Review of biological and silvicultural characteristics of timber trees planted in Cambodia

Compiled by

Norn Narong and Kim Sobon

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<td>a.s.l.</td>
<td>Above sea level</td>
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<td>cm</td>
<td>Centimetre</td>
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<td>CITES</td>
<td>Convention on International Trade in Endangered Species</td>
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<td>CTSP</td>
<td>Cambodia Tree Seed Project</td>
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<tr>
<td>DBH</td>
<td>Diameter at breast height</td>
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<tr>
<td>e.g.</td>
<td>For example (Latin <em>exempli gratia</em>)</td>
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<tr>
<td>EN</td>
<td>Endangered</td>
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<td>FA</td>
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<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
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<td>FORRU</td>
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<td>International Union for Conservation of Nature</td>
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<td>Ministry of Agriculture, Forestry and Fisheries</td>
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<td>mm</td>
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<td>n.a.</td>
<td>Not available</td>
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<td>NFP</td>
<td>National Forest Programme</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-governmental organization</td>
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<td>UTM</td>
<td>Universal Transverse Mercator</td>
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Albizia lebbeck (L.) Benth

Local name : Chres  
Scientific Name : Albizia lebbeck (L.) Benth  
Family : Leguminosae  

1. Botanical Description

Albizia lebbeck can grow up to 30 m tall (Joker 2000). It produces boles from 30-40 cm in dbh (Dy Phon 2000). The color of the bark is gray. Leaf is compound; bi-pinnate leaves have 2-4 pairs of pinnae in which there are 2-11 leaflets each. There is no growth in early dry season and then the leaves start to fall in 2-3 months later. At the end of dry season this species start to produce leaves, continue growing and flowering (Joker 2000).

2. Natural distribution and habitat

Albizia lebbeck is found in dense deciduous forests in tropical and sub-tropical region of Asia, such as Indochina, Indonesia, Africa and Australia (Dy Phon 2000). In Cambodia, it is found in Stung Treng, Ratanakiri, Koh Kong, Battambang, Preah Vihear, Kampong Speu and Kampong Thom provinces. The species grows poorly on heavy clays, but grows well on fertile, well-drained, loamy soils, in areas that receive annual rainfall between 600 and 2,500 mm. It is normally encountered below the altitudes 1,800 m a.s.l. with the average temperature varies between 20 and 35°C. As a legume species, it produces root nodules which harbour nitrogen-fixing bacteria. It can grow on acidic, alkalin, heavy and eroded soils, waterlogged soils, and tolerates to drought. Older trees can withstand forest fires, but young trees do no have this ability. If young trees are burned, new seedlings will emerge from the stumps (Joker 2000).

3. Uses and products

Albizia lebbeck produces high-quality wood which is suitable for making furniture and construction materials. Some parts of the tree such as leaves, seeds and bark are used for traditional medicine. With the nitrogen-fixing ability and root structure, the species is planted for improving soil fertility and erosion control. Young leaves contain about 70% of protein, and therefore, they are used for animal food (Joker 2000).

4. Seed source

There is no identifiable seed source of Albizia lebbeck in Cambodia. Currently, seeds can be collected from natural habitats across the country.
5. Seed collection and processing

Flowering begins in the month of September to October and the mature fruits are found in the month of February to May. The flower is green or creamy-white, fragrant. They form in large heads around 5-7.5 cm wide. Flower has stamens from 1.5-2 cm long. Mature trees produce lots of pods. Fruits can remain on the tree for 3-4 months. There are about 7,000 to 12,000 seeds/kg (Joker 2000).

The right time for seed collection is when the color of the pods turns brownish. Seeds should be collected as soon as possible in order to reduce the severe damage by insects. If the collected pods are still green, drying them in the sun is needed until the color of the pods turn brownish and completely dry. The seeds can be extracted from the pods manually or by using a thresher. Seeds then dried in the sun before packaging. Seeds with low moisture content can be stored for a few years in low temperature condition (CTSP 2003).

6. Seed pretreatment method

The seed is orthodox. Soaking the seeds in 80 °C water for 10 minutes and putting them in tap water overnight will increase the germination rate up to 100% (CTSP 2003).

7. Plantation establishment

Before planting the seedlings in the field, the seedlings should be raised and maintained in nursery for 1 year in order to get high survival rate (CTSP 2003). For fuelwood purpose, the spacing is 3 × 3 m, and for timber production, spacing should be 5 × 5 m (Orwa et al. 2009). Very close spacing can be used initially, for example 2×2 m, in areas where weed competition is a main problem. Then thinning is required when the canopy completely cover the ground. Testing of direct seeding in the field in Siem Reap province has shown that A. lebbeck is one of the promising species. The seedlings are drought tolerant, so weeding twice a year is required during the first few years after planting in the field.

8. Growth and Yield

For fuelwood production, A. lebbeck is usually planted for 10-15 years, and 30 years rotation is recommended for timber production (Sosef et al. 1998). Fuelwood plantations spaced at 3 × 3 m clear felled on a 10-year rotation produce about 50 m³/ha of stacked fuelwood (Orwa et al. 2009). Data from field measurement indicate that, maximum growth was observed on Alluvial lithosols soil in Prey Veng province (UTM 539048-1272926) where trees reach 11.5 m height and 26 cm dbh in six years (Annex 1). In average, the annual increment of height and diameter in the first 14 years is about 1.5 m and 3.5 cm, respectively.
A. *Albizia lebbeck* growing on the dike a rice field, B. Close view of the bark, C. A seedling of *A. lebbeck* grown from seed in an experimental plot (direct seeding experiment) in Siem Reap province, D. Flowers.
Reference


Albizia lebbekoides (DC.) Benth

Local name: Chres
Scientific name: Albizia lebbekoides (DC.) Benth
Family: Leguminosae

1. Botanical description

*Albizia lebbekoides* is a medium tree growing up to 8-15 m tall (Dy Phon 2000). Leaves are alternate, minutely stipulate, bipinnately compound with 5-13 cm long rachis provided with glands near base and top. Petiole 2.5-6 cm long, pinnae in 3-8 pairs; leaflets (5-) 15-25 (-35) pairs per pinna, (narrowly) oblong, 6-20 mm × 2-6 mm. Flowers in axillary up to 18 cm long panicles composed of 10-15-flowered headscaly narrowly campanulate, very small, corolla tubular, 5-lobed, filaments united into a tube. Fruit is a strap-shaped dehiscent pod, 7-15 (-20) cm × 1.5-2 cm. the color of the pod is when ripped dark brown. There are up to 12 seeds per pod (Lemmens 1991).

2. Natural distribution and habitat

This species is widely distributed in South-East Asia, Thailand, Laos, Cambodia, Vietnam, the Philippines, southern Sulawesi, Java and the Lesser Sunda Islands (Sosef 1998). It is usually found in secondary forest or in desiduous forest (Dy Phon 2000).

3. Uses and products

In Java, local people usually use the bark to tan hides and fishing nets. Moreover it provides a red dye, formerly used for coloring cloth and known as 'soga tekik' in eastern Java. In the Philippines it is frequently used in the manufacture of a fermented drink made from sugar cane, just like the bark of *Macaranga tanarius* (L.) Muell. Arg., which also yields tannin. The timber is suited for indoor construction. *A. lebbekoides* is sometimes planted as a shade tree. Production of bark and timber is exclusively for local use and production data are not known (Sosef 1998).

4. Seed sources

There is no identified seed source of *Albizia lebbekoides* in Cambodia. Seeds should be collected from trees with good stem form.

5. Seed collection and processing

The best season for seed collection in Cambodia is between February and April. There are about 49,000-59,000 seeds per kilogram (Sosef 1998). Seeds can be collected when the color of the
pods turns brownish. To avoid the damage by insect, seed need to be collected when it is ripped. Dry the fruit in the sun until they are completely dried then extract the seed from the pods manually. Then dry this orthodox seeds in the sun. With low moisture content, this seed can be store for several years under room conditions.

6. Seed pretreatment method

In order to increase the germination rate some pretreatment methods are carried out such as soaking in boiling water, around 70°C, or buy nicking the seed coat. For the sfreshly collected seeds, soaking in tap water overnight can generate 80% of germination. Sowing - seeds can be broadcasted in seedbed or seed box or sow in furrows. Germination starts in 3 to 4 days. To assure optimal germination, seeds should be sown in full sunlight. Potting - transplant the germinants when the first pair of leaves appear (Florida 2001).

7. Plantation establishment

Seedlings are ready for outplanting when they reach 25 to 30 cm tall. Seedlings with the height up to 100 cm have been successfully outplanted (Florida 2001). Suitable spacing is 3 × 3 m. Ring weeding is necessary during the first two years. Seedlings may be attacked by rats especially during droughts (Florida 2001).

8. Growth and yield

Tree reach a total heigh of 14 m and dbh of 38.5 cm in a 34 year-old plantation on Alluvial lithosols in Prey Veng province (UTM: 539048-1272927) (Annex 1). In trials in Java, the mean annual clear bole volume increment for 12 year-old trees is 2.8 m³/ha. In these trials, A. lebbekoides developed a poor stem form due to forking and formation of low and heavy branches (Sosef 1998).
A: Seeds of *A. lebbekoides* (good seeds). B: Late collection of seeds resulted in poor seeds. C: Close view of a tree trunk, D: Overall view of *A. lebbekoides* tree.
Reference


Smitinand, T. and Larsen, K., 1985, Flora of Thailand, Royal Forestry Department, Bankok.

Anisoptera costata Korth.

Local Name: Phdeak
Scientific name: Anisoptera costata Korth.
Family: Dipterocarpaceae

1. Botanical Description

Anisoptera costata Korth is a large tree that can grow up to 50 m tall and the diameter can be up to 170 cm. Bole is rounded and straight up to 35 m height (Soerianegara and Lemmens, 1994). Few buttresses of up to 4 m high, thick, rounded, straight and spreading out up to 2.5 m, continuing up the bole as ribs up to 10 m high. Branches thick, flat or angular and densely yellow stellate hairy. The bark is greyish brown to light yellow, smooth and hairless when young, deeply fissured when old and shedding off into small rectangular patches. Inner bark can reach the thickness of up to 3 cm with the color of cream yellow to brown yellow. Leaf is elliptic to obovate, has an apex with a short obtuse point and the base is rounded or cordate. The inflorescence is conical, axillary or terminal, 10-15 cm long, with star-shaped hairs. Flower is cream-colored. The outer flower leaves are 5, hairy and lobes triangular. The inner flower-leaves are 5 and have blunt and narrow elliptic shape. The fruit is subglobose and brown in color with 1-1.5 cm in diameter and with two large wings 10-16 × 1-1.5 cm and three short wings 1.5-2.5 x 0.2-0.5 cm (Sam et al. 2004). One kilogram of seeds has 1,500-2,000 seeds (Joker 2004).

2. Natural distribution and habitat

It is native to Indochina peninsula, Thailand and Malaysia. Sometimes it grows gregariously in pure stands. It is one of the dominant species in the evergreen and dryevergreen forests of Cambodia. It normally occurs with Dipterocarps and Shorea (Sam, 2004). A. costata occurs at an altitude of up to 700 m a.s.l. in humid areas with a mean annual rainfall of 1,500-2,200 mm and an average annual humidity of 75-85%. The mean annual temperature is 25-27°C. The dry season can last for four to six months (Sam and Nghia 2002).

3. Uses and products

The wood of this species is used for veneer, plywood, furniture, flooring, interior finish, ship planking and general construction (Sam et al. 2004). Wood is easy to saw. Its resin is good odour and is used for ship painting. Sometimes, it is planted along the streets as shade trees (Joker 2004).
4. Seed source

There is one identified seed source (UTM: 0551500, 1448000) in natural forest established by the Cambodia Tree Seed Project in 2002 in Sandan District, Kampong Thom province (CTSP 2003). The seed source is accessible during the seed collection season (dry season).

5. Seed processing and storage

Flowering starts from November to January while fruiting occurs between February and May. The tree produce flower every year. However, mass production of seeds occurs every 3-4 years irregularly. So, seedlings must be maintained for yearly forest planting plans (Sam and Nghia 2002).

6. Seed pretreatment method

After the seeds are collected, they must be sown immediately because the germination rate will decrease rapidly. Seeds are sown in seedbeds and then planted in pots (20×25 cm) filled with potting mix consisting of surface layer soil in the forest (80%) and decomposed farmyard manure (20%) (Sam and Nghia 2002).

7. Plantation establishment

Seedlings can be planted when they reach a mean height of 0.6-0.8 m and with the age of one year old. At an early stage of development, the seedlings need partial shading. For successful planting, seedlings can be planted during the wet season. *A. costata* plantations can be established under the crowns of *Indigofera teysmanii* at a density of 600 trees/ha (Sam and Nghia 2002).

