

Initial Growth of Four Provenances of Cempaka (*Michelia champaca* Linn.) at a Genetic Conservation Plot

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ABSTRACT

Cempaka (*Michelia champaca* Linn.) belongs to Magnoliaceae family. The wood of cempaka has fine fiber, and can be used as raw material for industry, construction, furniture and decoration items. Beside the wood, the species produces flowers used for perfumery raw materials and essential oils that have a high price. In Indonesia, the species of cempaka is distributed in Sumatera, Java, Celebes and Lesser Sunda Island. However, nowadays, it is difficult to find natural populations of *M. champaca* at some areas. It was reported that the genetic diversity of cempaka from three provenances was relatively low. To maintain and to conserve genetic diversity of cempaka, a genetic conservation plot of cempaka has been established at Pasir Hantap Research Forest, as an *ex-situ* conservation strategy. The genetic materials collected from four provenances/populations and 27 mother trees. Average survival of the young cempaka planted at the plot was 82.1% at 12 months old, the highest survival was found at Lahat provenance (90.6%). The highest initial growth and those the best performance of cempaka plants was shown by Lahat provenance as well. Soil properties at the conservation plot are optimal to support plant growth and are relatively uniform among the blocks, so it might not give a significant different effect to the cempaka growth. It was suggested that characteristics of the mother trees and the seed quality gave a significant effect to the cempaka plant growth.

KEYWORDS: *ex-situ* conservation, population, mother tree, performance, soil properties

INTRODUCTION

Yellow cempaka (*Michelia champaca* Linn.) belongs to Magnoliaceae family, and synonym to *M. Velutina* BL or *M. pilifera* Bakh, f.(1). In Indonesia, it is known with some of local names, such as cempaka, campaka honeng, campaga, jeumpa, campaka and campaka giraji (2). In South Sumatera Province, the tree was known with bambang lanang or medang bamban as local names. The wood of cempaka has fine fiber, and can be used as raw material for construction, furniture and decoration items. Beside the wood, the species produces flowers used for fragrances and essential oils raw materials that have a high price. Kalima (3) described the yellow cempaka is closely related to the white cempaka (*Michelia alba* DC.), morphology characteristics of the two tree species has considerable resonance.

In Indonesia, this species distributes in Sumatra, Java, Celebes and Lesser Sunda Islands. It grows at an altitude of 250- 1500 m above sea level (4). Cempaka grows well in soils dominated by loam or clay, slightly moist soil conditions and normal pH (5). However, nowadays, it is difficult to find natural population of *M. champaca* at some areas. Although cempaka is not endangered species, it has good prospect to be developed and maintained the sustainability because of its multiple uses.

Genetic diversity is the basis of the nature carrier of a plant to grow, develop and sustain the life of the next generations, so that it can adapt to the site, pest and disease attack, as well as to the climate change. The higher genetic diversity of a tree species, the higher the adaptation capacity. It was reported by Widyatmoko *et al.* (6) that genetic diversity of *M. champaca* with sample came from provenance/population of South Sumatera and East Java Provinces (Indonesia) within provenances was relatively low and tend to decrease from tree to pole and to seedling stages.

In order to maintain and to conserve the genetic diversity of cempaka, a genetic conservation plot of the species has been established at a representative area as an *ex-situ* conservation strategy. The seeds come from four provenances/populations and 21 mother trees. The genetic conservation plot is expected to function as back-up of *in-situ* conservation. The genetic conservation plots can also provide genetic materials for breeding program and maintain broad genetic base so that genetic variation of the species can be saved. This report discusses the initial survival and growth of the four provenances of cempaka at the genetic conservation plot in relation to their mother trees characteristics and the soil properties.

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MATERIALS AND METHODS

A. The Research Site and Time

A genetic conservation plot of cempaka (*Michelia champaca*) has been established at the Pasir Hantap Research Forest, located in Sukabumi District, West Java Province, Indonesia in year 2011. The genetic materials of the cempaka were explored and collected from South Sumatera and East Java Provinces. Observation and measurement of the initial survival and growth of the cempaka plants at the conservation plot as well as soil samples collections and analysis were conducted along the year of 2012.

