

## Storage techniques of the twenty seed species of urban forests

N Yuniarti<sup>1</sup>, Y Bramasto<sup>1</sup> and D Syamsuwida<sup>1</sup>

<sup>1</sup>Forest Tree Seed Technology Research and Development Centre  
Jl. Pakuan, Ciheuleut, PO Box 105, Bogor, Indonesia

E-mail: naningbtp@yahoo.co.id

**Abstract.** To guarantee the continuous supply of seed for supporting plantation programs in city forests, techniques to store the seeds that can prolong their life are required. The objective of the paper was to review the seed storage techniques of 20 (twenty) species of city forest trees, with locally named as: asam jawa, ampupu, bungur, cempaka kuning, cemara laut, damar, gmelina, jati, johar, kenari, kayu afrika, kecap, mangium, mindi, pulai, rasamala, sawokecik, suren, tusam, and tanjung. The storage techniques of those twenty seed species are classified based on their physiological characteristics, i.e: orthodox (asam jawa, ampupu, bungur, cemara laut, gmelina, jati, johar, kenari, mangium, mindi, sawokecik, tusam, and tanjung), recalcitrant (damar and kecap), and intermediate (cempaka kuning, kayu afrika, rasamala and suren). The review results indicates that (1) The techniques to store orthodox seeds are to put the seeds in a room with a temperature of 0°C-20°C with a relative humidity of 40%-50% and a seed moisture content of 5% - 7%, (2) recalcitrant seeds are stored at a temperature of 12°C-15°C with a relative humidity of 60% - 70%, and a seed moisture content of 20%-35%, and (3) intermediate seeds storage applies the temperature of 20°C and seed moisture content of 12% - 17%.

### 1. Introduction

City forest or urban forestry is a specific area with a number of trees or woody vegetation managed in urban and suburban areas (e.g cities, towns, villages etc) [1, 2]. The goals of urban forestry include sustaining tree health, performing aesthetics, protecting flora and fauna, enhancing the physical, biological, economic, and social environment of the community. According to [3] a city forest is a site where the trees are grown within urban areas either in state or privately owned lands that serves as a buffer environment for water and air management, flora and fauna habitats and other ecosystem services. It is important to note that the area is set by the authorities as urban forest.

Considering the importance of city forest development, efforts are needed to support the success of plantation. One of the important factors is the availability of quality seeds in a sustained-adequate quantity. To ensure the availability of seeds for a long time, it requires techniques to store the seeds to prolong their life. The main goal of seed storage is to ensure the procurement of quality seeds for a planting programme. An unappropriate storage will lead to the decrease of seed viability.

Before storing seeds, we need to pay attention to their physiological characteristics. Based on the seed characteristics, in [4] we generally classify seed into two categories i.e: orthodox and recalcitrant. However, [5] pointed out another category that is set between the two categories, to be called as intermediate. Orthodox seeds can be stored under cold and dry conditions, while recalcitrant seeds will die if stored under such manner [6]. Intermediate seeds can be stored under dry conditions but can not stand to the exposure of low temperature [7].



There are many species of forest trees that can be grown in a city forest, among others, 20 (twenty) selected species belonging to three categories of physiological characteristics of seeds. Understanding the seed, physiological characteristics is important for city forest managers. Therefore, this paper will review the seed storage techniques of asam jawa (*Tamarindus indica* L.), ampupu (*Eucalyptus urophylla* S.T. Blake), bungur (*Lagerstroemia speciosa* (L.) Pers.), cempaka kuning (*Michelia champaca* L.), cemara laut (*Casuarina equisetifolia* L.), damar (*Agathis loranthifolia* Salisb), gmelina (*Gmelina arborea* Roxb.), jati (*Tectona grandis* L.f.), johar (*Cassia siamea* Lam.), kenari (*Canarium indicum* L.), kayu afrika (*Maesopsis emenii* Engl.), kecap (*Sandoricum koetjape* (Burm.f) Merr.), mangium (*Acacia mangium* Willd.), mindi (*Melia azedarach* L.), pulai (*Alstonia scholaris* (L.) R.Br.), rasamala (*Altingia excelsa* Noronha), sawo kecil (*Manilkara kauki* (L.) Dubard), suren (*Toona sureni* (Blume) Merr.), tusam (*Pinus merkusii* Jungh.& de Vriese) and tanjung (*Mimusops elengi* L.).

## **2. General features of 20 species of city forest**

The botanical and ecological features of the twenty species of the city forest is described in table 1.