From year one to year three, the plantation of *A. costata* requires weeding, heaping soil to tree base, breaking the hard pan and cutting of climbers (twice a year, one before the wet season and the other after the wet season) should be carried out. Thining can be carried out in the 6th or 7th. About 50% of the planted trees can be removed. Fire control in the dry season must be made in order to protect the plantation from fire destruction (Sam and Nghia 2002).

8. Growth and Yield

There is no old plantation of *A. costata* in Cambodia. Measurement from three young plantations in Kampong Thom and Siem Reap provinces, aged between 12 and 18 years, indicate that the average annual increment of dbh and height is 1.4 cm and 0.9 m, respectively. At the age of 18 years old, the trees reach an average dbh of 23 cm and heigh of 14 m (Annex 1).

The wood of this species is of high commercial value. The price of *A. costata* in the world is USD 2,000-2,500/m³ (Sam and Nghia 2002). The price of sawn wood in Phnom Penh is USD 350/m³ (Pers. comm. with a wood seller in Phnom Penh, 05 April 2014).
A. *Anisoptera costata* bole at the age of 10 years. B. Leaves. C. Close view of bark.

**Reference**


**Cassia siamea** Lam.

Local name: Ang Kanh  
Scientific name: *Cassia siamea* Lam.  
Family: Leguminosae

1. **Botanical Description**

*Cassia siamea* is an evergreen or semi-evergreen tree that grows up to 20 m tall and 45 cm in diameter (Sam *et al.* 2004). Stem cylindrical, twisted, early branching, covered with fine hairs when young. Bark grey, with regular small and narrow cracks, sometimes segments are formed due to twisted stem. Leaves paripinnate, alternate, 10-15 cm long, leaflets 20-40, rectangular, oblong at both ends, green in colour, 3-7 cm long, 1-2 cm wide. Stipules small, caducous. Inflorescence racemose, straight, apical with many yellow flowers. Petals 5, yellow, rounded, thick, uneven, tomentose in the outside. Sepals soft, caducous with short claw. Stamens 2, opening at the apex. Ovary oblong, tomentose, glabrous style. Fruit long, narrow, flat, straight, black in colour, ridge at the margin. Fruit 20-30 cm long, 1-2 cm wide, 20-30 seeded. Flat seed in thick relief on the pod, hard. One kg seed contains 32,000-35,000 seeds (Sam and Nghia 2002).

This species starts flowering from May to June and the fruit starts ripening from February to April (Sam and Nghia 2002).

2. **Natural distribution and habitat**

This species is distributed natively in South and Southeast Asia from Thailand to Myanmar to southern India and Sri Lanka. It is widely cultivated in the tropics (Hanum *et al.* 1997). In Cambodia, *C. siamea* is widely used as ornamental trees that are planted in parks and street sides.

*Cassia siamea* is found in regions with annual rainfall over 600 mm. Mean annual temperature is 20-26 °C, average temperature of coldest month is not less than 15 °C. *C. siamea* is a light demanding tree. It is distributed on yellowish red feralit soil generated on basalt, porphyry, mica schist, limestone, with soil texture varies from sandy loam to light loam. *C. siamea* can grow on poor soil but the trees are stunted, low, small, early branching, crooked stem. *C. siamea* grows into population in secondary forest below 1,200 m elevation and usually occupies the upper storey of the forest margin. Natural regeneration is found in open areas (Sam and Nghia 2002).

3. **Uses and products**

Young fruit, leaves and flower are used as vegetable. Its wood makes excellent charcoal and firewood. Wood is use as joinery, cabinet making, inlaying, handles, sticks and other decorative uses. It has been used for poles, posts, mine poles and beams. Its fruit can be used as traditional
medicine for getting rid of intestinal worms and convulsion in children (Orwa et al. 2009). In Cambodia, it is commonly used as ornamental and shade trees along the streets in towns because it has beautiful yellow flowers, and provides shade.

4. Seed sources

There is no identified seed source of *C. siamea* in Cambodia. However, finding of seed bearing trees is not difficult as the trees are widely distributes in the country.

5. Seed collection and processing

At the age of four or five years old, *C. siamea* trees already produce flowers and fruits but seeds should be collected from the trees with the age of eight years old and over. The mature fruit can be recognized when coat of fruit is dark brown in color, and the seed is black and hard (Sam and Nghia 2002).

6. Seed pretreatment method

Immersing the seeds in concentrated sulphuric acid for 10-30 minutes has been proven to be effective, and germination can be up to 90% within 60 days. Germination of untreated seeds is about 75% in 4-29 days. Viability can be maintained for 3 years in hermetic storage at room temperature with 11-15% moisture content (Orwa et al. 2009).

7. Plantation establishment

Seedlings can be planted at the age about three months old, and its height is 0.3 m (Sam and Nghia 2002). For fuelwood plantations, spacing ranges from 1 × 1 m to 1 × 3 m. In hedges, used for alley cropping or as a shelterbelt, spacing between plants in the row should be 0.25-0.5 m (Orwa et al. 2009).

Weeding needs to be carried out in the first and second year. Moisture conservation (e.g. trenching, microcatchments and mulching) helps in the establishment phase and accelerates the growth for trees planted in semi-arid areas (Orwa et al. 2009).

8. Growth and Yield

*Cassia siamea* does not fix nitrogen. However, it is one of the fast growing tree species. A height increment of 2.5 m/year has been recorded, and in West Bengal it can attain a height of 7.9 m with a stem girth of 24.1 cm in three years. It reaches 15 m in height and 15 cm in dbh after 10 years. Unless carefully pruned, the tree ages ungracefully, the crown is becoming straggling and misshapen with upright and drooping branches. It shows high coppicing abilities and is suitable for pollarding. In fuelwood plantations the wood yield amounts up to 10-15 m³/ha/year or 74-198 t/ha at a rotation of 7-10 years (Orwa et al. 2009).
A. Seedling of *Casia siamea* established from direct seeding (Direct Seeding Experiment in Siem Reap province). B. Close view of bark. C. Ripe fruit. D. Seeds of *C. siamea*.

**Reference**


**Dalbergia cochinchinensis Pierre**

Local name :   Kra Nhoung  
Scientific :   *Dalbergia cochinchinensis* Pierre  
Family :   Leguminosae  

1. **Botanical Description**

*Dalbergia cochinchinensis* is a big tree that can grow up to 30 m tall and 60 cm dbh (sometimes 1.20 m). The bark is light yellow and the canopy is ramified. The leaves are pinnate with 7 – 9 leaflets. The leaflet is oval and alternate. Inflorescence is axillary and the flowers are white. Pod is flat with the size of 5-6 cm long and 1 cm wide consisting of 1 or 2 seeds (Tan Dung 1996).

2. **Natural distribution and habitat**

*Dalbergia cochinchinensis* is native to Cambodia, Vietnam, Laos and Thailand. In Cambodia, the species is found in Kampong Thom, Preah Vihear, Ratanakiri, Pursat, Siem Reap, Kratie, Koh Kong, Stung Treng, and Modulkiri (Sareth 2002). It can tolerate to shade even when it is young. *D. cochinchinensis* is normally found in open and semi-deciduous forests from 400 – 500 m a.s.l., and is able to grow well in deep sand, clays, or calcareous soils (Sareth 2002). The species requires rainfall ranges from 1,200 to 1,650 mm per year. This species need plenty of sunlight to grow and it tolerates to dry season. It can survive on most soils (Joker 2000).

3. **Uses and products**

*Dalbergia cochinchinensis* is classified in the luxury tree species under the Forestry Administration’s classification. Its wood is very valuable, and it is used for making high quality furniture, decoration materials, and musical instruments. The base and root can also be used for attractive decorations (CTSP 2003).

4. **Seed source**

A number of identified seed sources of *D. cochinchinensis* in natural forests were established in Koh Kong, Rattanak Kiri, Pursat and Siem Reap by the CTSP in the early 2000s (CTSP 2003). Currently only one seed source in Siem Rea province (Sre Noy commune, Varin District, UTM, 400757,1520273) is well protected. Seeds of *D. cochinchinensis* can also be ordered from a Leap Kuy community forest (CF) in Phnom Sruoch District, Kampong Speu province. The community forest possesses more than a hundred of mature trees, and some of them produce seeds. Another community forest, O Soam CF, Prasat Balang District, Kampong Thom province, holds a number of seed bearing trees. Currently, seeds of *D. cochinchinensis* are of high demand, therefore, seeds must be ordered quite advance to guarantee seeds availability for tree planting program. In 2014, a kilogramme of seeds cost about USD 300-350.
5. Seed collection and processing

This species produce flower in May and June, and the fruits ripen in November and January (CTSP 2003). In Laos, flower starts in March to August while the fruiting is in September to December (Sam et al. 2004). The pod is long and tapering, and there are 1 or 2 seeds in one fruit. 1 kg of seed contains about 35,000 seeds (Joker 2000). The maturity of the seeds can be recognized when the pod is dark brown in color. The fruits are often collected as soon as the color turns from green to yellow, in order to avoid the damage from insects. The pods can be collected by cutting or shaking the branches so that the pods will fall on the ground. Covering the ground with canvas around the base will help the collection of the seeds more easily (Joker 2000).

After the pods are collected, dry them in direct sunlight for around two days. Seeds can be extracted from the pods using a seed thresher, but care is needed to avoid damage to the seeds (Joeker, 2000). Seeds can be extracted from the dried pods manually. Clean seeds should be dried in the sun for 1 day before sowing or storage. Dried seeds can be stored in a seal container (e.g. plastic bag) under room conditions for about five years (CTSP 2003).

6. Seed pretreatment method

Fresh seeds can be soaked seed in tap water over night gives best germination rate with 82% (CTSP 2003). Old seeds must be pretreated by immersing them into the boiling water for about 30 s followed by soaking in tap water over night. Seedlings emerge about 7-10 days after sowing.

7. Plantation establishment

Suggested spacing for D. cochinchinensis is 3 × 3 m so the total number of trees is 1112 trees/ha (FA & CTSP 2003). Seedlings with the high of 60 cm or with the age of 12 months are suitable for planting as they are capable to compete with grass for growing (CTSP 2003).

Weeding is normally carried out during the initial growth to promote the growth of young seedlings and reduce competition with weeds. Weeding can be practice until the seedling is tall enough to withstand the competition from grass. Weeding and annual application of fertilizer (30 g of NPK (15:5:15) for each seedling for the first four years to accelerate the growth of D. cochinchinensis to become taller than the grass (So et al. 2010).

8. Growth and Yield

The dbh and height of 5-year-old D. cochinchinensis planted in Kbal Chay Watershed protected area, Phreah Sihanouk, is 6.7 cm and 5.7 m, respectively (So et al. 2010). Based on a field measurement in 2013, An18-year-old D. cochinchinensis reach a height of 13.67 m and the dbh diameter of 29.63 cm (Annex 1).
Vietnam and China are the biggest buyers of *D. cochinchinensis*. Vietnamese traders buy the wood with the cost of around USD 40,000/m³ while Chinese traders pay around USD 70,000/m³ for the best quality wood (So et al. 2010). However, a much lower price in China was reported by the Environmental Investigation Agency; there the wood of *D. cochinchinensis* was traded at USD 50,000/m³ (EIA 2012).

A: A mother tree of *Dalbergia cochinchinensis* tree in an identified seed source in natural forest, Siem Reap province, was marked for seed collection. B: Seedlings of *D. cochinchinensis*
tending in nursery before planting out in the field. Note the seedlings are too tall which are susceptible to wind break. C: Cleaned seeds of *D. cochinchinensis* before pretreatment. D: A seedling of *D. cochinchinensis* planted in an experimental plot in Siem Reap province.
Reference


FA and CTSP, 2005. Guideline for Site Selection and Tree Planting in Cambodia, Forestry Administration (FA) and Cambodia Tree Seed Project (CTSP), Phnom Penh.


Saret, K., 2002. Distribution of Selected Tree Species for Gene Conservation in Cambodia.


**Dalbergia oliveri** Gamble & Prain

Local name :   Neang Nuon
Scientific name : **Dalbergia oliveri** Gamble & Prain
Family :   Fabaceae

1. **Botanical Description**

*Dalbergia oliveri* is a large tree that grows up to 30 m in height (Dy Phon 2000) and 90 cm in diameter (Tan Dung 1996). The color of its bark is grey. The branches are stout and slightly pubescent. Leaves are pinnate compound with 13 to 17 leaflets and occasionally with 9-11 or 19-21 leaflets. The leaflets arrange alternately. Inflorescence is corymbose-pinulate, axillary or nearly terminal. Inflorescence is 10-20 cm long and 7.5-15 cm wide. Flower is white in color and the inner part is purple in color. The fruit is flat with 6-7 cm long and 1.7 cm wide consisting of 1 seed, but sometimes the pod contains 2 or 3 seeds.