B. Design and Steps of Genetic Conservation Plot Establishment

A genetic conservation plot of cempaka was established by planting cempaka seedlings. The seeds were collected at four provenances/populations of cempaka mother trees, namely Lahat and Empat Lawang (both in South Sumatera Province); Malang and Pasuruan (East Java Province). The seeds from Lahat were collected from five mother trees, Empat Lawang four mother trees, Malang four mother trees and Pasuruan eight mother trees. In total, the cempaka seeds were collected from 21 mother trees. All the seeds were germinated in the nursery of the Center for Forest Conservation and Rehabilitation Research and Development in Bogor, West Java Province. The nursery period was about eight months. Mean while, field preparation was conducted including field survey and site selection to choose suitable site for genetic conservation plot of cempaka. Once the definite site was chosen, measuring and designing of the plot was conducted. Land clearing was done according to planting lines. Planting holes was done with planting distance 4m x 4m. The plot size was about 2 ha and was designed according to source of the seedlings (provenances/populations). Therefore, there were four blocks of cempaka plantation according to the provenances of the mother trees and each block consisted of three sub plots/compartments. Distance among the blocks or provenances were minimal 50 m to avoid pollination among provenances and to maintain the genetic purity of each provenance. According to Hakim and Widyatmoko (7), design for an *ex-situ* conservation plot of a tree species with genetic materials come from several provenances have to be separated among provenances with enough distance (≥ 50 m) to avoid pollination among the provenances and to maintain the genetic purity of each provenance.

Prior to planting, each seedling container (plastic bag) was carefully removed, then the seedling was carefully planted with its soil clod intact. Total number of planted seedlings were 816 consisted of 250 from Lahat provenance, 211 from Empat Lawang, 193 from Malang and 162 from Pasuruan provenance. A slow release NPK fertilizer was applied with dosage 5 g/seedling, 2 and 12 months after planting. The plantation was maintained manually every three months by clearing the planting lines about 2 m wide.

C. Data Collection

As parameters of tree growth, the survival, stem height and stem diameter (above root) of cempaka were measured 2, 6 and 12 months after planting. The measurement values of stem height and stem diameter at two months after planting were recorded as initial measures of those parameters. So the height growth and diameter growth at 6 and 12 months were calculated based on those values. The stem height was measured from the ground level to the end of growing point of the main axis. The diameter above roots was measured a few cm above the ground if no roots were visible, and above the roots if those could be seen.

Soil samples were collected to determine the soil chemical and physical properties. For determining chemical properties, composite soil samples were collected according to the sub plots. Undisturbed soil samples were collected by using soil rings over a depth of 0 to 20 cm to determine the physical soil properties. The soil samples were analysed by the Soil and Plant Laboratory, SEAMEO BIOTROP.

D. Data Analyses

Average values of each growth variable covering survival, stem height and stem diameter were calculated for each provenance of cempaka plants. Then, the data were interpreted in relation to the provenance and the mother tree characteristics. Beside, the average growth data were discussed with refers to the chemical and physical soil properties.

RESULTS

A. Characteristic of Mother Trees and Sites

Genetic materials of cempaka in form of seeds were collected from four provenances/populations, two provenances in South Sumatera Province (Lahat and Empat Lawang) and two populations from East Java Province (Malang and Pasuruan). All four populations are plantation trees since natural population was difficult to be found.

Lahat population is located at Muara Payang Village with coordinate S 03°54'20"- 03°54'30", E 103°7'28" - 103°7'34", elevation ± 700 m above sea level. During year 2010, number of rainfall in Lahat area

was 4,182 mm (8). It is an identified seed stand, consisted of 30 mother trees with 30 years old. The mother trees characteristics are straight stems, clear bole heights are relatively high (almost ≥ 10 m). The seeds were collected from five mother trees.

Empat Lawang population is located at Padang Titiran Village. Seeds of cempaka were collected from cempaka stands at community farm, managed in Agroforestry Systems, mixed with coffee and fruit trees. Characteristic of the mother trees are straight stems, clear bole height are relatively high (almost ≥ 10 m). In this place, the seeds were collected from four mother trees.

Cempaka seeds of Malang population was collected at Wonorejo Village located at S 07° 49' 05" – 07° 49' 15", E 112° 40' 37" - 112° 40' 51", elevation ± 650 m asl. In this site, most of cempaka trees were cultivated by communities at their homegarden to obtain the flowers. Therefore, the cempaka trunks have many branches and clear bole heights of the trees are low. The seeds were collected from four mother trees.