**Table 1.** General features of 20 species of city forest

No.	Local and latin names	Family	Distribution	Utilization	Botanical and ecological types
1.	Asam.jawa ( <i>Tamarindus indica</i> L.)	Fabaceae	<ul style="list-style-type: none"> <li>- Tropical areas [8]</li> <li>- Spread out in the Island of Java - Indonesia [11]</li> </ul>	<ul style="list-style-type: none"> <li>- The pulpy fruit is used as materials for food and traditional medicine industries [11]</li> <li>- The tree is good for windbreak, shading and erosion break [11]</li> </ul>	<ul style="list-style-type: none"> <li>- The tree could reach a height of 30 m, branchless trunk of (1 to 2) m, and a diameter of 2 m [9]</li> <li>- Grow in low lands up to highland areas (&gt; 1000 m a.s.l) [11]</li> <li>- Grow well in a rainfall of 500-1500 mm/year, in sandy to clay soil and less fertility soils [8, 35]</li> </ul>
2.	Ampupu ( <i>Eucalyptus urophylla</i> S.T. Blake)	Myrtaceae	<ul style="list-style-type: none"> <li>- Naturally grow in the eastern part of Indonesia, such as Mount Mutis-Soe and East Timor island [12]</li> </ul>	<ul style="list-style-type: none"> <li>- The timber is used as raw materials for building and making pulp and paper. The tree is good for reforestation and shading tree [11, 13]</li> </ul>	<ul style="list-style-type: none"> <li>- The tree height can reach 35 m with a diameter of about 120 cm [11]</li> <li>- Grows at an altitude of 200 to 1500 m a.s.l with a rainfall of 130 to 2400 mm/years [14]</li> <li>- It grows well in a good drained site and tolerance to compact and acid soils, as well as fire resistance [14]</li> </ul>
3.	Bungur ( <i>Lagerstroemia speciosa</i> (L.) Pers.)	Lythraceae	<ul style="list-style-type: none"> <li>- Distributed in many areas of Indonesia such as Sumatra (Riau, Jambi, South Sumatera), throughout Java</li> </ul>	<ul style="list-style-type: none"> <li>- Utilized as ornamental trees in the city. Part of the plant such as leaf can be used to cure malaria, boiled leaves and ripe fruits are good for diabetes and the</li> </ul>	<ul style="list-style-type: none"> <li>- The tree height can reach about 10 to 45 m [11]</li> <li>- Grow in either low lands or highland areas up to 800 m a.s.l. as well as on marginal soils [11]</li> </ul>

No.	Local and latin names	Family	Distribution	Utilization	Botanical and ecological types
4.	Cempaka kuning ( <i>Michelia champaca</i> L.)	Magnoliaceae	and Bali, West Kalimantan, South Selatan, the entire Island of Sulawesi and Nusa Tenggara Timur [15]	bark for diarrhea[11]	- It can be grown on wet soil or waterlog, but not on peat soil. In addition, the species can grow in dry soils, less fertilized and savanna. The species is preferred to wet climate [16]
			Sumatera, Java, Kalimantan, Sulawesi and Sunda kecil Islands [15]	- Used for shading trees in urban areas and one of the essential oil producing plant [11]	- The tree can reach about 50 m height, but usually 15 to 25 m with a diameter of 40 to 50 cm. Grow swell at 1.200 m a.s.l and fertile site, at maximum temperature of 35°C to 40°C and minimum temperature of 3°C to 10°C [11]
5.	Cemara laut ( <i>Casuarina equisetifolia</i> L.)	Casuarinaceae	Spread out in Sumatra, Kalimantan, Sulawesi, Java, Madura, Ternate and Halmahera [15]	- The wood has the best quality of fuelwood in the world [11] - The economic value of the wood is very good due to its utilization for wood carpentry. It is also a beautiful tree for ornamental plants in urban green lines [11]	- Tree height can reach up to 15 m to 25 m with a diameter of about 30 cm to 40 cm [11] - Grows in a variety of locations and climate, from coastal areas to high mountain slopes, with warm tropical and semi arid climates [20] - Grows at an altitude of 0 to 1500 m a.s.l. The best site to grow is in the coastal areas with a soil pH of 5 to 8. Tolerance to drying season is 6 to 8 months. Maximum temperature of 30°C to 35°C and minimum 7°C to 18°C.

No.	Local and latin names	Family	Distribution	Utilization	Botanical and ecological types
6.	Damar ( <i>Agathis loranthe folia</i> Salisb)	Araucariaceae	Planted as damar seed sources in Sukabumi (West Jawa), Baturaden (Central Jawa), Banyuwangi and Probolinggo (East Jawa) [14]	Planted in urban areas as road side plants or shading trees. The timber is good for carpentry which is a high economic valuable tree. Produces resin gum and is an important export ingredient [11]	Mean annual rainfall of 1400 mm [11] - It reaches about 45 m height, with a stem diameter of 200 cm [11] - This species grows well in a good drained site and tolerance to compact and acid soils [14]
7.	Gmelina ( <i>Gmelina arborea</i> Roxb.)	Verbenaceae	Is an exotic species. The distribution in Indonesia include Jawa, Kalimantan and Nusa Tenggara. Seed sources plantation are in Central Jawa, East Jawa and East Kalimantan [14]	- Planted as regreening plants in urban areas. The wood is used for carpentry wood [11]	- Grows naturally at an altitude of 0 to 800 m a.s.l with a rainfall rate of 120 to 3000 mm/years. The species grow in deep soils, fertilize, and bad drainage [14] - The tree height can attain to 20 to 25 m, with a diameter of 30 cm [11]
8.	Jati ( <i>Tectona grandis</i> L.f.)	Verbenaceae	Distributed throughout Jawa, South Sulawesi, Southeast Sulawesi, Sumbawa, Maluku, and Lampung [16]	- The timber is good for carpentry and furniture. The wood is durable and expensive. Jati is wind resistance and hence good for wind break [11]	- The tree can reach a height of 45 m with a diameter > 150 cm [11] - Grows at an altitude of 0 to 900 m a.s.l with a rainfall of 1500 to 3000 mm/years. It requires deep soil, fertilizer, good drainage and neutral pH to grow. Tolerance to compact

