of tetranor-triterpenoids, Cedrelone, including Toonacilin.

Red heartwood also contain good amount of coumarin, geranylgeraniol and its fatty esters. Toonacilin and its hydroxy derivatives are antifeedant (Khare 2008).

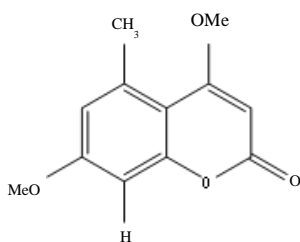
Neto *et al* 1998 isolated two new norlimonoids on the basis of spectroscopic analysis, 5 $\alpha$ , 6 $\beta$ , 8 $\alpha$ -trihydroxy-28-norisotoonafolin and 5 $\alpha$ , 6 $\beta$ , 8 $\alpha$ , 12 $\alpha$ -tetrahydroxy-28-norisotoonafolin. Limonoids, like cedrelone and toonacilin and the sterols, sitosterol, stigmasterol, campesterol and 3 $\beta$ -O- $\beta$ -d-glucopyranosylsitosterol were also isolated.



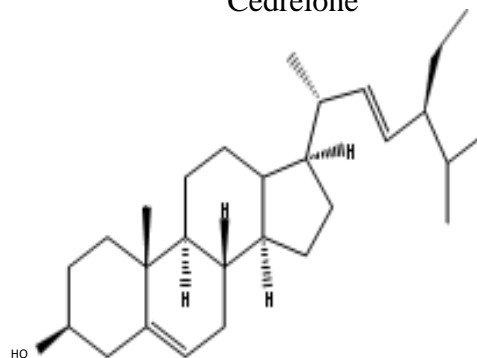
Toonafolin



Cedrelone



Siderin



Stigmasterol

The ethanol extract of the heart wood of *T. hexandra* was found to be effective for anti-ulcer activity against aspirin plus pylorus ligation induced gastric ulcer (antisecretory), HCl-ethanol induced ulcer (cytoprotective) and water immersion stress induced ulcer in rats (Malairajan *et al.* 2007).

Chen *et al.* (2009) reported terpenoids from the leaves and twigs of *T. hexandra*, of which three were new norlimonoids, two were new tirucallane-type triterpenoids, and was one new pimaradiene-type diterpenoid, and two were known limonoids and eight were known tirucallane-type triterpenoids. These new molecules are Toonaciliatin H to M. Toonaciliatin M (6) showed moderate antifungal activity against *Trichophyton rubrum*.

Liu *et al.* (2011) reported 23 compounds from leaves and stems of *T. hexandra* (as *T. ciliata* var. *pubescens*). Those compounds are siderin; 4, 6, 7-trimethoxy-5-methylcoumarin; 6, 7-dimethoxycoumarin; isoscooletin; scooletin; 7-hydroxy-6, 8-dimethoxycoumarin; dehydrodiconiferyl alcohol; (-)-lariciresinol; thero-2, 3-bis-(4-hydroxy-3-methoxyphenyl)-3-methoxy-propanol; cycloeucaenol; 8(14), 15-isopimaradiene-2, 3, 19-triol; 3S, 5R-dihydroxy-6R, 7-megstigmadien-9-one; (-)-loliolide; (+)-catechin; dimethyl malate; diisobutyl phthalatesyringic acid; dibutyl phthalate; 1, 3, 5-trimethoxybenzene; vanillic acid; syringaldehyde; vanillin and 3, 3', 5, 5'-tetra-tert-butyl-2, 2'-dihydroxybiphenyl.

Eight Toonaciliatavarins were isolated from stem bark of *T. hexandra* (as *T. ciliata* var. *henryi*) by Zhang *et al.* (2012). There were three new protolimonoids (Toonaciliatavarins A to C), two new tirucallane-type triterpenoids (Toonaciliatavarins D & E), and three new tetranortriterpenoids (Toonaciliatavarins F to H). Toonaciliatavarins D & E showed moderate cytotoxicities, and the Toonaciliatavarins A, B & C exhibited marked inhibitory effects on LPS-stimulated NO production.

**Timber uses:** The heartwood is red brown, cedar brown, dark red-brown when first cut, darkening upon exposure to a rich reddish-brown with darker brown streaks. The sapwood is red or pale yellow-brown, pinkish and smells strongly like cedar when cut. The smell is very strong, fragrant and long-lasting. The wood is moderately hard, lightweight, tough and durable with satisfactorily stained. The timber takes water and oil-based paints. The wood has great extent of uses and that includes carvings, boat building, cabinet making, decorative plywood and veneer, food containers, high-grade furniture, interior trim, joinery, musical instruments, cigar boxes, matchboxes, building materials, exterior uses, veneer, plywood and pencils mill work, ornamental work, panelling, boxes and crates, mouldings. The timber of this species has always been highly regarded in the manufacture of light-weight racing boats particularly sailing boats and dingi.

**Other Uses:** *Toona hexandra* is very large and fast growing tree with huge canopy tree. The red timber is also very demanding for various industries. Due to faster growth and canopy size it is highly preferred as shade tree, street tree or avenue trees in different cities of African, Asian countries and Australia.

Mountain cedar has been used in afforestation program by silviculture department and is also planted to provide firebreaks in forested areas.

The floral parts contain a red colouring matter and also a sulphur-coloured dye. Cotton and woollen fabric can be dyed a dull yellow by mere immersion in a boiling extract of the flowers.

The bark is very rich in tannin. A fibre obtained from the bark of *T. hexandra* has been used traditionally for making twines and string bags.