2. **Natural distribution and habitat**

This tree species is found in Cambodia, Laos, Thailand and Vietnam (Dy Phon 2000). In Cambodia, this species distributes in Kratie, Preah Vihear, Kampong Thom, Ratanakiri, Stung Treng, Pursat and Siem Reap provinces. The species occurs individually or in a group of 5 – 10 trees. It is found in evergreen forests or semi-evergreen forests dominated by *Lagerstroemia* and Dipterocarps. The species is present at the altitude below 900 m, normally near water and on hill sides. Trees are able to grow under the shade when they are young, but they need sunlight at mature stage. *D. oliveri* can produce lots of seeds, but natural regeneration is usually low because of inadequate germination rates. Trees generally grow slowly under both natural and plantation conditions.

3. **Uses and products**

The wood of this tree species is hard and beautiful. The color of heart wood is dark red and sapwood is white. It is used for ornamental purpose such as for making good quality furniture, arts, musical instruments, agriculture implements and other decorations (Dy Phon 2000; Sam *et al.* 2004).

4. **Seed source**

Seeds of *D. oliveri* can be sourced from a number of identified seed sources in natural forests, such as Pal Hal commune, Tbeng Meanchey District, Preah Vihear province (04 94 650,15 16 781) or Prognel commune, Phnom Kravanh District, Pursat province (CTSP 2004). The remnant forest surrounding Boeung Yak Loam in Rattanak Kiri province is home to a number of mature trees of *D. oliveri* where seed collection is possible.
5. Seed collection and processing

In Cambodia, the tree starts flowering in May to July, and the fruit ripening in November to January. The seed is orthodox, and can be stored in cool dry place for several years. Seed has oval shape. The seed is brown in color with 10 mm long and 6 mm width. There are about 6,100 seeds per kilogramme (CTSP 2003). The young pods are green in color, and it will turn to dark brown when it ripens. The fruits need to be collected as soon when it starts to mature in order to avoid the damage from insect attacks. The best season for seed collection is December and January. Cover the ground around the base with canvas then shake the branch. Pruning the small branches are the simple methods of seed collection. The pods need to be dried in sunlight for 2-3 days. Seed can be extracted from the fruits bythreshing (CTSP 2003).

Before storage, damaged seeds need to be removed by putting the seeds in water. The floating ones are the damaged seeds and the good seeds will sink. Remove the good seed and dry them in the sun for one day before storage. Seed can be stored in a cold room, at 10 °C, for several years. However, storage at ambient temperature, below 30 °C, for 1-2 years, can maintain good germination rate.

6. Seed pretreatment method

Soaking the seeds in warm water, 40 °C, and left them to cool down overnight will result in germinate rate up to 64 %. Lower germination rate is achievable if seeds are soaked in tap water overnight.

7. Plantation establishment

After seed pretreatment, the seed then can be sowed in the nursery bed. When the seedlings produce a pair of leaves, they can be transplanted into the bags in the nursery (CTSP 2003). The duration for maintaining seedling in the nursery is about 9-12 months. In plantation, the seedling can be planted in an appropriate space of 3 × 3m. So the total number of tree per hectare is 1112 individuals (FA & CTSP 2005).

*Dalbergia oliveri* is a very slow-growing species at the early stage of development; therefore, weeding is necessary, particularly in the areas infested by *Imperata* grass. Ring weeding by uprooting grasses within 0.5 m from the base is usually practiced under plantation conditions. Weeding can be practiced until the seedling is tall enough to withstand the competition from grass. After weeding, application of fertilizer should be practiced to accelerate the growth. For example, 30 g of NPK (15:5:15) is applied once to each seedling for the first four to five years.

8. Growth and Yield

Based on a field measurement in 2013, a 16-year-old *D. liveri* can grow to the height of 11 m and the DBH of 24 cm (Annex 1). *D. oliveri* is exported to China with the price ranging between USD 2,000 and 3,000/m³ (Wenbin and Xiufang 2013). The current price of *D. oliveri* in Phnom
Penh ranges between USD 1,800 and USD 3,600 according to the quality and size of the piece of wood (Pers. comm. with wood seller in Phnom Penh, 05 April 2014).
A: A 10-year-old tree of *D. oliveri* in the species screening trial in the Kbal Chhay Watershed Protected Area has the height of 5 m and the dbh of 10 cm. B. Ripe fruit of *D. oliveri*. C: Seeds of *D. oliveri*. D: Cross-cutting section of wood of *D. oliveri* showing the different color of heartwood (dark) and sap wood (yellow).
Reference


CTSP, 2004. Cambodia Tree Species Monographs, Cambodia Tree Seed Project, Forestry Administration. Phnom Penh


FA & CTSP, 2005. Guideline for Site Selection and Tree Planting in Cambodia, Forestry Administration (FA) and Cambodia Tree Seed Project (CTSP), Phnom Penh.


Dipterocarpus alatus Roxb

Local name : Chheu Teal Teuk
Scientific name : *Dipterocarpus alatus* Roxb
Family : Dipterocarpaceae

1. Botanical description

*Dipterocarpus alatus* is a large tree up to 40 m height and 2 m dbh with a clear bole of about 20 m. Bark thin, smooth greyish. Leaves 10-20 cm long, elliptic or oval, dark green on the upper surface, light green and with stellate hairs on the lower side.

2. Natural distribution and habitat

The tree is indigenous to Bangladesh, Cambodia, India, Myanmar, Philippines, Thailand, Laos and Vietnam. It is a canopy tree that belongs to the evergreen or semi-evergreen forests, often occurring in areas with heavy rainfall. Within the area of natural distribution it is found at 0-500 m altitude with annual rainfall of 1,100-2,200 mm and mean annual temperature of 20-30°C. Seedlings are tolerant to shade and they can survive under the forest canopy for years. The bark is thin and does not withstand fire well and once burnt, seedlings and saplings hardly recover (Joker 2002).

3. Uses and products

*D. alatus* wood is good for construction, board, furniture, tools and household materials. It produces resin that is used in paint industry (Hoang et al. 2004). One mature tree is able to provide 30-35 liters of resin annually (FA 2010).

4. Seed source

As the tree is widely planted in Cambodia, particularly, in the pagoda compound, therefore, finding mature trees for seed collection is not difficult. One of the good seed sources is the area inside Angkor Thom, Siem Reap province (CTSP 2003).

5. Seed collection and processing

Flowering occurs in January - February and fruiting occurs in April - May. Some fruits ripen as early as January but they are invariably attacked by insects. There are about 260 seeds per kilogramme fruits. Seed collection should be done at the peak of fruiting when the wings of the fruits turn from green to brown, and the fruit-coat changed from green to grey. Trees with the age of 10 years start producing flowers, but seed should be collected from trees older than 15 years. Collection the seed on the ground is widely practiced in Cambodia. Seeds should be collected every day days to avoid damage by insect (Joker 2002).
6. Seed pretreatment method

Seed should be sown immediately after collection as the germination rate drop quickly. For example, two weeks after seed collection the germination drop to 50% (Sam and Nghia 2002). The seed is recalcitrant, which is not dormant, therefore seed pretreatment is not required. However, soaking the seed in water for four hours will help increase the germination rate (LTSP 2009).

7. Plantation establishment

Seedlings which are about 0.60-0.80 m tall and at the age of 12-14 months old are appropriate for planting in the field. Planting should be done after the first rainfall of the rainy season in order to archive successful result (Sam and Nghia 2002). Artificial or natural fertilizer should be used to enhance seedling growth, depending on the soil conditions. In a diameter of 0.50 m around each seedling, 10 gram of fertilizer NPK 15-15-15, 16-20-00 or 46-00-00 is applied after one month of planting. A second application of 50-100 g is given after two - three months, and another one at the end of the rainy season (LTSP 2009). Dipterocarpus alatus can be planted with the spacing of 3 × 3 m or 4 × 4 m leading to the density of 1,100 trees/ha or 600 trees/ha, respectively.

Plantation maintenance should be carried out for the first seven years. During the first three years, weeding and cutting climbers should be done at the beginning of rainy season and at the end of rainy season. And in year four and year five, thinning the shoot and shaping the stem should be done to get better shape trees. In year six and seven, canopy opening and thinning to regulate the density should be undertaken. Ten years after planting, thinning should be carried out leaving a final density of about 280-300 trees/ha (4× 8m or 6× 6m) (Sam and Nghia 2002) (Sam and Nghia 2002).

8. Growth and Yield

Base on the field measurement conducted in 2013, 28-year-old D. alatus has the height and diameter of 17 m and 38 cm, respectively (Annex 1). The increment of wood product is 10 m³/ha/year (Kha et al. 2003). Current local price of D. alatus wood in Cambodia is USD 600/m³ (Pers. comm. with wood seller in Phnom Penh, 05 April 2014).
A: *Dipterocarpus alatus* tree in natural forest in Mundolkiri province. B: A resin tapping hole from *D. alatus*. Its resin is an important NTFP of this species. C: Fruits of *D. alatus*. 
Reference


Dy Phon, P. 2000, Dictionary of Plants used in Cambodia, Olympic printing House, Phnom Penh.


Kha, L.D., Lieu, N.X., Nghia, N.H., Thinh, H.H., Dong, H.S., Quan N.H. and Me, V.V., 2003, Forest Tree Species Selection for Planting Programmes in Vietnam, HANOI.


**Dipterocarpus intricatus** Dyer

Local name: Trach  
Scientific name: *Dipterocarpus intricatus* Dyer  
Family: Dipterocarpaceae

1. **Botanical description**

*Dipterocarpus intricatus* is a large deciduous tree that can grow up to 30 m high and 80 cm in diameter. Twigs and buds are covered with many star-shaped grey yellow to brown hairs (Dy, 2000). The bark surface is grey brown or dark brown and longitudinally splitted into pieces. The inner bark is orange pink in color, and is 8-10 mm thick or more. The leaves are simple, alternate and egg-shaped to oblong with a wedge-shaped base and a blunt leafrip, 10-30 × 8-14 cm in size, and the leaf is hairy on both surfaces. The secondary veins occur in 14 (-21) pairs. Petioles are 3-4.5 cm long. The stipules are 3 cm long. Inflorescence is racemose, 16-18 cm long, and has 2-4 branches on which consist of 6 to 8 flowers each. Fruit is obovoid and has five wings. The color of the fruit changes from red (when young) to brown (when mature) (Tan Dung 1996).

2. **Natural distribution and habitat**

*Dipterocarpus intricatus* is a native species of Cambodia, Vietnam, Thailand, and Malaysia where it is commonly found in dry deciduous dipterocarp forests. It is sometimes found with other Dipterocarps species such as *Dipterocarpus obtusifolius* and *Dipterocarpus tuberculatus* on ferrallitic or sandy soil (Appanah and Turnbull 1998).

3. **Uses and products**

The color of sapwood is reddish while the heartwood is dark red in color. Wood density is 0.66-0.93. The wood is durable, and hard (Appanah et al. 1998). So it is commonly suitable for house and carts construction. The grey brown resin collected from the tree is commonly used for torches production (Dy Phon 2000). The oleoresin can also be used for industrial use purpose such as producing paint and varnish (Luu et al. 2007).

4. **Seed source**

There is no identified seed source of *D. intricatus* in Cambodia. However, seeds can be collected from a number of places, such as O Sandan communce, Rolea Phea District, Kampong Chhnang province.

5. **Seed collection and processing**

Flowering starts in January and fruiting occurs from March to April (Tan Dung 1996). The average seed number per kilogram is 1,200 seeds (Appanah and Turnbull 1998). Seeds can be
collected from the trees or at the grounds. *Diptercarpus intricatus* is recalcitrant seed which is has short-live viability, therefore, is not recommended.

6. Seed pretreatment method

The seed of *D. intricatus* required no pretreatment method. So, after seed collection is done, the seeds should be sown immediately in the nursery bed (CTSP 2003).

7. Plantation establishment

When the seedlings are planted in open areas shade trees are used, such as *Acacia auriculiformis*. Usually, the seedlings will be tended in nursery for about nine month until they reach the height of 50 cm before planting out in the field (Appanah, and Turnbull 1998).

Dipterocarpus seedlings and saplings can persist in the forest for years under heavy shade. In the first two years, major openings in the canopy are not tolerated, but after the seedlings are well established (about 120 m tall) the canopy can be opened to speed up growth. Many species regenerate well only in primary forest (Digital Species).

8. Growth and Yield

At the age of 18 years old *D. intricatus* has the diameter of 19 cm and the height of 12.5 m (Annex 1). The price of sawn wood is not much different from other dipterocarp species, it is about USD 350 /m³ (Pers. comm. with wood seller).
A: *D.intricatus* tree with straight bole in deciduous forest. B: Bark of *D.intricatus*. C: Young fruit of *D.intricatus*. D: Hairy leaves of *D.intricatus*. 
Reference


CTSP, 2005. Guideline for Site Selection and Tree Planting in Cambodia. Cambodia Tree Seed Project (CTSP), Phnom Penh.