No.	Local and latin names	Family	Distribution	Utilization	Botanical and ecological types
9.	Johar ( <i>Cassia siamea</i> Lam.)	Caesalpinaceae	It originates from South and southeast Asia which includes Indonesia, the distribution is widely spread in tropical areas [15]	Widely used for greening, ornamental or protective plants in the urban areas. The wood is widely used for firewood, its leaves for fodder. In addition, effective for erosion control and land reclamation [11]	soil, as well as fire and wind [14]  Can grow in wide climatic ranges, but grows better in lowland with a rainfall of 500-2800 mm/years, mean temperature of 20°C to 31°C, dry season for 4 to 8 months. Cannot grow at an altitude >1300 m a.s.l, cannot stand to temperature >10°C. Preference of moist soils, good drainage, fertilize, pH of 5,5 to 7,5, but can grow on marginal sites [15]
10.	Kenari ( <i>Canarium indicum</i> L.)	Burseraceae	Natural distribution is in Sulawesi, Maluku Islands and Papua [11]	Kenari can be used as shade plants, because of the evergreen-dense canopy. The fruit, in this case the seeds are edible, while the outside of the seed (exocarp) can be used as handicraft materials. The wood can be used as wood tools [11]	The height of the tree can reach 45 m with a diameter of 70 cm [15]  Grows in the lowland tropical rain forests, but can be cultivated at an altitude of more than 600 m above sea level. [11]

No.	Local and latin names	Family	Distribution	Utilization	Botanical and ecological types
11.	Kayu afrika ( <i>Maesopsis emenii</i> Engl.)	Rhamnaceae	This species grows naturally in the tropical areas of East Africa. First, introduced to Indonesia was in West Java [15]	Kayu afrika is a fast growing species, with leafy leaves that can be used as a reforestation plant in urban areas, especially in relatively high altitude areas. The wood is popular in the community therefore it is suitable for the development of the community forests. The leaves can be used as fodder [11]	This species grows well at an altitude of 100-1500 m a.s.l with a rainfall of 1400-3600 mm / year. It grows well in deep, fertile and free from waterlog soils, tolerant of infertile soil, sandy soils, and acidity [15]  - This tree is deciduous, with a height that reaches 45 m - branchless of 2/3 of the total height [11]
12.	Kecapi ( <i>Sandoricum koetjape</i> (Burm.f) Merr.)	Meliaceae	This species originates from Indo-China and West Malaysia, has developed into landrace and widely accepted in tropical Asia, especially Indonesia, Malaysia, Phillipine, Thailand, and Vietnam [15]	The fruit is edible. The wood can be used for making furniture. The plant is growing fast with a nice shape of canopy that makes it good for ornamental and shading trees. The bark can be utilized as medicine to cure scabies and the mixed-boiled roots and gingers are used to cure diarrhea [11]	- Grow well at the altitude of 0 to 1000 m a.s.l and be able to survive in areas with a long dry season. Preference to clay or sandy fertile soil and contain of humus [15]  - The tree height attains to 25 to 30 m and diameter of 70 to 90 cm [11]

No.	Local and latin names	Family	Distribution	Utilization	Botanical and ecological types
13.	Mangium ( <i>Acacia mangium</i> Willd.)	Leguminosae	Natural distribution is in Indonesian Papua and The Island of Maluku. The sources of seed source are found in Subanjeriji (South Sumatera), Banten, Bogor and Purwakarta (West Java) [14]	The plant is used as shading trees in urban areas. The canopy and leaves are able to absorb a high concentration of Carbon, so it is good to mitigate air pollution. The timber is worth as a substitution to carpentry wood [11]	<ul style="list-style-type: none"> <li>- Grows well at the altitude of 500 to 1200 m a.s.l, with an annual rainfall of &gt;1920 mm/year. Grows on sandy fertilize soils. Tolerance to acid soil, less nutrition and bad drainage [14]</li> <li>- these species are fast growing plants, plant height can reach 20 to 25 m, with a diameter of more than 100 cm [11]</li> </ul>
14.	Mindi ( <i>Melia azedarach</i> L.)	Meliaceae	Natural distribution is found in Java, Bali, East Nusa Tenggara and West Nusa Tenggara [16]. It is also found many in highland in Bogor, Sukabumi, Cianjur and Bandung (West Java) and Bondowoso (East Jawa) [14]	The flower can be used as medicine for headaches, leaf for exuviate urine and helminth, and the fruit for fever relief, the roots for scabies treatment. Natural insecticide can be extracted from mindi leaves. The plant grows quickly with beautiful flowers that make it suitable for a garden in urban areas [11]	<ul style="list-style-type: none"> <li>- Grows well at an altitude of 700 to 1400 m a.s.l, with the rainfall of &gt;900 mm/year. Grows on a good drainage system, fertilizer and sandy soils. Resistance to cool temperature [14]</li> <li>- Tree height could reach to 40 m with branchless stem with a height of 20 m, a diameter around 185 cm and no buttressed [11]</li> </ul>
15.	Pulai ( <i>Alstonia scholaris</i> (L.) R.Br.)	Apocynaceae.	Distribution areas are throughout Indonesia [16].	The main utilization of this species is its timber and used a lot for carpentry. The bark is useful for malaria, fever and cholera medicines.	<ul style="list-style-type: none"> <li>- Growth distribution is in secondary swamp areas up to the high altitude area of about 1000 m a.s.l. The plant has a straight trunk, the height may reach up to 40 to 45 m, a</li> </ul>