Pasuruan population is located at villages on the hillside of Arjuno Mountain. The areas are about 410 to 764 m above sea level at coordinate S 07°47'05" - 07°47'43", E 112°40'02" - 112°43'38". Similar with Malang population, most of cempaka trees cultivated on community homegardens to obtain the flowers, so the trunks have many branches with height of clear bole were very low. However, a few cempaka trees have opposite characteristic since the flowers were not harvested, the trunks are straight and clear bole height are relatively high. At this site, cempaka seeds were collected from eight mother trees.

B. Initial Growth of Cempaka

Initial growth of cempaka plants which seeds come from four populations/provenances covering survival, stem height and stem diameter is presented in Table 1.

Table 1. Average survival, stem height and stem diameter of cempaka plants according to origin of the genetic materials (provenance) during the first year of plantation.

Provenance	Number of plant	2 months old			12 months old			Growth	
		Stem Height (cm)	Stem Diameter (cm)	Survival (%)	Stem Height (cm)	Stem Diameter (cm)	Survival (%)	Stem Height (cm)	Stem Diameter (cm)
Lahat	250	55.2	0.58	93.2	142.7	1.69	90.6	87.5	1.11
Empat Lawang	211	46.0	0.54	85.7	114.8	1.40	82.2	68.8	0.86
Malang	193	33.8	0.53	94.7	98.1	1.25	73.0	64.3	0.72
Pasuruan	162	35.2	0.56	98.7	84.4	1.08	82.7	49.2	0.52
Total/Average	816	42.6	0.55	93.1	110.0	1.36	82.1	67.5	0.80

Average survival of cempaka plants of four provenances was decreased for about 11,0%, from 93.1% at 2 months old to 82.1% at 12 months old. The highest survival at 12 months old occurred on cempaka plants which the seeds come from Lahat provenance (90.6%) and the lowest one indicated by cempaka plants from Malang (73.0%). Average height growth of cempaka plant was 67.5 cm within a period of 10 months or 81.0 cm in the first year, whereas average growth of the stem diameter was 0.80 cm within a period of 10 months or 0.96 cm in the first year (Table 1). Base on the average height and diameter growth of cempaka, it can be said that the best performance of the cempaka plant during the first year indicated by Lahat provenance, followed by Empat Lawang, Malang and Pasuruan provenances.

C. Soil Properties

Results of soil samples analysis, collected from the genetic conservation plot of cempaka are presented on Table 2 (chemical soil properties) and Table 3 (physical soil properties).

Table 2. Chemical soil properties at the genetic conservation plot of cempaka

Items	Places of the soil samples collected				Average
	Block 1 (Lahat Provenance)	Block 2 (E. Lawang Provenance)	Block 3 (Malang Provenance)	Block 4 (Pasuruan Provenance)	
- pH H ₂ O	5.5	5.4	5.8	5.3	5.5
- pH KCl	4.8	4.6	5.0	4.5	4.7
- Organic matter:	3.38	2.96	2.82	2.87	3.01
- C _{org} (%)	2.03	1.96	1.82	1.87	1.92
- N _{total} (%)	0.19	0.21	0.19	0.18	0.19
- C/N ratio	10.7	9.3	9.6	10.4	10.0
P _{available} (Bray 1) mg/kg (ppm)	7.3	6.8	8.3	7.2	7.4
Cation Exchange Capacity (CEC) (meq/100g)	18.25	16.94	17.16	16.38	17.18
Base Saturation (%)	52.4	49.6	56.1	52.9	52.8
Acidity (meq/100g):					
- Al ⁺⁺⁺	0.12	0.14	unmeasurable	0.16	0.14
- H ⁺	0.08	0.11	0.06	0.13	0.10
Texture	Loam	Loam	Loam	Heavy loam	-

Table 3. Physical soil properties at the genetic conservation plot of cempaka

Items	Places of the soil samples collected				Average
	Block 1 (Lahat Provenance)	Block 2 (E. Lawang Provenance)	Block 3 (Malang Provenance)	Block 4 (Pasuruan Provenance)	
Bulk density (g/cc)	1.00	0.93	0.82	0.89	0.91
Porosity (total) %	62.26	64.91	69.06	66.42	65.66
Field capacity (vol.%)	52.22	54.24	57.76	55.89	55.03
Permeability (cm/hour)	11.26	12.77	12.81	13.38	12.56

Chemical soil properties as presented in Table 2 indicated that in general, soil fertility at the conservation plot are optimal to support plant growth and relatively uniform among the blocks. According to classification of Balai Penelitian Tanah (9), organic matter content (2.82 to 3.38%) categorized as moderate and total nitrogen is low (0.19 and 0.21%). Ratio carbon-nitrogen (C/N) is low (9.3-10.7), available P is moderate (7-8 ppm) and CEC is also moderate (16.4-18.3 meq/100gr). Soil reaction or soil pH is rather acid to acid (5.3-5.8).