**Peltophorum dasyrhachis**

Local name: Tra Sek  
Scientific name: *Peltophorum dasyrhachis*  
Family: Leguminosae

1. **Botanical description**

*Peltophorum dasyrhachis* is a large-sized timber species with a height up to 25m and dbh 50-60 cm. Bark has many rings around the stem, peeled when mature, pale brown in colour. Bole straight with small buttress. Leaves bipinnately compound, 7-16 pairs of secondary particles, each with 5-12 pairs of leaflet, ovoid-elliptic, 1cm long, 4-9 mm wide. Young leaves ferruginous, stipule caducous. Inflorescence apical racemose. Flowers with bracts, caducous, petals yellow. Pedicel is 2-3 times longer than the bud. Fruit flat, 9-13 cm long, 2.3 cm wide, brown in colour. Seed arranged in 45° angle in the fruit. Seed is covered by hard coat (Sam and Nghia 2002).

Flowering season occurs between February-April and the fruit ripen from July-October (Sam et al. 2004). One kilogram of seed contains about 9,500-11,000 seeds (Sam and Nghia 2002).

2. **Natural distribution and habitats**

*P. dasyrhachis* is distributed in Cambodia, Vietnam, Thailand, Laos, Indonesia and Malaysia. It is widely planted in the tropical areas (Sam et al. 2004). It is found below 1,000 m a.s.l. The species is distributed in regions with a range of annual rainfall between 700 and 2,500 mm with one to three months of dry season and mean annual temperature between 20 and 25°C. It grows on many reddish yellow feralit soils on mica schist, gneiss, reddish basalt, sedimentary soil. *P. dasyrhachis* is a light demanding species. It usually occupies the upper storey of secondary forests. It has a strong regeneration capacity in large opened areas in forests and at forest margins. It is usually found mixed with other broad-leaved species in evergreen forest such as *Canarium* sp., *Lithocarpus* sp., *Cinnamomum* sp. and *Erythrophloeum fordii* (Sam and Nghia 2002).

3. **Uses and products**

It is commonly planted for shading and ornamental purpose because of shady crown and beautiful yellow flowers. It is distinctive between sapwood and heartwood which is pink in colour. Specific density is 0.7. Wood is used for making furniture, household utensils and in construction (Sam and Nghia 2002). The timber of *P. dasyrhachis* is also suitable for poles, railway sleeper and for construction of boats and ships (Sam et al. 2004). In the first half of the 20th Century, *P. dasyrhachis* was used as a shade tree mainly in the coffee plantations in Java. In central Thailand, it is maintained after bush fallow as a shade tree for fruit trees and for its role in...
soil improvement. It is used in the reclamation of grassland dominated with *Imperata cylindrica* (Hanum and Maesen 1997).

4. **Seed source**

There is no identified seed source of *P. dasyrhachis* in Cambodia. The trees are scatters abundantly in open areas inside degraded forest or at the forest margins.

5. **Seed collection and processing**

With the age of 10 years old, *P. dasyrhachis* produce flowers. However, fruit should be collected only from trees over 20 years of age and over. A period between July and August is the fruits collection season. Fruits should be sun dried and beaten to release the seeds. The coat of fruit is very coriaceous. After being taken from the fruit, seeds should be dried before storage. Germination rate about 70% is obtainable after two years of storage (Sam and Nghia 2002).

6. **Seed pretreatment method**

To increase germination rate, the seed should be placed in boiling water and then leave it to cool down. The seed is sown in pot when it begins sprouting (Sam and Nghia 2002).

7. **Plantation establishment**

The seedlings aged between five and six months old with height of 30-50cm is suitable for planting in the field (Sam and Nghia 2002). The recommended spacing for *P. dasyrhachis* is 3 × 3 m making the density of 11,000 plants/ha.

Maintenance of the species should be done for the first three years. Pruning is the most important silviculture practice for good stem shape (Sam and Nghia 2002). Weeding is also recommended to reduce the competition for nutrition.

8. **Growth and yield**

This tree is a light demanding species. In 1984, there was an experiment on planting *P. dasyrhachis* on poor forest soil in Vietnam. After planting for one year, the survival rate was 90%. The length of bole of this species does not meet the standard of commercial timber. *P. dasyrhachis* with the age of 10 years old reached the height of 14 m and the dbh of 15 cm (Annex 1). The price of sawn wood of *P. dasyrhachis* is about USD 600/m³ in Phnom Penh (Pers. comm. with wood seller in Phnom Penh, 05 April 2014).
A: *P. dasyrhachi* tree at the age of 10 years old in an experimental plot in the Kbal Chhay Watershed Protected Area. The tree reaches the height of 14 m and the dbh of 25 cm. **B:** Ripped fruit of *P. dasyrhachis*. **C:** Beautiful yellow flower of *P. dasyrhachis**. **D:** Leaves, flowers and fruits of *P. dasyrhachis*.

**Reference**


Tarrietia javanica BL.

Local name: Daun Chem
Scientific name: Tarrietia javanica BL.
Family: Sterculiaceae

1. Botanical description

Tarrietia javanica is a large tree with a total height up to 30-45 m. It has a straight, round bole with dense canopy. Leaves palmately compound with 3-7 leaflets, glabrous on upper surface but with tufts of hairs in the axils of secondary veins; petioles 5-10 cm long, blade 7-15 cm long, obovate with pointed apex. Inflorescences are axillary panicles. Flowers lacking corolla, small, reddish, unisexual, in large (to 13 cm long) terminal panicles. Male and female flowers usually bear sterile organs of the other sex (Joker 2004).

2. Natural distribution and habitat

Tarrietia javanica is indigenous to Indochina, Thailand, Malaysia, Indonesia and the Philippines (Soerianegara, 1994). It is commonly found in evergreen and semi-evergreen lowland forests with latitudes below 800 m a.s.l. and annual rainfall about 2,000 mm. It usually grows on well-drained clay or lateritic soil. In natural forests, it is in the upper storey.

3. Uses and products

Tarrietia javanica is a good general purpose timber. The wood is fairly resistant to fungi, termites and salt water. It is suitable for indoor construction, furniture, flooring and joinery. Sometimes, the wood is used for ship building and outdoor construction purposes, such as telegraph poles and bridges.

4. Seed source

There is one identified seed source of Tarrietia javanica located in Mean Rith commune, Sandan District, Kampong Thom province. The total area of the seed source is 117 ha. This area is home to other high-value timber species, such as Sindora cochinchinensis, Anisoptera costata, Shorea farinosa, Shorea guiso and Dipterocarpus costatus. Accessibility to the area is possible through motorbike (20 km) during the dry season. Currently, there is no big threats to the seed source as it is located in a remote area. Seeds can be sources from other parts of the country, such as Pursat, Koh Kong and Rattanak Kiri province.

5. Seed collection and processing

Trees flower in January-February and fruiting occur in May-June. The mature fruit is brown in color and it can be collected. The seed need to be dried in the sun to lower moisture content for
longer storage. Moisture content for storage should be reduced to 9-10%. After drying, 50% of the fruit weight might be lost. Wing can be removed to reduce bulk. Under ambient storage conditions seeds will lose viability within six months. Storage at 5-10°C can maintain viability for more than one year (Joker 2004).

6. Seed pretreatment method

There is no dormancy, but the pericarp exhibits some restriction to water uptake. Removal of the outer pericarp or/and soaking in tap water overnight to enhance germination. Seeds can be sown in seed bed, which need transplanting later, or poly-pots directly and cover the seeds with about 1 cm soil. Germination is hypogeal. Germination starts after 7 days, and ends after 20 days. Germination rate is about 70% for fresh seeds.

7. Plantation establishment

No large-scale plantation of this species is found in Cambodia. *Tarrietia javanica* grows and develops well on feralit soil generated on acidic magma, sandstone, deep soil layer, abundance of nutrients. Thus *T. javanica* can be planted on depleted secondary forest soil. Planting under partial shading, 50% shading, was reported in the initial stage (Sam and Nghia 2002). However, the trial in Kbal Chhay (Preah Sihanouk province) demonstrates that the species can be planted under the full sun from the initial stage. Seedlings can be produced by stump cutting, and the survival rate is about 60% (Moon *et al.* 2011). For plantation establishment, the spacing suggested is $3 \times 4$ m, so the number of trees is approximately 830 trees per ha (Moon *et al.* 2011).

Weeding is recommended to promote the growth of young seedling during the initial grow. Tending is needed in five to seven consecutive years till canopy closure. If plantation is established under partial shading, light adjustment is required. Thus in the tending process During the first three years, conduct weeding twice a year at beginning and at the end of the wet season. Cutting climber is also needed. From year four to year six, conduct canopy opening and stem shaping. At year seven, thinning, adjusting the density and creating suitable growing space for planted trees are necessary (Sam and Nghia 2002).

8. Growth and yield

Data from the field trial in Kbal Chhay Watershed Protected Area (annual rainfall about 3,000 mm) indicate that the trees reach an average height of 12 m and dbh of 20 cm at the age of 10 years old (Annex 1). The annual wood increment of *T. javanica* is 10-13 m$^3$/ha (Kha, 2003). The wood of this species is range between USD 700 and USD 900/m$^3$ (Pers. comm. with wood seller in Phnom Penh, 05 April 2014).
A: *Tarrietia javanica* trees at the age of 10 years old planted in an experimental plot at Kbal Chhay Watershed Protected Area. It can reach to 20 cm in diameter and 12 m in height. **B:** A seedling of *T. javanica* in a field plantation. **C:** A section log of *T. javanica* showing the color of the wood and bark.
Reference


FA & CTSP, 2005. Guideline for Site Selection and Tree Planting in Cambodia, Forestry Administration (FA) and Cambodia Tree Seed Project (CTSP), Phnom Penh.


Kha, L.D., Lieu, N.X., Nghia, N.H., Thinh, H.H., Dong, H.S., Quan N.H. and Me V.V. 2003. Forest Tree Species Selection for Planting Programmes in Vietnam, HANOI.


**Hopea odorata** Roxb.

Local name : Koki Msao  
Scientific name : *Hopea odorata* Roxb.  
Family : Dipterocarpaceae

1. **Botanical description**

*Hopea odorata* is a large tree which can grow up to 35 m tall (Dy Phon 2000) with the maximum diameter of 120 cm. Trunk is straight and round up to 15-25m. The wood density is about 98g/cm³ with the moisture content of 15%. Wood has a light and gray-yellow color. Bark color is dark grey-brown, usually exuding droplet of yellowish resin. Leaf is narrowly ovate, almost oblong and rounded base, 8-16×3-7.5 cm size. Young leaves densely covered with grey star-shaped hairs and mature leaves are dark green. Flower is yellow, 0.8-1 cm, where branching sprays of up to 50 flowers at the end of twigs and upper leaf axils (Gardner et al. 2007). Fruit has two long wings, slightly narrowed towards the base, and three much shorter wings, overlapping but not completely covering the nut (Gardner et al. 2007).

*Hopea odorata* reaches reproductive maturity at the age of more than 10 years. Flowering season occurs from January to March and fruiting occurs from April to May. Mast fruiting occur at more or less regular intervals every two years. There are about 1,400 to 2,200 fruits per kilogram equal to 3,000 to 4,600 seeds (Orwa et al. 2009).

2. **Natural distribution and habitat**

*Hopea odorata* is found in dense forests in the Indochinese, Malay Peninsula and Andaman islands in Cambodia, Laos PDR, Vietnam, Thailand, Myanmar and India (Dy Phon 2000; Toyama 2013). The tree growing in lowland evergreen and mixed deciduous forests, along streams on deep rich soil (Ashton 1998). Record of the World Agroforestry Center 2013, showed that *H. odorata* can grows commonly along the streams and situation up to 600 m altitude, mean annual rainfall 2,200 to 5,000 mm and temperature 36-40 °C.

In Cambodia, the tree grows in small group or alone in dense evergreen forests in wet and deep soil. It is found in Kratie, Koh Kong, Kampong Thom, Steung Treng, Preah Vihear, Ratanak Kiri, and Siam Reap provinces.

3. **Uses and products**

The wood is a strong light hardwood used for construction, furniture, veneer, railway sleepers train-carriages and boats (Joker 2000). In Cambodia, the wood is widely used in construction of traditional racing boats. The wood is hard and heavy (755 kg/m³) and resistant to termites (CTSP 2003). The bark contains tannin that is suitable for tanning leather (Joker 2000). The bark is used to treat diarrhea and as part of remedy for the treatment of inflammations of the gums and
incontinence. The bark can replace areca nut in betel quid (Dy Phon 2000). The tree is sometimes used to provide shade and for reforestation in Southeast Asia (Orwa et al. 2009).

4. Seed source

As the tree is widely planted in Cambodia for shading and street beautification, particularly, in the pagoda compound together Dipterocarpus alatus, finding mature trees for seed collection is not difficult.