No.	Local and latin names	Family	Distribution	Utilization	Botanical and ecological types
				The leaf for liver, and the resin for ulcer, scabies and toothache treats. The architecture of the crown is beautiful, like tiled dome make this species is interesting to be planted in a city forest [11]	diameter of 40 to 60 cm [11]
16.	Rasamala ( <i>Altingia excels</i> Noronha)	Hamamelidaceae.	Natural distribution in the forests of Priangan and Bukit Barisan mountains. The sources of the Seed have been found in Sukabumi and Cianjur (West Java). Rasamala forest is also found in Bedugul, Bali [35]	The wood can be utilized for building and construction materials. The plant may be used as shading trees along the road sides due to the dense-evergreen of the canopy [11]	-Grows at an altitude of 600 to 1000 m a.s.l [35] -The tree may reach of > 50 m high, and a diameter up to 150 cm. The stem is erected and straight [11]
17.	Sawokecik ( <i>Manilkara kauki</i> (L.) Dubard)	Sapotaceae	Natural distribution is in the Island of Java along the south coast of Banyuwangi and Karimun, Java. Outside Java they are found in Bali, Buton, Sulawesi, Kangean, Pulau We	The wood is good for carving materials in Bali. It is also used for furniture. The wood is durable so it is able to submerge in a mud and soil. The fruit is edible, the flower can be used as a medicine. The plant has a strong root that is good for conservation	- The tree height may reach 30 m, possesses a thick trunk with a diameter of > 100 cm [11]

No.	Local and latin names	Family	Distribution	Utilization	Botanical and ecological types
18.	Suren ( <i>Toona sureni</i> (Blume) Merr.)	Meliaceae	and Bima [15]  Growth distribution in Indonesia are Sumatera, Java, and Sulawesi. [11,16]	along the coast to prevent erosion and aberration. The crown is dense, so it's suitable for shading trees [11]  The wood is used a lot for carpentry and carving. The tree can be roadside and shading plants [11]	- Grows at an altitude of 1200 m a.s.l on fertile soil, in the mountains, climate type of A to C, with mean annual temperature of 22°C [11,16]  - The tree reaches a height of 40 m and a diameter of 200 cm [11]
19.	Tusam ( <i>Pinus merkusii</i> Jungh.& de Vriese)	Pinaceae	Natural distribution is found in Aceh, South Sumatera and Jambi. Plantation forests are spread out in the Island of Java, Sumatera and Sulawesi. Seed sources are planted in Sumedang and Banjaran (West Java), Baturaden and Paninggaran (Central Java) and Sempolan (East Java) [39]	The wood is used for carpentry and tool woods. The resin is utilized for turpentine industry. The beautiful stem form and its' needle leaves allows the plant able to be ornamental and shading trees, especially in a highland of urban areas [11]	- The Height of a tree may reach up to 20 to 60 m with a diameter of 100 cm, no buttressed [11]

No.	Local and latin names	Family	Distribution	Utilization	Botanical and ecological types
20.	Tanjung ( <i>Mimusops elengi</i> L.)	Sapotaceae	Distribution in Indonesia including Aceh, South Sumatera, Lampung, Java, Bali, Southeast Sulawesi, Maluku, Nusa Tenggara and Indonesian Papua [15]	The timber is good for construction. The fragrance flowers, the dense crown makes this species convenient to be in the roadside or a shading tree. [11]	<ul style="list-style-type: none"> <li>- Generally grows on fertile soil with an altitude of &gt; 600 m a.s.l. [15]</li> <li>- Reaches a tree of 25 m, branchless height of 8 to 17 m with a diameter up to 100 cm, buttressed up to 2 m. [11]</li> </ul>

### 3. Seed characteristics and storage techniques of twenty species of city forests

Seed storage techniques of twenty species are categorized based on their physiological characteristics, i.e orthodox seeds (asam jawa, ampupu, bungur, cemara laut, gmelina, jati, johar, kenari, mangium, sawokecik, tusam, and tanjung), recalcitrant seeds (damar and kecap) and intermediate seeds (cempaka kuning, kayu afrika, mindi, rasamala, and suren). Storage techniques of the seeds are summarized in table 2.

**Table 2.** Seed storage techniques of twenty species of city forest.

No.	Seed species	Seed characteristics	Storage techniques
1	Asam jawa ( <i>Tamarindus indica</i> L.)	Orthodox	Seeds should be stored at low temperatures (5-10°C). At this temperature, the viability of seeds can be prolonged for several years [8]. Storing the seeds in a porous gunny sack will be able to increase their potential viability and vigor of seedlings after being storage for 12 weeks [43].
2	Ampupu ( <i>Eucalyptus urophylla</i> S.T. Blake)	Orthodox	Seeds can be stored up to 3.5 years with an initial moisture content of 10%, placed in an air-conditioned room (T 18-20°C, Rh 50-60%), pack in an air-tight container (plastic bag or tin). The germination capacity achieves 90% [44].
3	Bungur ( <i>Lagerstroemia speciosa</i> (L.) Pers.)	Orthodox	Seeds are air dried and stored in a closed container. Stored in a low moisture content. Viability maintained even after 2 years, in hermetic storage at room temperature. Germination increases during the first 3-12 months of storage [45].
4	Cempaka kuning ( <i>Michelia champaca</i> L.)	Intermediate	Seeds are stored at cold room temperatures (5°C). The viability can be maintained for 7 months [46].
5	Cemara laut ( <i>Cassuarina equisetifolia</i> L.)	Orthodox	The seeds are resistant to drying. Before storage, the seeds are dried under the sun to a moisture content of 5-6%. Packed in a tin and placed under room temperature. Durability of storage up to 3 months [47].