Aromatic oil can be extracted from the fruit. Some extracts from the bark have insect-repellent properties. Extracts from the leaves and bark have affective insecticidal properties.

**PESTS AND DISEASES:** *Toona hexandra* is infected by some fungus and moth species. Leaf blight is very common disease of *Toona hexandra* caused by *Phytophthora* has been reported from different silviculture nurseries in India. The species is also reported as susceptible to the species *Fusarium*. One new fungal foliar disease caused by *Rhytisma acerinum* is reported from Himachal Pradesh and the symptoms on upper surface of the leaves as numerous small, superficial and blackish lesion.

The most important are *Ganoderma lucidum*, causing root and butt rot, which may be lethal, *Phellinus* spp., causing white rot of fallen timber or gaining access through wounds exposing dead sapwood, and *Trametes straminea* (white stringy rot), usually saprophytic but also a wound parasite causing trunk rot. In many part of the world plantations *Toonaciliata* are severely damaged by attacks of cedar tip moth (*Hypsipyla robusta*), *Hypsipyla grandella* of Lepidoptera group that mostly attack young shoots, flowers, fruits and seeds. *T. ciliata* is susceptible to attack by dry-wood termites, Anobium borers and Lyctus. In some places, young saplings are attacked and even killed by the parasite *Loranthus scurrula*. Due to seasonal attack of Tip moth and some other pests may cause severe seed losses.

#### **PROPAGATION AND CULTIVATION:**

*Toona hexandra* reproduces through wind dispersed seeds and seed dispersal starts with splitting of fruits (Fig. 7). The capsules maturation period varies in different climatic zone and it was reported that the fruits maturation period in India is March to April in most of the areas but in northern states it would be May-July. In China fruit maturation periods is March to June where flowering occurs from March to June (Li et al. 2015) and flowering stars in Australia during September to December. Seeds of *Toona hexandra* are very small samara type with two large wings and are quite light in weight. Quantity of seeds required for raising seed is one kg that includes 3,40,000 – 3,50,000 seed (approx.). After collection of seeds, it viability may persist from 3 month to 12 month based on preservation quality.

**Method of collection of seed:** Mature ripen fruits are usually collected from the tree during the month of October. After collection the hard rind of the fruit is peeled off and winged seeds are then carefully taken out.

**Method of treating seed:** No special treatment is required for the seed. Seed germinates quicker and better under shade. It should be broadcast thinly on raised and shaded nursery beds soon after collection.



**Fig. 7:** *Toona hexandra*. A) Dry & dehiscent fruits, B) Samara type seeds.

**Sowing:** Seed sowing is direct in loose sand in shaded mother bed. If the seeds are put in sterile sand bed followed by gular watering, 60% success in germination may be obtained and maintained preferred pH in the range 5.5 - 6.5.

**Germination (time & percentage):** Germination is moderate. It commences within one week and completes in two weeks. Germination % may ranging from 40 to 60%.

**Treatment in nursery:** No special treatment is required except the standard method of weeding and slight watering. Seed should be sown thinly with sands in shaded beds for better germination percentage. Leaf mould manure / cow dung manure will certainly help, but is not an input.

**Method of propagation:** The species mainly propagates by means of seed. During month of May-June the mature fruits are collected. After drying completely the fruits are spread out for 3-4 days until they start to split naturally or sometimes it would be beaten with sticks to get the seeds. The clusters of seeds are separated by winnowing. The collected winged and delicate seeds are sown in the month of July-August and maintaining the temperature within the range 18 - 34°C which is best for seed germination. Initially during the month of August 10-12" tall seedlings were transplanted in a pit in a spacing of mt. under proper protection care against grazing & other biotic interference.

**Treatment after transplanting:** Just after transplanting weeding & cleaning in one month or two months interval is necessary followed by two soil mulches at a suitable interval in order to ensure better growth of the seedlings. Regular weeding, cleaning, climber cutting operations are to be carried out up to 5th year after planting because in North Bengal Plain weed growth is a major problem in the course of establishing a successful plantation. Germination test: The normal germination of *Toona hexandra* varies from 40-60%.

#### **INVADER TENDENCY:**

Wide spreading superficial root system of *Toona hexandra* absorbed huge soil moisture that may have adverse effects on the growth of other species. One mature tree can produce large amount of seeds and the seeds are winged that helps the species in successful long distance seed dispersal. The 40-60 % successful germination process huge individuals but that much huge successful individual is not noticed in wild. So, its aggressive invasive tendency is not



observed in the forested areas of sub-Himalayan region though, it has great capability to spread over short and medium distances through wind-dispersal (anemochory). Allopathic effect of the species is also not observed severely on other native species that are grows nicely around them and the tree trunk allows the growth of several epiphytes on it.

### **CONSERVATION STATUS**

In many regions within the natural area of distribution of *Toona hexandra*, the timber is highly prized and has been much overexploited. Nowadays it is exploited in many areas in South-East Asia and exported in small amounts to China and Japan. The species is well adopted in tropical climates and propagate through winged seeds. The population of *Toona hexandra* in different forested areas are quite high and IUCN keep this species in Lower Risk and/or least concern status in their Red List of Threatened Plants. The Forest department of different Eastern and North eastern states keep this species in their preferred list for afforestation plan. Due to low level of extinction risk no such specific conservation measure yet been initiated anywhere. A good number of individuals of varies age group are frequently observed in different conservatories like Mahananda WLS, Gorumara NP, Chapramari WLS, Buxa NP, Jaldapara NP. Apart from the conservatories, the species are also frequently planted in various public and Govt. occupied areas of various districts of Northern West Bengal.

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