5. Seed collection and storage

The fruit collection season is from April to May when fruits turn from green to yellow brown and the wing-tips are grey-red. It is recommended to collect the fruits directly from the tree by climbing or by shaking the fruiting branches over tarpaulins. Fruits collected from the ground have low viability or are already damaged by insects. Fruits should be kept in baskets out of direct sunlight. The wings of the fruits should be removed by hand before storage. Seed are recalcitrant and die within five days due to dehydration. If dried at 35 °C with moisture content of 33%, seeds could stay viable for 1-2 months at 15°C (with a germination rate of about 60%). If stored at 4°C, the seed can stay viable for about three months (Orwa et al. 2009).

6. Seed pretreatment method

Seeds are not dormant and do not need pretreatment. Seeds can be soaked in tap water for 8 hours before sowing. After 7-15 days of sowing, seedlings can be transplanted into polythene bags. Soil mixture for the sowing bed should contain 3 parts of sand and 1 part of forest topsoil. Potting mixes for filling the polythene bags contain about 70% of topsoil and 30% of composted cow dunk. Sometime up to 10% of coconut-husks can be added to the mix to improve the root formation (LTSP 2009).

7. Plantation establishment

Seedlings reaching total height of 40 to 60 cm are suitable for planting. One month before planting, the seedlings need to be hardened off by exposing the seedlings to direct sunlight. A suitable spacing for *H. odorata* is 3 × 3 m or 4 × 4 m. *Hopea odorata* is needed to maintain at the first five years (Chanhsamone et al. 2012). Weeding should be carried out 2 times per year with the first weeding after 3 months of planting. Thinning should be carried out when the canopy closes.

8. Growth and yield

*H. odorata* is best grown in open areas. Result from an enrichment planting in a degraded forest in Siem Reap province indicates that the survival of *H. odorata* was 88 at 18 months (Sobon 2013). The prospected height growth in 5 years of the *H. odorata* was 7.40 m (Parsada 2013). Data
collected from Kampong Thmar Forestry Administration Division, Kampong Thom province, indicate that the total height of 15 m and dbh of 24 cm are achievable at the age of 18 years old.

*Hopea odorata’s* log is worth at least three to four times more than acacia logs, they take at least 30 years to mature (Ives 2010). The timber price of *H. odorata* in Chaomksan District, Prah Vihear province, the original source of timber, is USD 150/m³. However, the timber price in Phnom Penh is approximately USD 700/m³ (Pers. comm. with wood sellers, April 2014). At the international market, the timber price of *H. odorata* is approximately USD 1,500/m³ (FOB 2014).

A: A stand of *Hopea odorata* in Chaomksan District, UTM (494260-1571454), age more than hundred years old. B: Narrow leaf, ovate and rounded base, mature leaves are dark green and flower yellow color, where branching sprays of up to 50 flowers at the end of twigs and upper leaf axils. C: Fruit has two long wings, slightly narrowed toward the base and closed to the round nut. D: *H. odorata* seedling planted under the canopy of *Acacia* sp. age one year old.
Reference


Pterocarpus macrocarpus Kurz

Local name : Thnong
Scientific name : Pterocarpus macrocarpus Kurz
Family : Leguminosae

1. Botanical description

Pterocarpus macrocarpus is a large tree with a total height up to 30 m and dbh of 70 cm. It is found in dry evergreen and deciduous forests (Dy Phon 2000). Leaves are odd-pinnate with 3-6(9) pairs of alternate leaflets. They are oval with abruptly pointed tip and rounded base. Young leaves are densely hairy, and mature leaves are bright green, smooth above but with scattered brown hairs on stalks and veins below. Flowers are bright yellow arranged in unbranched clusters at leaf axils. Fruit is circular, with a broad, wavy wing surrounding the central seeded capsule (Gardner et al. 2007). There are about 1,400-2,000 winged fruits per kg, 3,600-5,000 dewinged fruits per kg and 25,000 seeds per kg (LTSP 2009; Joker 2000).

2. Natural distribution and habitat

Pterocarpus macrocarpus grows naturally in Cambodia, Laos, Vietnam, Thailand, and the greater part of Myanmar. It is seen distributed in the areas with altitude of 100-800 m a.s.l. with annual rainfall between 1,000 and 2,000 mm and a mean annual temperature of 23-27 °C (Joker 2000). This species prefers well-drained, light textured soils with shallow depth and poor in humus. Its habitats are open deciduous and dry evergreen forests, of the provinces of Kampong Thom, Steung Treng, Preah Vihear, Ratanakkiri, Kratie, Siem Reap, Kampot, Pursat, and Mondulkiri (Sareth 2002).

3. Uses and products

This species produces a strong wood and valuable timber which is used for luxury furniture, cabinetwork, art handicrafts, musical instruments and floor (CTSP 2003). In Cambodia, the wood is classified in the luxury category. In Thailand, it is one of the main exporting timbers (Joke 2000). The bark provides a red dye and tannin. It is a nitrogen-fixing tree which is suitable for agroforestry systems and soil improvement (LTSP 2009).

4. Seed sources

The species is widely distributed in Cambodia; therefore, finding mature trees for seed collection is not difficult. There are two identified seed sources in Siem Reap province, one each in Svay Loeu and Chikreng Districts. In addition, seeds can be ordered from a community forest in Kampong Leng District, Kampong Chhnang province (Phnom Neang Kangrei).
5. Seed collection and storage

Flowering is in March to May and fruiting in December to February. Generally, fruit ripening starts in late of October. The flowering period only takes about 2 weeks. The fruits remain on the tree for several months (LTSP 2009; CTSP 2003). The seeds are mature and collected when the fruits turn from greenish yellow to straw color or light brown and dry. They are collected by shaking branches or clipping with pruning poles (Francis 1989). Pterocarpus macrocarpus are orthodox seeds that can be stored (place in airtight containers) in a cool, dark place. At moisture content about 10%, the seeds can be stored for one year storage (Francis 1989; LTSP 2009; FAO 1989).

6. Seed pretreatment method

Before sowing, the wing is removed then the fruit is dried under the sun light. It is a very hard work to remove the wing that most places are not performed (Joker 2000). The seeds are needed to soak in warm water with temperature of 35-40 °C for 10 minutes, the germination should be started at 4-15 days (FAO 1989). As a result, the germination rate is 70% after 5 days. In case of wingless fruits germination, the rate is only 64% after 11 days (CTSP 2003). After the true leaves developed, the small seedlings are transplanted from the bed into plastic bags (Joker 2000).

7. Plantation establishment

Seedlings are ready to plant at the age of 8-12 months with the height of 40 cm. In Cambodia, the spacing for planting is 4 × 4 m (CTSP 2003). Replacement planting can be carried out after 2-4 weeks (LTSP 2009). Thong is a light demanding and drought-tolerant tree, so only weeding can be practiced to improve growth (Saret 2002). Weeding is carried out 2 times per year for 5 years. The first weeding is undertaken after three months of planting. Pruning of branches to improve the stem form can be done after 5 years. Thinning should be carried out at every 5 years in rotation periods of 60 years (LTSP 2009).

8. Growth and yield

Data collected from a small plantation in Prey Veng province indicate that *P. macrocarpus* reaches a total height of 18 m and dbh of 34 cm at the age of 28 years old (Annex 1).

The rotation for harvesting timber of *P. macrocarpus* is 60 years (LTSP 2009). However, a farmer in Takeo province started harvesting his planted trees at the age of 25 years old (Manigo, 2014). The price of this species in the market in Phnom Penh is USD 1,500/m³ (Pers. comm. with wood seller in Phnom Penh, 05 April 2014). At the international market, the price at Thailand port is USD 2,000-2,200/m³ (FOB 2013).
A: A Pterocarpus macrocarpus tree in its natural habitat. B: Leaf odd pinnate, alternate and rounded base. C & D: Fruit with a broad, wavy wing surrounding. E: Bark thick, outer bark light brown, sap dark red. F: Seedlings of P. macrocarpus in a germination tray, age approximately 7 days.
References


**Pinus merkusii Jungh & de Vries**

**Local name**: Sral  
**Scientific name**: *Pinus merkusii* Jungh & de Vries  
**Family**: Pinaceae

### 1. Botanical description

*Pinus merkusii* is a large tree with height from 30 m and the diameter of 80 cm (Dy Phon 2000). Sometimes, it can grow up to 70 m tall that making it one of the world’s tallest pine (Rozal 2005). Trunk looks straight and cylindrical bole. Young trees have pyramidal or conical crown form while old trees have a flatter and spreading crown. Bark is rough and thick. Leaf is 15-25 cm long, and needles are in bundles of two (Gardner et al. 2007). Flower is monoecious in which male flowers are borne in clusters or spikes at the lower part of the crown with 6-10 cm from the branchlets and the female flowers are at a few centimeters over the male. Fruit is cylindrical cone with 5-10 cm length, 2-4 cm wide and up to 10 cm wide after opening (Reungchai et al. 1986). There are about 30,000 seeds/kg (Reungchai et al. 1986).

### 2. Natural distribution and habitat

*Pinus merkusii* is found in South East Asia, including Cambodia, Thailand, Vietnam, Burma, Laos, Indonesia (Sumatra) and the Philippines. It is the only species that occurs naturally at South of the equator (Jajat and Christian 2002; Razal 2005). In Cambodia, this species is seen in pure or almost pure stockings on the Kirirom plateau and covers about 12,000 ha (Dy Phon 2000). It is also found on nutrient-deficit sandy soil of dry deciduous forests in Kampong Thom province. The suitable altitude ranging from 30 m to over 1,800 m a.s.l. with mean annual rainfall from 1000 mm to 3,800 mm. It is found growing in cold areas where mean annual temperature varies between 19 °C and 28 °C (Jajat and Christian 2002).

### 3. Uses and products

*Pinus merkusii* produces softwood which is useful for construction and joinery (Reungchai et al. 1986). It is needed in high demand for local construction such as cottages, cabinetwork, woodwork, and casing and for making railway carriages and boats. Some countries have been practiced commercial tapping of resin that can provide crude gum in the yield of 30-60 kg per tree (Reungchai et al. 1986). The wood also has high resin content, which is a precious material for medicine, paints, printing and the perfume industry (Rozal 2005). The production capacity of pine gum resin of the Indonesia is more than 1.66 tons per year, and Indonesia is the largest resin producer after China and Portugal (Wiyono et al. 2006).

### 4. Seed source
There is no identified seed sources of *P. merkusii*. The best place of collection of seeds is Kirirom National Park.

5. Seed collecting and storage

*Pinus merkusii* starts flowering from October to November and producing fruit from May to June. (Jajat and Christian 2002; Nghia 2004). The seeds have no specific color or pale yellowish brown and black, but some have color in uniform or pale reddish brown. Naturally, the wind is a factor to make seed dispersal from March to June (Reungchai *et al.* 1986).

Normally, the seeds are collected by climbing the tree and removing the ripe cones before they are dispersed by wind. The right time to collect the cones is when they have changed color from green to brownish or cut to see white color and solid endosperm on the entire space of the seed (Jajat and Christian 2002). The cones should be kept in well spaced bags on the racks about 50 cm off the ground under shelter in order to allow free air circulation. They are kept until all cones have turned completely brown (it may take 7-14 days).

In order to keep the seeds for long time, the seed should be dried to 8% of moisture content and packed in the polythene bag. Then, store the seeds in a cold room with temperature of 4-5 °C (Reungchai *et al.* 1986).

6. Seed pretreatment method

An easy way, the seed is soaked in tap water for 24 hours before sowing so that germination can be preceded fast. It takes 7 days for germination after sowing and germination often reaches 80% after 12-15 days. The seed usually is sown in containers (1-2 seeds in a container) or in sowing bed (Jajat and Christian 2002). When the seedling reaches 3-4 cm tall, it is transferred to containers. The seedling takes 9-10 months of growing in the nursery (Jajat and Christian 2002).

7. Plantation establishment

*Pinus merkusii* can be plant on bare or bushy hills, having the function of protecting against erosion and land-deformation (Jajat and Christian 2002). This species is generally good in open areas particularly when adequate protection from fires and other disturbances (Rozal 2005). For timber production the spacing is $3 \times 2$ m, and for resin production the recommended spacing is $4 \times 4$ m (Soerianegara and Lemmens 1994). *Pinus merkusii* is required more weeding even it can grow in poor soil. In plantation, thinning usually practiced when it reaches 9 or 10 years old and thereafter every 5 years (Orwa *et al.* 2009).