No.	Seed species	Seed characteristics	Storage techniques
6	Damar ( <i>Agathis loranthifolia</i> Salisb)	Recalcitrant	Seeds are air dried for 24 hours to get 30% of moisture content, then add fungicide of mancozeb + karbendazim (Delsene MX-200) with a dosage of 4.01-4.05 g/kg seeds. Packed in a plastic bag and placed either in an air-conditioned room (T 18-20°C, Rh 50-60% ) or a regular room (T 28-33°C, Rh 60-70%). This condition can keep the germination capacity of 70% for 9 months [48].
7	Gmelina ( <i>Gmelina arborea</i> Linn.)	Orthodox	Seeds are stored at a low moisture content of 5-8%. Drying for two days to get 5-8%. Packed in an air tight container. Placed in an air-conditioned room (T 18-20°C, Rh 50-60%). The viability can be maintained for 12 months with germination capacity of 60-70% [49, 50].
8	Jati ( <i>Tectona grandis</i> Linn.f.)	Orthodox	Seeds are stored at a temperature of < 20 °C and a relative humidity of < 60% [51].
9	Johar ( <i>Cassia siamea</i> Lamk.)	Orthodox	No specific method of storage required. Packed in a plastic bag or tin and place in a regular room [47].
10	Kenari ( <i>Canarium indicum</i> L.)	Orthodox	Seeds are packed in a hermetic container (plastic bag or tin can). Seed moisture content before storage is 5-8%. Air-conditioned room (18°C) is suggested to store the seeds [52].
11	Kayu afrika ( <i>Maesopsis emenii</i> Engl.)	Intermediate	Seeds can be stored under low temperature (4-8°C) by using an impermeable container [53].
12	Kecapi ( <i>Sandoricum koetjape</i> (Burm.f) Merr.)	Recalcitrant	Seeds have a relatively high moisture content after being extracted from the fruits i.e around 55%. It is suggested to store temporary (during transporting) kecap in the form of fruits, to keep the water content of the seeds high. The temporary storage can be carried out under room temperature of 18-20°C or a refrigerator (T 7°C ) [54].

No.	Seed species	Seed characteristics	Storage techniques
13	Mangium ( <i>Acacia mangium</i> Willd.)	Orthodox	Seeds are stored at a low moisture content (5-8%) by drying under the sun for two days. Packed in a hermetic container (seeds are put in plastic bags then placed in a tin can). The storage room is either an air-conditioned room or a dry cold storage. By this manner the viability could be maintained for three years [55].
14	Mindi ( <i>Melia azedarach</i> Linn.)	Intermediate	Seeds should be kept in high moisture content (10-15%). The seed moisture content is decreased by aerating in air conditioned room (T 18-20°C ) on a flat container for 3 days. The seeds will die if the moisture content < 10%. Fresh stones (moisture content $\pm$ 22%) are kept in plastic and then stored in a tin can in a cold room with a temperature of 18-20°C, RH 70-80%. Using this treatment, the germination percentage of the seeds can be maintained up to 20-30% after 10-12 weeks in storage [56].
15	Pulai ( <i>Alstonia scholaris</i> (L) R.Br.)	Intermediate	Seeds are stored at low temperature. Due to its thin seed coat, the viability rapidly losses if it is stored under high temperature [57]. The safe moisture content for storage is around 7.5-9.0%, achieved from aerating the seeds for 2-3 days under room temperature (T $\pm$ 25°C, Rh 70-90%). Seeds are then packed in a tight plastic bag ( $\geq$ 4 mm thick) and stored in a cool room (Dry cold storage or refrigerator). The germination capacity reaches 82% after 6 months storage [58].
16	Rasamala ( <i>Altingia excelsa</i> Noronhae)	Intermediate	Seeds can be stored with their viability remain good when seed moisture content is lowered to 7 - 8% and stored in a cool room or refrigerator with a temperature of 4-8 °C by using packaging material formed as a plastic bag with a width of 0.1 [59].
17	Sawokecik ( <i>Manilkara kauki</i> Dubard)	Orthodox	Moisture content of the seeds should be decreased by drying up, stored in an hermetic container and placed in a low temperature room (air conditioned room or refrigerator) [60].