Physical soil properties as presented in Table 3 shows that soil permeability is optimal ranging from 11.3 – 13.4 cm/hour (moderate). Soil textures are dominated by clay-loam.

DISCUSSION

A. Survival of Cempaka Plants

Average survival of cempaka plants until 7 months old were still high (\pm 90%) for all provenances. However, long dry season was occurred during June to November 2012 and survival of cempaka plants was also decreased 11%. Cempaka plants from Malang provenance indicated the lowest survival (73%). This may be caused by the position of the plots, which very steep slopes and low shading, so the small plants continuous exposure to sunlight with very limited water availability. Lukman (10) reported that during initial growth, cempaka species needs shading and intolerant to the full sunlight. The highest survival showed by cempaka plants from Lahat provenance, this assumed supported by the high seeds quality from the identified seed stand.

B. Growth of Cempaka in Refer to Mother Tree Characteristics

Tabel 1 showed that based on the height and diameter growth of cempaka, the best performance of cempaka plants indicated by cempaka from Lahat provenance and the poor performance found at Pasuruan provenance. It is understandable since the seeds of Lahat provenance is high quality, collected from an identified seed stand with a superior properties of the mother trees (straight trunk, clear bole is high and mature trees). The other provenances, the seeds come from common cempaka trees. In addition, seeds of Malang and Pasuruan provenances collected from cempaka trees that managed to produce flowers, so the trunks have many branches and the clear bole were low. Growth of plants are influenced by genetic and environment factors. In this case, it seems that mother tree characteristics contribute to the plants growth significantly. Hadiyan (11) reported that variation of growth (plant height and stem diameter) of sengon (*Falcataria moluccana*) four months old was significantly affected by variants of seed sources (provenances).

C. Growth of Cempaka in Relation to the Site

Several site factors affect plant growth, covering elevation, soil properties, climate etc. Habitat of the cempaka mother trees located at elevation of 410-764 m above sea level and the conservation plot of the cempaka placed at 650 m asl. So, the plot elevation is optimal and might not give a negative effect to the cempaka growth.

Soil properties of the plot as presented on Table 2 and 3 are optimal to support cempaka plant growth in term of soil pH, organic matter content, C/N ratio, available P, Cation Exchange Capacity and soil permeability. The soil permeability is classified as moderate (11.3-13.4 cm/hour). Arsyad (12) stated the optimal permeability to support plant growth ranging from 6.3 to 12.7 cm/hour (moderate category). Content of total N is low, between 0.19 and 0.21%, whereas it plays significant role in plant growth. To overcome the low nitrogen content, it is necessary to apply nitrogen fertilizer, either organic or an organic. Atmojo (13) explained that application of organic matters could create suitable condition for the plants through improve soil structure, soil aeration and water holding capacity, increase soil pH, CEC, nutrient uptake and decrease toxics capacity of exchangeable Al. Research result of Gong *et al.* (14), showed that application of organic manure and NPK fertilizer could increase the soil carbon and nitrogen content significantly and is significantly higher than application of mineral fertilizer only. Siregar (15) indicated that charcoal application at the rate of 10 % for *Acacia mangium* and 20 % for *Michelia montana* would be adequate to improve the availability of soil nutrients, and hence significantly induce a better plant growth. Charcoal treatment significantly increased soil pH, soil organic C, total N, HCl 25 %-extractable P, HCl 25 % and Bray-extractable K, exchangeable bases (Ca, Mg, Na, and K), percentage of base saturation, and significantly decreased CEC, and significantly decreased KCl 1 N-extractable Al and H cations.

The chemical and physical soil properties are relatively uniform among the blocks. Therefore, it may be did not give a significant different effect to the growth of cempaka of different provenances.

CONCLUSION

Based on the initial stem and diameter growth of the cempaka plants at the genetic conservation plot, the best performance was shown by cempaka plants from Lahat provenance. The highest survival rate of the plant was indicated by Lahat provenance as well. Characteristic of mother trees and seed quality gave a significant effect to the cempaka plant growth, while the plot site characteristics did not give a significant different effect to the growth of cempaka of different provenances.

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