8. Growth and yield

It is estimated that growth rate of this species is 22 m$^3$ per ha with the rotation of 25 years (Soerianegara and Lemmens 1994). In Indonesia, the rotation cycle is 30 years recommended for optimal timber production. A cutting cycle of 15 years is practiced for the production of
pulpwood. The mean annual increment of the tree is 22 m³/ha in a 25 years rotation. In Sumatra, the tree ages 30 years old can have average volume of 397 m³/ha and the yield of resin of 420-750 kg/ha (Orwa et al. 2009).
A: Trees and bark of *P. merkusii*. Bark is thick, ray-brown or reddish brown, deeply fissured. B: Wood is slightly yellowish, C & D: Young trees with flowering and have pyramidal or conical crown form. E: Young seedlings with the age less than 1 month are prepared to displaying in national Arbor Day at Mundulkiri province. F: Seedling with the age of 2-3 months in a nursery.
Reference


**Toona sureni** (Blume) Merr.

Local name : Chham Chha  
Scientific name : *Toona sureni* (Blume) Merr.  
Family : Meliaceae

1. **Botanical description**

*Toona sureni* is a medium-sized to fairly large tree growing in dense coastal formations of Southeast Asia (Dy Phon 2000). It is a deciduous tree with height up to 40 m and diameter up to 100 cm or rarely reaches to 300 cm in mountainous areas (Dharmavati 2003). The tree has a straight stem and buttress at the base. Bark is thick, brownish grey color. Leave rarely odd pinnate, paripinnate and alternate, leaflets usually have eight pairs, nearly opposite, base unequal and margin entire. Flower is bisexual, corolla white bisexual or yellowish white with strong smell. Fruit is a capsule. Seed is flat, brilliantly brown. It has wings at both ends (Huy 2002). Normally, there are about 64,000 seeds per kilogram (Orwa *et al.* 2009).

2. **Natural Distribution and habitat**

*Toona sureni* is found in evergreen and semi-evergreen forests, on riparian and slope hillsides. It is native to Bhutan, Cambodia, China, India, Indonesia, Malaysia, Myanmar, Nepal, Papua New Guinea, and Thailand (Orwa *et al.* 2009). This species is found in the area with altitude from 1,200-2,700 m, mean annual temperature around 22 °C and mean annual rainfall from 1,120-4,000 mm (Dharmawati 2003). It usually grows on deep, rich, moist, loamy soils with good drainage. It prefers fertile and moist soils (Lemmens *et al.* 1995). It also can grow on acidic or alkaline soils as well (Huy 2002). In Cambodia, the species is found in evergreen forests of Mondul Kiri province.

3. **Uses and products**

The wood is used for high class cabinet wood, furniture, interior finishing, decorative paneling, crafts, musical instruments, veneers and construction. The color of sapwood is pink and that of heartwood is light red or brown (Dharmawati 2003). Its bark and fruits produce essential oils. The bark and roots are astringent and tonic which is used to cure diarrhea (Orwa *et al.* 2009). *T. sureni* is one of potential plants to have some secondary metabolism compounds (Desi 2011). *T. sureni* roots and seeds can be used as medicines (Huy 2002). Its wood has 270-670 kg/m³ of density at a moisture content of 15%. The species is planted for windbreak in tea estates and also for shading roads. It is considered as an agroforestry species for intercropping with other species (Orwa *et al.* 2009). Moreover, leave of *T. sureni* is used as a material mixed with other local organic ingredient to make organic fertilizers as well as bio-pesticides (Irawan *et al.* 2012).
4. Seed source

There is one seed source of *T. sureni* in Andoung Kraloeung village, Dak Dam commune, O’Reang District, Mondulkiri province (UTM coordinates: 07 27 650, 13 58 515). The total area of the seed source is 4 ha. Mature trees are found along the road from Andoung Kraloeung village toward the headquater of Seima Protected Forest, between kilometer posts no. 60 and 80. There is no report about illegal cutting of the species. In Indonesia seed of *T. sureni* was rated at USD 32 /kg (Barokah 2014).

5. Seed collection and processing

There is no survey of flowering and fruiting season and study of seed handling technology of *T. sureni* in Cambodia. The following information is based entirely on literature.

Seeds of *T. sureni* can be collected, when the fruits turn brown, from April to May, the right time when they fruits just ripe. In Indonesia, the seed collection time is either March or October (Orwa *et al.* 2009). The method of seed collection includes shaking or cutting of branches before the fruits open to avoid losing seeds. After collection, the fruits are dried under the sun light for 1-2 days until they open. Then, the wings are removed from the seeds by dewinging and winnowing (Huy 2002).

Seeds can maintain their viability for 2-3 months or longer if they are stored in a cold room. A case study in Indonesia showed that seeds maintain their viability for 5 months, with 56% of germination rate, when they are stored in an air-conditioned room with temperature between 18-20 °C (Dharmawati 2003).

6. Seed pretreatment

Germination is easy because there is no requirement of seed pretreatment. The seeds are sown in seedbed with shade limited 60%. The germination reaches to 80% within 4-7 days and the seedlings can be transplanted into containers after one month (Dharmawati 2003).

7. Plantation establishment

*Toona sureni* is a fast-growing and light demanding species that require fertile soil. The sheltered valley with well drained areas without weed is good for natural regeneration. In plantation, the planting space is usually 1.5 × 1.5 m that is practiced in Vietnam. The tree can produce high productivity with yearly increment of 0.9 m of height and 1.4 cm of diameter (Orwa *et al.* 2009).

The species is noticed that its new shoots, flowers, fruits and seeds are attacked by a lepidopteran stem borer or tip moth, *Hypsipyla robusta*. The larvae also cause to lose of tree form because it tunnels the shoots. So, it is recommended to use pesticide in plantation to avoid the damages (Orwa *et al.* 2009).
8. Growth and yield

The experimental trial with *T. sureni* by enrichment planting in Vietnam show that the survival rate is low as many seedlings were damaged by shoot borers. The species has high growth increment 0.9 m/year, diameter increment 1.4 cm/year (Huy 2002). The harvesting cycle of the *Toona sureni* is more than 50 years (Con 2013). At the international market, *T. sureni* has a high price approximately USD1,000/m³, price at Shenzhen Yantian port (FOB 2014).
A: The *Toona sureni* tree, in the identified seed source in Andoung Kraloeung village, is marked for seed collection. B: A naturally regenerated sapling maintained by a villager, age about 2 years old. C: Leaves rarely odd pinnate, and alternate, 10 pairs, nearly opposite. D: Wood is medium hardness quality, yellowish color.
Reference


Azadirachta indica Ant. Juss.

Local name : Sdav
Scientific name : *Azadirachta indica* Ant. Juss.
Family : Meliaceae

1. Botanical description

*Azadirachta indica*, Neem tree is a fast growing tree, generally 20 m tall, sometimes up to 40 m tall with a crown diameter up to 20 m (Steve 2008). Bark is moderately thick and with small scattered tubercles, dark grey outside and reddish inside. Leave is alternate, crowded near the end of branches, simply pinnate, 20-40 cm long. Fruit is drupe, single seed, rarely 2 to 3 seeds, smooth, greenish or greenish-yellow to yellow or purple when ripe (ICRAF 2014; Steve 2008). Neem seed approximately 4,000 seeds per kilogram, annual seed production per tree is about 44,000 to 20,0000 seeds (Steve 2008).

2. Natural distribution and habitat

*Azadirachta indica* is native to Asia such as northern part of Myanmar and India. It is currently widespread introduced to South-East Asia, the Pacific Islands, Australia, South and Central America, the Caribbean, sub-Saharan Africa, and the Middle East (Stoney 1997; Steve 2008; Dhaliwal *et al.* 2004). Neem can adapt to a wide range of temperature and rainfall regimes. It can be established in hot and dry region, where altitude ranging from 0-1,500 m, mean temperature up to 40°C (Orwa *et al.* 2009), and annual rainfall from 450-1,150 mm (Lars *et al.* 2000).

As general observation, neem tree growth almost all provinces in Cambodia. The species grows on almost all kinds of soils including clayey, saline and alkaline soils. Neem also grows well on some acidic soil, but does not grow well on black cotton soils.

3. Uses and products

Neem is called “the tree of a thousand uses”. It is used for medicinal, cosmetic, agricultural pesticide and other purposes due to its antifungal, antibacterial, antiviral, pest-control and many more effects (Ajay *et al.* 2011). According to local knowledge, neem is used for fodder, soap, shade, soil conservation and insecticide (Lars *et al.* 2000). In India, local villagers apply neem oil to the hair to kill head lice. Neem seed oil and leaf was extracted to cure for psoriasis. It is also popularly used for tooth brushes every day and dentist reporting that it effectively preventing periodontal disease. Many research found that use of botanical insecticides produced from neem seed shows a strong potential in fight against agriculture pests (Ven *et al.* 2003). Neem is an excellent carving wood in Kenya (Alex *et al.* 2004). In Australia, various parts of the neem trees are used to treat fevers, thirst, nausea, vomiting, some skin diseases, heat rash and boils (Steves 2008).
4. Seed source

There is one seed source of Neem in Mongkul Borey District, Battambang province. As the species is widely distributed, finding seed bearing trees for seed collection is not difficult.

5. Seed collection and processing

Flowering of the *A. indica* generally occurs in the dry season and fruit ripening at the early of the rainy season. The tree starts flowering and fruiting at age 5 years old (Larset *et al.* 2000). The flowering season of Neem is from January to April and the fruits ripening time from May to August (Swaminathan *et al.* 2008). Neem seeds can be collected when its fruit turn to yellow green. Therefore, mature seeds are collected. After collection the fruits are depulped immediately. Neem seeds can store for 5 months at 40% natural moisture content at 16°C. Storing in shade room for 2 months will maintain the seeds viability (Shafie1 and Almahy 2012).

6. Seed pretreatment

The seed is soaked in tap water for 24 h and then remove the endocarp or cutting of the seed coat at the round end by a sharp knife. Kerala agriculture center record that germination rate of neem varies between 15% for stored seed and 85% for fresh seeds. Viability of seeds can be examined before sowing by cutting across the seed with sharp blade. If the cotyledons still green, it is viable and if they are yellow or brown, then seeds are not suitable for sowing. It is recommended that seeds should be sown four months before planting. The potting mix comprised of 50% sandy loam, 40% river sand and 10% composted fertilizers.

7. Plantation establishment

Seedling is ready to plant when the height is about 45 cm. Taller of seedlings will promote better survival rate. For plantation purpose under farm forestry a spacing of 5 × 5m is recommended. Two times weeding in the first year and one weeding during the second year is recommended. The first thinning should be applied at the age of 5 years old.

8. Growth and yield

Data collected from a plantation in Siem Reap province show that total height of 10 m and dbh of 17 cm is achievable at the age of 11 years old (annex 1). The main use of Neem is seeds for extracting oil, but the tree can be harvested for timber after 35-40 years of planting.
A: Leave is alternate, light green with 2 pairs of glands at base. Flower is an inflorescence an axillary and many flowered thyrsus. 

B: Fruit and seeds. Fruit is fleshy fruit.
Reference


**Xylia xylocarpa** (Roxb.) Taub.

Local name : Sokrom  
Scientific name : *Xylia xylocarpa* (Roxb.) Taub.  
Family : Leguminosae

1. **Botanical description**

It is a deciduous tree that can grow up to high of 25 m (Dy Phon 2000) and sometimes up to 40 m when it grows in moist and fertile soil. Trunk is straight with slender drooping branches (Gardner *et al.* 2007) and branchless is up to 12 m and 75 cm in diameter (Sosef *et al.* 1998). Bark is grayish to reddish with small lenticels kilogram (Schmidt 2004) and the inner part is pink (Gardner *et al.* 2007). The bark is thin and peeling in rounded flakes. Leaf is compound. There are about 3-7 pairs of leaflets and the top one is the largest. Young leaves are delicate with pink color and mature leaves are smooth with minute pale brown hairs below. Flower is pale yellow in dense spherical heads. Flower appears on non-branch clusters in axils of fallen leaves (Gardner *et al.* 2007). Calyx is in funnel-shaped, tomentose to woolly, and triangular-ovate, acute, with 2.9-4 mm long. Petals are narrowly oblong, acute and puberulous to tomentose with 3.5-4.6 mm long. Stamens contain pollen with 5-12 mm long and ovary is 2-2.5 mm long (Larsen *et al.* 1985). Fruit is thick and woody with 10-15 × 5-6 cm sizes and is slightly curved and gradually narrower at base. At first, the fruit is pale creamy brown then it becomes darker brown (Gardner *et al.* 2007).

2. **Natural distribution and habitat**

*Xylia xylocarpa* is naturally distributed in Cambodia, Vietnam, Laos, Thailand (Dy Phon 2000), and Myanmar spreading westward to India (Schmidt 2004). It is found growing in dense Dipterocarpus forest with frequent forest fires (Dy Phon 2000) and mixed deciduous forests (Larsen *et al.* 1985). This species can grow in the altitude up to 850 m with average annual rainfall of 1,200 to 1,700 mm (Larsen *et al.* 1985).