No.	Seed species	Seed characteristics	Storage techniques
18	Suren ( <i>Toona sureni</i> (Blume) Merr.)	<i>Intermediate</i>	Seeds are drying up to lower their moisture content, then put in a clothed bag and placed in an air conditioned room (T 18-20°C). With this treatment, the viability of the seed can be kept for 4 months with the germination capacity of 56,66% [61].
19	Tusam ( <i>Pinus merkusii</i> Jungh. et de Vriese)	Orthodox	Seed moisture content kept at 5-8% can maintain the viability for a period of 2 years. The container uses a plastic bag that is put in a tin can and placed in a dry cold storage (T 4-8°C, Rh 40-60%) [62].
20	Tanjung ( <i>Mimusops elengi</i> L.)	Orthodox	Seeds are stored in an air conditioned room (T 18-20°C, Rh 50-60%) by using a container of a tight plastic bag, at seed moisture content of 5-8%. The seeds can be stored for a nine-months period [63].

The results on storage techniques of the twenty species of city forest indicated that the orthodox seeds should be stored at a low seed moisture content, tightly packing, stored in low temperature and humidity. Contrary to orthodox seeds, the recalcitrant seeds require a high moisture content at the time of storage, preferred mixed medium for storage, porous packaging, room storage at a relatively high temperature and humidity. Seeds of intermediate characteristic are in between of orthodox and recalcitrant features. They need a lowered moisture content like orthodox, but they can not withstand if stored in low temperature and humidity like recalcitrant does [64].

#### 4. Closing Remarks

The availability of a good quality seed is necessary to support the successful planting of 20 tree species in urban forests. The quality seeds are obtained through proper handling of seeds starting from collection, processing to storing the seeds. Through many research and testing activities, the seeds have to be stored based on their physiological characteristics such as orthodox, recalcitrant and intermediate. Considering the characters possessed by each seed species, orthodox forest tree seeds could be prioritized for urban forests. This is due to its capability to be stored in a long period making them more available as planting stock as necessary. However, the recalcitrant and intermediate seed species are also recommended to be planted in city forests, however the seeds should be processed properly before being stored. The best practice is to sow the available fresh seeds as soon as possible for seedling production.

#### References

- [1] Fakuara Y, Sadan W, Bambang P and Soedaryanto 1987 *Konsepsi pengembangan hutan kota* (Bogor: Faculty of Forestry, Bogor Agricultural University)
- [2] Nowak D J and Dwyer J F 2007 Understanding the benefits and costs of urban forest ecosystems *Urban and Community Forestry in the Northeast* ed Kuser J (New York: Springer Science and Business Media) pp 25–46
- [3] Direktorat Jenderal Reboisasi dan Rehabilitasi Lahan Departemen Kehutanan 1991 Pedoman Umum Pembangunan Hutan Kota (Jakarta: Ministry of Forestry)
- [4] Roberts H F 1973 Predicting the viability of seeds *Seed Science and Technology* **1**:499–514

- [5] Pammenter N W and Berjak P 1994 Recalcitrance is not an all-or-nothing situation *Seed Science Research* **4**:263–26
- [6] Mycock D J Blakeway F C and Watt M P 2004 General applicability of *in vitro* storage technology to the conservation and maintenance of plant germplasm *South African Journal of Botany* **70**(1):31–36
- [7] Ellis R H Hong T D and Roberts E H 1990 An intermediate category of seed storage behaviour *I. coffee Journal of Experimental Botany* **41**:1167–1174
- [8] Joker D 2002 *Tamarindus indica* L. *Informasi Singkat Benih* (Jakarta: Direktorat Perbenihan Tanaman Hutan Jakarta)
- [9] Brown S H 2013 *Tamarindus indica* (Florida: Fact sheet US Department of Agriculture Cooperative Extension Service University of Florida)
- [10] ECHO 2006 Tamarind ECHO Plant Information Sheets ([www.echonet.org](http://www.echonet.org))
- [11] Bramasto Y Nurhasybi Danu Syamsuwida D Zanzibar M Pujiastuti E and Mokodompit S 2015 *Trees of the city profil tanaman hutan untuk perkotaan wilayah Jawa Barat, Banten dan DKI Jakarta* ed Sudrajat D J (Bogor: Balai Penelitian dan Pengembangan Tanaman Hutan Bogor)
- [12] Boland D J Brooker M I H Chippendale G M 1980 *Forest trees of Australia* (Australia: NELSON-CSIRO)
- [13] Orwa C Mutua A Kindt R Jamnadass R and Simonis A 2009 *Agroforestry Database: a Tree Reference and Selection Guide Version 4.0* (Kenya: World Agroforestry Centre)
- [14] Wadsworth F H 1987 Forest production for tropical America *Agriculture handbook* (Rio Piedras: USDA Forest Service)
- [15] Heyne K 1987 *Tumbuhan berguna Indonesia III* (Jakarta: Badan Penelitian dan Pengembangan Kehutanan Departemen Kehutanan Jakarta)
- [16] Martawijaya A I Kartasujana Y I Mandang S Prawira A and Kosasih K 1989 *Atlas kayu Indonesia jilid II* (Bogor: Badan Penelitian dan Pengembangan Kehutanan)
- [17] Natesh S 2014 Pride of India Remarkable tree on NII campus ([www1.nii.re.in/pdf/prideofindia.pdf](http://www1.nii.re.in/pdf/prideofindia.pdf))
- [18] PROSEA 1998 *Plant resources of South-East Asia 5(3) timber trees lesser-known timbers* ed Sosef M L Hong T and Prawirohatmodjo S (Leiden: Backhuys Publishers)
- [19] Tony P Wheeler G Langeland K Golden E Purcell M Taylor J Brown K Taylor D S and Allen E 2013 *Australian pine management plan for Florida* (Florida: Florida Exotic Pest Plant Council)
- [20] National Academy of Sciences (NAS) 1980 Firewood crops: shrub and tree species for energy production (Washington DC: National Academy Press)
- [21] Wati H 2012 Model struktur tegakan hutan tanaman *Agathis loranthifolia* di Hutan Pendidikan Gunung Walat Sukabumi Jawa Barat ( *Stand structure model on agathis (Agathisloranthifolia) plantation forest in Gunung Walat University Forest Sukabumi West Java*) [*Undergraduate thesis*] (Bogor: Faculty of Forestry, Bogor Agricultural University) (In Indonesian)
- [22] Kang K S Cappa E P and Hwang J 2010 Growth Characteristics of 100 Open-pollinated Families in an Early-age Test of *Agathis loranthifolia* in West Java Indonesia *Jour Korean For Soc* **99**(2):213–219
- [23] Monim Y Rahmah N Jusoff K Heliawaty Nikoyan A Ismail I Y Meisanti Uslinawaty Z and Batoa H 2013 Sustainable management of teak plantation forest by local farmers in Sulawesi Indonesia *World Appl Sci J* **26**(Natural Resources Research and Development in Sulawesi Indonesia):105–111
- [24] Palanisamy K 2014 *Cultivation Techniques for Teak Transfer of Tree Cultivation Technologies to Krishi Vigyan Kendras (kvks) of Tamil Nadu and Puducherry* ed Buvaneswaran C Sivakumar V Prasanth R S Krishna N Kumar (Coimbatore: Institute of Forest Genetics and Tree Breeding (Indian Council of Forestry Research and Education)) Coimbatore
- [25] Pandey D and Brown C 2000 Teak: a global overview an overview of global teak resources and issues affecting their future outlook *Unasylva* **201**(51):3–13