3. **Uses and products**

*Xylia xylocarpa* is classified in the first category. As a legume tree with light penetrable crown structure, it is suitable for planting in agroforestry system (Larbi *et al.* 2005). Wood is heavy, hard and durable which is resistant to insects, and is used mainly for construction (Larsen *et al.* 1985), houses pillars, cabinetwork, boat and making cart (Dy Phon 2000). The basic density of this species is 720 kg/m$^3$ at the moisture content of 50% (Josue 2004). Barks and fruits are used in traditional medicine (Schmidt 2004). Cambodian people use the bark to cure haemoptysies (Dy Phon 2000).
4. Seed source

Two identified seed sources were established by the Cambodia Tree Seed Project, one each in Siem Reap (Khun Ream commune, Banteay Srey District) and Pursat (Kampeng Community Forest, UTM coordinates: 03 74 329, 13 70 194) parovinces. Seeds can be collected from natural forests. *Xylia xylocarpa* is one of the main species of mixed deciduous forest which is dominated large part of the forest areas in Cambodia.

5. Seed collection and processing

Flowering starts from November to December after its leaves has fallen during dry season (Schmidt 2004). Fruiting season is between March and May. A fruit contains 5 to 10 seeds and there are about 4,000 seeds per kilogram (Schmidt 2004). After the seeds are mature, fruits or seeds are not easy to fall to the ground, and sometimes it extends to a long time until rainy season. Seed collection can be conducted when fruit changes color from green to yellow and looks dry. Pods start to open when they have stayed long time on the tree, so seeds can release from the pods to the ground. Climbing on the tree and using handled tools are good harvesting methods before seeds fall. Fruits have to be dried in full sun light until they are fully dried. Then, seeds can be removed from the fruits. The seeds can be stored for more than 2-3 years under room conditions (Schmidt 2004). It is recommended reducing moisture content of the seed to about 3% to avoid insect attacks and storing seeds in cool airtight containers (Schmidt 2004).

6. Seed pretreatment

Seed treatment can be done in several ways. For the freshly collected seeds, soaking in tap water over night is sufficient for promoting the germination rate. For the old seeds, put them in warm water, about 70-80°C, for about 1 min then leave them into tap water over night (Schmidt 2004). Clipping of seed coat at the oposit direction of hilum and soak seeds in tap water over night is also applied. After pretreatment, seeds can be sown into polythene bags. Seeds germinate after 5-8 days (Schmidt 2004).

7. Plantation establishment

Generally, seedlings can be planted in the field when they are 8-12 months old. *X. xylocarpa* is light-demanding species, so it can be planted in open area or associated with other species (Sakai *et al.* 2011). For timber production, normal spacing, either 3 × 3m or 4 × 4 m, is recommended. For fodder production, a narrow spacing is used, for example 2.5 m between rows and 0.5 m within rows (Larbi *et al.* 2005).

Seedling of *X. xylocarpa* is generally attacked by caterpillars (Schmidt 2004) so spraying of pesticide is necessary during nursery time. Fire break should be established around plantation because young seedling is not resistant to fire (Sosef *et al.* 1998). Silviculture practice is also important as it can improve growing rate and fodder for livestock.
8. Growth and yield

In Malaysia, this species is a priority species for plantation because of its fast growing (Josue 2004). At the age of nine years old, the tree can grow up to an average height of 23 m and dbh of 26 cm (Josue 2004). The seedling is favoured on loose, bare, and well drained soils under shade (Sosef et al. 1998). Seedling planting have been practiced successfully in India and Bangladesh (UNEP-WCMC 2007). This species can produce about 10 t/ha of litter annually when the tree is at the age of 26 years (Sosef et al. 1998). In a trial inside the Rubber Research Station in Chob, Thbong Khmum province, red soil, the tree reaches a total height of 10 m and dbh of 15 cm in six years. The growth may be slower than this in areas with lower soil fertility.

In Chhaeb District, PreahVihear province in 2014, sawn wood of *X. xylocarpa* is priced about USD 188/m³ (the origin of wood from natural forest). The price of sawn wood in Phnom Penh is USD 600/m³ (Pers. comm. with wood seller in Phnom Penh, 05 April 2014).
A: *Xyilia xylocarpa* in the middle of the dry season. Note that the trees are almost leafless. B and C: Fruit is thick and woody, slightly curved and narrow at base, the fruit is pale creamy brown. D: Leaf is compound with 3-7 pairs of opposite leaflets. E: Seedling planted in degraded forest age about 1 year.

References


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**Shorea guiso (Blanco) Blume**

Local name : Chor Chong  
Scientific name : *Shorea guiso* (Blanco) Blume  
Family : Dipterocarpaceae

1. **Botanical description**

*Shorea guiso* is a Dipterocarp species with the height of 20-40m (Dy Phon 2000), the diameter up to 200 (-300) cm and prominent buttresses up to 3 m high (Soerianegara and Lemmens 1994). Trunk is straight and cylindrical, and the bole can reach up to 25 m (Rudjiman and Adrijanti 2002). The wood density is from 675 to 1,000kg/m³ at the moisture content of 15% (Soerianegara and Lemmens 1994). Bark color is brownish grey, irregular scaly and soft flakes while inside surface is light pinkish brown and thin laminated (Rudjiman and Adrijanti 2002). Leaf is oblong lanceolate, thinly leathery and alternate. There are about 15 to 19 pairs of secondary veins (Soerianegara and Lemmens 1994). Flower petals are narrow with 20-28 stamens and few bristles (Soerianegara and Lemmens 1994). Fruit has 5 wings in which three are longer and two are shorter (Soerianegara and Lemmens 1994).

2. **Natural distribution and habitat**

*Shorea guiso* is indigenous to Cambodia, Laos, Vietnam, Thailand, Peninsular Malaysia, Sumatra, Borneo and the Philippines (Meijer 1974). In Cambodia, it is found in evergreen forests of Kampong Thom and Preah Vihear province at the altitude of 600 m (Dy Phon 2000). In natural forests, it is associated with other species that dominate the canopy cover, such as *Dipterocarpus costatus* and *Anisoptera costata*, but it is rarer. It is common in slightly seasonal climate area on well drained red soils in lowland forest and other parts of Borneo around limestone hills areas (Soerianegara and Lemmens 1994).

3. **Uses and products**

The timber is classified in the second category under Cambodian classification. The species is used for general construction, like *Dipterocarpus costatus*, *D. alatus* and *Anisoptera costata*, and veneer. The tree also produces resin which is mainly used for boat varnishing, furniture and preparation of the torches (Dy Phon 2000). The price of resin is about USD 0.9/kg in a village in Chheb District, Preah Vihear province. In Philippines, the timber is rarely seen to be used in heavy construction because of its low wood density (Soerianegara and Lemmens 1994).

4. **Seed source**

One idenproified seed source of *S. guiso* was established by the Cambodia Tree Seed Project in Kampong Thom province (see description of the seed source in *Tarrietia javanica*).
5. Seed collection and processing

Flowering season starts in January to February and it takes about two months to form as maturity fruits. Fruiting season is from April to May that is the time for seed collection (CTSP 2002). It is estimated that there are about 1,500 seeds per kilogram (CTSP 2005).

Seeds can be collected after fruits are mature. Seed collection should be done immediately when fruit falls naturally on the ground (Patricio 2006) or it should be conducted by cutting stems or shaking branches to release seeds. After collection, it should be kept in cloth bags and stored at a cool place (CTSP 2002). Seed can be stored more than one week (CTSP 2002).

6. Seed pretreatment

Remove wings manually before sowing. Seeds do not need pretreatment (CTSP 2002). They can be sown directly into plastic bags in the nursery and the germination rate can reach to 82% at the moisture content of 34% (CTSP 2002).

7. Plantation establishment

Shorea guiso was considered as endangered species (FAO 2005) and the most common species for plantation in the Philippines (Appanah and Turnbull, 1998). This species performs well in slightly moderated light intensity so initial shading is good condition for planting this species (Tomas 2012). However, trial in Kbal Chhay Watershed Protected Area indicates that the species performed well in the open area. The recommended spacing is $3 \times 3$ m in open plantation (FA and CTSP 2005). Weeding should be done after planting at least at the five years.

8. Growth and yield

S. guiso planted in the Kbal Chhay Watershed Protected Area reaches a total height of 11 m and dbh of 17 cm at the age of 10 years old. Sawn wood of S. guiso is priced about USD 188/m$^3$ in Chheb District, PreahVihear province (origin of the wood) in 2014.
A: A demonstration plantation of *S. guiso* in Kbal Chhay Watershed Protected Area, Preah Sihanouk province, B: Fruit with two wings E: Seeds after removing wings.

References


FA and CTSP, 2005. Guidelines for Site Selection and Tree Planting in Cambodia. Cambodia Tree Seed Project (CTSP), Forestry Administration (FA).


**Sindora cochinchnensis Baill**

Local name: Kokoh  
Scientific name: *Sindora cochinchnensis* Baill  
Family: Leguminosae

1. **Botanical description**

*Sindora cochinchnensis* is a deciduous tree which grows up to 15 m tall. Trunk is strait and solid-looking with big branches, rounded crown and spreading (Gardner *et al.* 2007). Young branches are finely pubescent and later glabrous (Larsen *et al.* 1985). When the tree is older, bark becomes slightly cracked and flaking. Leaf is 15-25 cm long and even-pinnate with 3-4 pairs of leaflets of 5-10 × 3-6 cm each. Flower is yellow-green arranged in narrow branched clusters at the end of twigs (Gardner *et al.* 2007). Fruit is dark green with, round and flat with a short curved tip (Gardner *et al.* 2007), and a fruit produces 1-3 large black seed which diameter from 1.5-2 cm (Larsen *et al.* 1985).

2. **Natural distribution and habitat**

*Sindora cochinchnensis* is a native species of Cambodia, Lao PDR, Malaysia, Thailand, and Viet Nam (WCMC 1998). It is defined as a dominant species in dry deciduous dipterocarp forest with highly characteristic tree taxa (Stott 1990). It is also found in clear Dipterocarpus forests and secondary forests (Dy Phon 2000). Normally, this species grows in the areas with annual rainfall between 1,000 and 2,000 mm or more at elevation up to 500 m (Larsen *et al.* 1985).

3. **Uses and products**

*Sindora cochinchnensis* has strong wood which is generally used for heavy constructions (Larsen *et al.* 1985), ship-building, furniture-making and carvings (WCMC 1998). The timber is also used for planking, poles, joinery, and firewood (Soerianegara and Lemmens 1994). In furniture-making, it gives excellent floors, beams and columns (Dy Phon 2000). Wood is good for charcoal production but it is not widely used since the wood is expensive. The wood density is about 880 kg/m³ at the moisture content of 12% (Soerianegara and Lemmens 1994). At the moisture content of 3.17%, the wood produces 73.92% of fixed carbon and ash content of 3.47% (Sayakoummane and Ussawarujikulchhai 2009). The bark is used for partition walls, the wood-oil for caulking boats (Soerianegara and Lemmens 1994) and dyeing fishing nets (Dy Phon 2000). Fruit can be used as medicine (Cruz-Garcia and Price 2011). Young seed is edible, and the aril of the seed is sometimes used as a substitute for betel (Soerianegara and Lemmens 1994).

4. **Seed source**

There is one identified seed source of *S. cochinchnensis* in Cambodia. It shares the same seed source with *Tarrieta javanica* and *Shoera guiso*. 
5. Seed collection and processing

The flowering starts in dry from March to June (LTSP 2009) and fruiting season is from December until March when fruit become brown (Phongoudome 2009). Seed takes long time to fall to the ground until the pod opens. So, seeds should be collected directly from the trees by shaking the branches or climbing on the trees (FA and CTSP 2005). The fruit is so hard and difficult to remove the seeds out, so dry the fruits in the full sun light to facilitate the removing seeds. Seeds can be stored in a cool-dry place for 2-3 years.

6. Seed pretreatment

Seeds are pretreated by soaking them in boiled water until the water cool down. Seed scarification is also a common method of seed pretreatment. Use metal file to scarify the seed coat, until the cotyledon is visible, at the oposit direction of hilum. Then soak the seeds in tap water over night. This method is labourous and time consuming, however, it garantee the heigh germination rate. After pretreatment, seeds can be sown in seedbed or in the containers. Germination is visible withing the second week of sowing.

7. Plantation establishement

Seedling of *S. cochinchinensis* is suitable for planting when it reaches the age of 1 year. Seedlings require open areas with full sun light, deep, sandy, brown, and grey loamy soil (Phongoudome 2009). The recommended spacing at the initial stage is 3 × 3 m (FA and CTSP 2005). Direct seeding of *S. cochinchinensis* has been tested in Kbal Chhay Watershed Protected Area and in Khun Ream commune, Siem Reap province with encouraging results. For direct seeding, much higher density, for example 3-4 seeds/m$^2$ should be used. Weeding should be practiced 2 times a year, during the first five years, to enhance growth and survival of seedlings.

8. Growth and yield

In Vietnam, this species is planted using enrichment planting under canopy of forest with a gap of 5m from the plant to the rows. As a result, it can grow between 32 and 54 cm/year with the survival rate of 95.6 % at first year and 80% after 4 years (Millet *et al.* 2012). It is concluded that the survival rate of seedlings one year after plantation was higher than 90 %, and three years later, the survival rate was still high, more than 95 % (Millet *et al.* 2012).

Data from the trial in the Rubber Reaesrch Station show that the tree reach a total height of 8 m and dbh of 17 cm in six years (UTM: 562126-1323148). In a site with lower soil fertility, a much slower rate is observed, for example, a small plantation in Prey Veng province (UTM: 531174-1250282), the tree reaches a total height of 12.4m and dbh of 26 cm in 29 years.

A survey in Dangplet village, Chheb District, PreahVihear province (the original sourse of wood) in 2014, sawn wood of *S. cochinchinensis* is traded at USD 250/m$^3$. The average timber price of *S. cochinchinensis* in 2008 was USD 350/m$^3$ at various locations (Hugh 2008).[5]
current price of the sawn wood in Phnom Penh is USD 700/m³ (Pers. comm. with wood seller in Phnom Penh, 05 April 2014).

A: The bole, bark is dark brown, when tree is older; bark becomes slightly cracked and flaking.
B: Fruits and seeds. Fruit is dark brown when ripe, round and flat with a short curved tip.
Reference


FA and CTSP, 2005. Guidelines for Site Selection and Tree Planting in Cambodia. Cambodia Tree Seed Project (CTSP). Forestry Administration (FA), Phnom Penh.


**Tectona grandis** L.f.

Local name : Mai sak  
Scientific name : *Tectona grandis* L.f.  
Family : Verbenaceae

1. **Botanical description**

It is a large deciduous tree that reach a height of 40 m in the dense forests of Thailand, Lao PDR, Myanmar and India. It has been grown in Asia since ancient time and now it is very popular for planting in moist tropical region. Trunk is tall, straight and clean cylindrical bole and becomes moderately fluted and buttressed when it is old (Moon *et al.* 2011). Branchless bole is up to 20 m with diameter up to 150 cm. Bark is grayish brown with longitudinal cracks and inner part is red and sticky sap (Sosef *et al.* 1994). Leaf is compound, alternate and green in color, and produces red tint when it is rubbed (Moon *et al.* 2011). Flower is small about 8 mm across and 45 cm long of head and color is pale purple to white. Flower appears on the top of branches in the non-shaded part of the crown (Orwa *et al.* 2009). Fruit is green, hairy, round and woody (Moon *et al.* 2011). When it is young, the fruit’s color is pale green, and brown when it is mature. One fruit can produce up to 4 seeds and there are 1,000-3,500 seeds per kilogram (Orwa *et al.* 2009).

2. **Natural distribution and habitat**

Teak is not indigenous to Cambodia. However, a number of plantations were established long before the civil war in the 1970s, such as in Kampong Cham, Pursat and Rattanak Kiri provinces. There are 29.035 million ha of natural teak forest estimated in India, Thailand, Lao PDR and Myanmar (Walter and Lucia 2012). The tree can survive and grow under a wide range of climate conditions. In Northern part of Togo, it grows in a region with annual rainfall of nearly 600 mm and in Bangladesh it grows in a region with annual rainfall close to 4,000mm. The altitude range of this species is 0-1,200 m a.s.l and mean annual temperature 14-36 °C. The most suitable soil is deep, well drained, fertile alluvial-colluvial soil with pH of 6.5-8 (Orwa *et al.* 2009).

3. **Uses and products**

Teak is used in varieties of things such as bridge building, docks, quays, piers and floodgates in fresh water. It is used for interior and exterior joinery windows, solid panel doors and framing. Other uses are for building, poles, transmission line poles, fence posts, wallboards, beams, woodwork, boxes, musical instruments, railway sleepers and railcar construction. Teak is also suitable for producing an attractive veneer, which is extensively used in the manufacture of furniture and interior fitting (Orwa *et al.* 2009).
4. Seed source

There is no seed source of T. grandis in Cambodia. In the early 2000s, some private companies imported seeds from Lampang province (Thailand).

5. Seed collection and processing

Teak, *Tectona grandis*, in Thailand starts flowering when it reaches the age of 8-10 years old. The flower usually appears during rainy season from June to September. Fruiting starts from November to January and fall in dry season, from May to September (Sosef *et al.* 1994).

Usually, teak fruits are collected from the ground. The ground floor is cleaned and sometimes burnt in advance to prepare seed collection. Fruits fall over a period of 3-4 months in the dry season (Keiding and Kaosa-ard 2002). After two months of storage, the germination of teak is 80%. The germination rate decline to 60% after an eight-month storage (Andrés *et al.* 2012).

The seed behavior is orthodox that its viability can be maintained for at least seven years in hermetic at room temperature of 0-4°C with 12% moisture content (Orwa *et al.* 2009).

6. Seed pretreatment

The best treatment for teak seeds is when the seeds are exposed to sunlight for three day, (78%) But if the seeds were soaked in fast-flowing water for 24h and exposed to sunlight for 24h, it will increase the germination rate up to 80% (Pedro *et al.* 2014). Generally, germination starts in 10-12 days after sowing (Keiding and Kaosa-ard 2002).

7. Plantation establishment

An initial spacing of 1.8 × 1.8 m was used in Myanmar, then mechanical thinning was applied when the stems reach an average height of 8-9 m. The second thinning in good quality plantation take place when the stem height reaches 12-13 m (Myanmar Department of Forestry 1999).

Teak is intolerant of crown friction. The optimum light for growth lies between 75 and 100% of full sunlight. Teak plantation is very high risk of fire, so fire protection is an important. The good ways for fire protection is establishing the fire line with 10 m wide, which is clear of all vegetation every year. Thinning takes place 4 times at 5,10,18 and 28 years interval after planting (Orwa *et al.* 2009).

8. Growth and yield

If plantations established on high fertility soils, the density of 2,200 trees/ha should be used. This density requires six thinning interventions, and mean annual increment is 7 to 10 m³/ha (Diego 2005). As many timber species, Teak grows fast when it is young, for example, at an age of 5 years, the average height is 13 m and dbh is 10 cm. After 20 years, the height is 21 m and dbh is 24 cm (Orwa *et al.* 2009). In Java, Indonesia, the average plantation yield is 60-100 m³/ha. The
final harvest may yield as much as 390 m$^3$/ha in stands of 80 years old. The mean annual volume increment is 3-6 m$^3$/ha (Orwaet al. 2009).

In a plantation in Tbong Khmum province, *Tectona grandis* reaches a total height of 17 m and dbh of 28 cm at the age of 25 years (Annex 1). The price of teak log ranging from USD 2,000/m$^3$ for 1$^{st}$ and 2$^{nd}$ grade quality to USD 600/m$^3$ for 4$^{th}$ grade log with minimum diameter of 29-48 cm (Diego 2005).

References


Canarium subulatum Guill.

Local name : Talat
Scientific name : Canarium subulatum Guill.
Family : Burseraceae

1. Botanical description

It is a large tree with straight trunk, growing in evergreen and semi-evergreen forests with a total height up to 25m tall and dbh 60-80 cm (Dy Phon 2000). The bark bark is dark gray splitting into small pieces along its length (Bruce 2013). Leaf, 20-45 cm, 2-5 pairs of opposite leaflets plus an end one. Leaf is oblong or lanceolate with pointed tip and oblique base, finely toothed. Mature leaflets smooth or sparsely hairy. Fruit is ovoid or bullet shaped with pointed tip and rounded base, persistent hard calyx. Stones slightly triangular in cross-section, not splitting, exuding a pale orange resin when cut, very hard 3-angled stone with 3(2) seeds (FORRU-CMU’s databases).

2. Natural distribution and habitat

Canarium subulatum is a subtropical and tropical plant. It is indigenous to Cambodia, China, Laos PDR, Thailand and Vietnam. It is found in North Vietnam growing below 500 m altitude. In Yunnan, China, it grows between 600-1,300 m altitudes. It likes deep, humid and fertile soil under partial shading. This species needs light when young so naturally regenerated seedlings are only found in open places (Bruce 2013). C. subulatum prefers climates with summer or uniform rainfall patterns. The suitable condition for the species is the areas with average annual rainfall more than 1,800 mm/year at elevation range 0-600 m a.s.l. (Thomson et al. 2006).

In Cambodia, the tree found in small group or alone in deciduous forest in Kampong Chhnang, Kampong Speu, Battambang and Siem Reap provinces (Toyama et al. 2012). The species is likely tolerant to short drought period with duration about 3-4 months. The mature trees produce maximum nut yields when grown in close to full sunlight (Thomson et al. 2006).

3. Uses and products

The fruit is used to facilitate digestion and to dispel drunkenness. The white and aromatic resin from the trunk is used for making incense sticks. The wood is commonly used to make drums. Seeds are well known vermifuge (Dy Phon 2000). The fruits are edible, and have been used by the local people as expectorant. Recently, a Thai medicinal plants agency studied the bioactive compounds on resin and powder extracted from the bark of this plant to against the Herpes simplex virus type 1 (HSV-1), a virus that causes itchy skin and burning blisters (Boonchoo et al. 2013). The fleshy mesocarp of the fruit is an important food for wildlife animals, in particular flying foxes and pigeons, who act as seed dispersal agents (Thomson et al. 2006).
4. Seed source

There is no identified seed source of \textit{C. subulatum} in Cambodia. However, seeds can be purchased from the provinces mentioned above. Specifically, Leap Kuy Community Forest, Phnom Sruoch District, Kampong Speu province, owns a number of mature trees, therefore, seeds can be ordered from this community.

5. Seed collection and preocessing

The flowering season of \textit{C. subulatum} starts from April to May and fruiting starts from September to October (Bruce 2013). If tree growth under good conditions it commence flowering and fruiting at about 7 years after planting (Thomson \textit{et al.} 2006). If the tree grows in an open areas, large quantity of fruits can be harvested.

\textit{Canarium Sp.} is readily propagated from seed, either as nursery-raised seedlings or by direct-seedling into the field (Evans 2004). The fruits should be collected from healthy, high-yielding trees with good nut characteristic. Collection time varies by locations and from year to year. Seed collection is carried out when fruits turn to deep dark green or black when ripe. \textit{Canarium} seed is recalcitrant, so the best option should be sown as soon as possible after collection. If seeds need to stored for a few weeks, then the outer flesh should be removed and the nuts are stored in shaded, cool dry place (eg. 15-25°C) (Thomson \textit{et al.} 2006).

6. Seed pretreatment

A quality seed should be identified by using floating technique, then discard any nuts that float or that do not sink completely to the bottom (Thomson \textit{et al.} 2006). Based on local knowledge, seed should be soaked in fresh water for 24 hours before sowing. Scarification and then soaking of seeds in tap water for overnight will promote germination rate.

7. Plantation establishement

The plants are ready for field planting after three months of germination with the height of about 25-30 cm. Seedlings should be kept in the nursery until the beginning of rainy season (Thomson \textit{et al.} 2006). An experience from FORRU-Cambodia, seedlings survive and grow best under 50% full sunlight. The spacing is 1.8 m × 1.8m and the canopy cover close about 2-3 years after planting (Sobon 2013). If saplings are used for planting, their leaves should be removed in advances to reduce evapotranspiration.

\textit{Canarium} grows best under 50% full sunlight. It may be useful to provide some temporary shading, using leafy branches, coconut or fern fronds, to cober the newly planted seedlings. Weeding should be applied regularly as needed. Cut weeds and other vegetation should be mulched back around the seedling, leaving a gap of about 10cm from the trunk (Thomson \textit{et al.} 2006).
8. Growth and yield

In a trail in Siem Reap province, the survival rate of *C. subulatum* at six months after planting was 88%. The survival rate decreased to 71% at 18 months. The growth rate at 24 months was 110 cm for height and 81 cm for crown canopy cover (Sobon 2013).

*Canarium subulatum* is a good species for inclusion in mixed or single species woodlots for provision of timber and/or nuts. The nuts are of considerable sustenance and commercial importance, including sale in local markets, processing and export. Usually the tree can provided fruit at the age of 7 years old. In Vanuatu, the price of *Canarium* nut is about USD 0.25-0.50/kg for nut in shell or 4-5USD/kg for nut removed off shell (Thomson *et al.* 2006).

Wood of *Canarium subulatum* is not commonly found in the market of Phnom Penh. The price of sawn wood in Pursat province is USD 500/m³ (Pers. comm. with wood seller in Pursat province, 05 April 2014).
A: The *C. subulatum* tree showing straight bole and dark gray bark. B: Leaf of *C. subulatum*. C&D: Fleshy fruit and seed is recalcitrant. E: A 30cm-tall seedling of *C. subulatum* just planted in the field. F: An 18-month-old sapling of *C. subulatum* after with the height of 250 cm.
Reference


Annex 1: Field measurement in December 2013.

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