- [26] Meenal R C and Sharma R 2016 Growth of *Cassia Siamea* Lam in semi- arid agroecosystem *International Journal of Science and Research* **5**(2):95–97
- [27] Evans B R 1999 *Edible nut trees in Solomon Islands: a variety collection of Canarium Terminalia and Barringtonia* (Canberra: Australian Centre for International Agricultural Research) 96p
- [28] Gami Pathak S and Parabia M 2012 Ethnobotanical, phytochemical and pharmacological review of *Mimusops elengi* Linn *Asian Pac J Trop Biomed* **2**(9):743–74
- [29] Nassar Z Aisha A and Majid A A 2011 The Pharmacological Properties of Terpenoids from *Sandoricum Koetjape* (<http://www.webmedcentral.com>)
- [30] Krisnawati H Kallio M and Kanninen M 2011 *Acacia mangium* Willd: *Ekologi, Silvikultur, dan Produktivitas* (Bogor: Center for International Forestry Research)
- [31] Syamsuwida D Bramasto Y Siregar I Z Irawan A Palupi E R 2016 Phenotypic variation of the progeny of mindi (*Melia azedarach* Linn) in a community forest stand of Wanayasa-Purwakarta *Proceedings of International Conference of Indonesia Forestry Researchers III-2015 Forestry research to support sustainable timber production and self-sufficiency in food, energy, and water* (Bogor Indonesia: Ministry of Environment and Forestry Research Development and Innovation Agency) pp 486–496
- [32] Wiart C 2006 *Medicinal plants of the Asia-Pacific drugs for the future* (Singapore: World Scientific Publishing Co Pte Ltd) pp 447–450
- [33] Pratap B Chakraborty G S Mogha N 2013 Complete Aspects of *Alstonia scholaris* *International Journal of PharmTech Research CODEN (USA) IJPRIF* **5**(1):17–26
- [34] Dey A 2011 *Alstonia scholaris* R Br (Apocynaceae): phytochemistry and pharmacology: a concise review *Journal of Applied Pharmaceutical Science* **01**(06):51–57
- [35] Prosea 1994 Pepohonan sumber penghasil kayu ekonomi utama ed Sutarno H Rifai M Nasution R E *Seri Pengembangan PROSEA 5(1)* (Bogor: Prosea Indonesia-Yayasan Prosea) p61
- [36] Hardiyanto E B 2008 *Seed collection and handling Sawokecik (Manilkara kauki* (L) Dubard) (Jakarta: Directotae General of Land Rehabilitation and Social Forestry Ministry of Forestry)
- [37] Purwaning D Tenggara N and Harum F 2005 *Manilkara kauki* (L.) Dubard *Seed Leaflet* (**107**)
- [38] Parvin S Zeng X N and Islam Md T 2012 Bioactivity of Indonesian mahogany, *Toona sureni* (Blume) (Meliaceae) against the red flour beetle *Tribolium castaneum* (Coleoptera, Tenebrionidae) *Revista Brasileira de Entomologia* **56**(3):354–358
- [39] Nurhasybi Iriantono D Marom O and Mulyanto Y 1997 Peta Pewilayahan Sumber Benih *Pinus merkusii* di Jawa (Bogor: Balai Teknologi Perbenihan Bogor)
- [40] Hidayat J and Hansen C P 2002 *Pinus merkusii* *Seed Leaflet* (**60**)
- [41] Kadam P V Yadav K N Deoda R S Shivatare R S Patil M J 2002 *Mimusops elengi*: A review on ethnobotany, phytochemical and pharmacological profile *Journal of Pharmacognosy and Phytochemistry* **1**(3):64–74
- [42] Kannadhasan M Valarmathi S Kadirvelmurugan V Karthik V Priya G Rajesh E Amarasuriyan C Raju K 2016 The medicinal plant of *Mimusops elengi* (Sapotaceae) in antimicrobial activities *Int. Journal of Engineering Research and Application* **6**(7):26–31
- [43] Erman T D 1995 *Pengaruh wadah simpan, cara pengeringan dan lama penyimpanan terhadap viabilitas benih asam (Tamarindus indica* L.) *[Undergraduate thesis]* (Bogor: Faculty of Agriculture, Bogor Agricultural University)
- [44] Danu 1998 Penyimpanan benih ampupu (*E. urophylla* S.T. Blake) selama 3 tahun *Buletin Teknologi Perbenihan* **5**(1)
- [45] Hong T D Linington R H and Ellis 1996 *Seed Storage behaviour : a compendium Handbook for Genebanks No 4* (Rome: International Plant Genetic Resources Institute)
- [46] Direktorat Perbenihan Tanaman hutan 2004 *Informasi singkat benih cempaka (Michelia champaca* L.) (Bandung: Indonesia Forest Seed Project (IFSP))

- [47] International Institute of Rural Reconstruction (IIRR) 1992 *Seeds and plant propagation agroforestry technology information kit (ATIK)* (Philippines: Dept of Environmental and Natural Resource The Philippines)
- [48] Kurnia W 1995 *Pengaruh periode konservasi, suhu dan fungisida terhadap viabilitas benih damar (Agathis loranthifolia Salisb) [Undergraduate thesis]* (Bogor: Faculty of Agriculture, Bogor Agricultural University)
- [49] Erizal 1990 Penentuan kondisi ruang simpan benih *Gmelina arborea* Linn (Bogor: Balai Teknologi Perbenihan Bogor)
- [50] Suyanto H and Darman E P 1991 Penentuan kadar air awal, kondisi ruang simpan dan periode simpan benih *Gmelina arborea* Linn (Bogor: Balai Teknologi Perbenihan Bogor)
- [51] Nurhasybi 2014 Jati (*Tectona grandis* Linn.f.) *Atlas Benih Tanaman Hutan Jilid I Publikasi Khusus* (Bogor: Balai Teknologi Perbenihan Bogor)
- [52] Anonymous 1989 *Diktat Perbenihan Kerjasama Pusat Pembinaan Pendidikan dan Latihan Kehutanan dan Asosiasi Pengusaha Hutan Indonesia (APHI)*
- [53] Nurhasybi 2001 Kayu afrika (*Maesopsis emenii* Engl.) *Atlas benih tanaman hutan jilid II publikasi khusus* (Bogor: Balai Teknologi Perbenihan Bogor)
- [54] Kartiko H D P and Kartiana E R 2002 Kecapi (*Sandoricum koetjape* (Burm.f) Merr.) *Atlas benih tanaman hutan jilid III publikasi khusus* (Bogor: Balai Teknologi Perbenihan Bogor)
- [55] Nurhasybi 2014 Mangium (*Acacia mangium* Willd.) *Atlas benih tanaman hutan jilid I publikasi khusus* (Bogor: Balai Teknologi Perbenihan Bogor)
- [56] Danu and Putri K P 1996 Pengaruh kadar air awal benih terhadap daya simpan benih mindi (*Melia azedarach* Linn.) (Bogor: Balai Teknologi Perbenihan Bogor)
- [57] Zanzibar M 1997 *Penentuan pengkondisian benih pulai (Alstonia scholaris (L) R Br) untuk penyimpanan laporan uji coba* (Bogor: Balai Teknologi Perbenihan Bogor)
- [58] Bonner F T Fozzo J A Elam W W and Land Jr S B 1994 *Tree seed tecnology training course instructurs manual* (New Orleans Lousiana: United States Departement of Agriculture Forest Service)
- [59] Muliawati E S 1987 *Pengaruh kadar air benih, kondisi ruang penyimpanan dan jenis bahan pengemas terhadap viabilitas benih rasamala (Altingia excelsa Noronhae) pada beberapa periode penyimpanan [Undergraduate thesis]* (Bogor: Faculty of Agriculture, Bogor Agricultural University)
- [60] Syamsuwida D 2001 Sawokecik (*Manilkara kauki* Dubard) *Atlas benih tanaman hutan jilid II publikasi khusus* (Bogor: Balai Teknologi Perbenihan Bogor)
- [61] Djam'an D F 1997 *Penanganan benih suren (Toona sureni (Blume) Merr.) laporan uji coba* (Bogor: Balai Teknologi Perbenihan Bogor)
- [62] Ditjen RRL 1988 *Petunjuk teknik: penanganan dan pengujian mutu benih Pinus merkusii* (Jakarta: Ditjen RRL)
- [63] Nurhasybi 2002 Tanjung (*Mimusops elengi* L.) *Atlas benih tanaman hutan jilid III publikasi khusus* (Bogor: Balai Teknologi Perbenihan Bogor)
- [64] Schmidt L 2000 Pedoman penanganan benih tanaman hutan tropis dan sub tropis (Jakarta: PT Gramedia)