

GROWTH AND MANAGEMENT OF *AQUILARIA MALACCENSIS* FOR AGARWOOD -A NEW DOMESTICATION PERSPECTIVE

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ABSTRACT

Most species in the genus *Aquilaria* are agarwood-producing species and is likely to be particularly affected by unsustainable resin collection. They are classified under Red List Category and Criteria: Critically Endangered (IUCN), 2012 and Threatened and Endangered (Appendix II, CITES, 2004). There are more than 17 known *Aquilaria* species in tropical Asia; most are naturally found in South and Southeast Asia. Interestingly, almost half of the total species are naturally found in Malaysia. However, among the most valuable species is *A. malaccensis*. It is a popular, well distributed, studied, domesticated and highly sought after agarwood and other related products species. However, the taxonomy of some other species are either relatively unknown or its occurrence can either be restricted or endemic to certain geographic regions. Agarwood or gaharu is a highly prized incense, extremely rare but highly possible for domestication using good management practices and application of specific holistic technical inducement techniques, so as to luxuriously induce gaharu resin formation. The resins from these trees can be used for the production of diverse pharmaceutical, medicinal, well-beings and fragrance products. Unlike most forest plantation tree species, this species is fast growing, hardy and can be harvested within a short rotation period of about 5-8 years through fatal harvest or sub-lethal harvest. This paper shares some of early and mature growth performance of the *Aquilaria* species, and discussed some of the successful management practices in agarwood production.

Keywords: *Aquilaria malaccensis*, domestication, cultivation, incense, optimum growth

Introduction

The genus *Aquilaria*, *Gyrinops*, *Gonystulus* and *Wikstroemia*, family *Thymelaeaceae* produce a unique fragrant wood called agarwood or gaharu. The *Aquilaria* tree is an angiosperm, evergreen tropical tree with about fifteen known species, mostly found in South and South East Asia countries but the taxonomy of these species is not well documented. Besides *A. malaccensis*, other potential species listed for domestication were *A. crassna*, *A. subintegra*, *A. hirta*, *A. rostrata*, *A. beccariana*, *A. filaria*, *A. khasiana*, *A. microcarpa*, *A. grandiflora* and *A. sinensis*. Interestingly, more than half are found within the states of Malaysia, with *A. malaccensis* as the most dominant, hardy and easily cultivated. Some other species, such as *A. hirta*, *A. beccariana*, *A. rostrata* and *A. microcarpa* are scarce while others maybe endemic, slow-growing, scantily distributed, confined to certain ecological sites and little is known due to lack of silvicultural and genetic background, growth results with specific ecological and domestication needs (The Star, 27 March, 2016). Other exotic *Aquilaria* species have also been domesticated locally, these were *A. crassna*, *A. subintegra*, *A. sinensis*, *A. hybrids* and *Gyrinops* sp. These species were first experimented probably derived from past technical knowledge acquired by the locals, seedlings availability, promotions and some preferences given by the planters. Agarwood and its fragrance derivatives from these species are highly prized, traditionally fetched as they are traded in several Middle East, Europe and Asian countries like Saudi Arabia, Dubai, Bahrain, China, Singapore, Hong Kong, Japan, Korea, and Taiwan. *A. malaccensis* or karas is a medium sized tree with light coloured soft wood, no distinction in colour between sapwood and heartwood (Corner, 1940; Desch, 1954; Wong, 1978). It is the world most precious, expensive fragrance wood and has long history on its uses for many religion ceremonies, including medicine as a digestive, sedative and antiemetic and for perfume and incense across all religions. The production of agarwood in *Aquilaria* is believed to be associated with the plant stress and defensive responses to wounding and microbial attack (Ng et al., 1997). Due to high economic value, slow nature of its production and great demand, indiscriminate felling of trees has led to the depletion of its natural resources in almost all countries. To prevent the unsustainable harvesting of *Aquilaria* genetic resources the species has been listed in Appendix II of the Convention on International Trade in Endangered Species of Fauna and Flora (CITES) since 1995 and have also been listed in the Red List of Threatened Plants published by International Union of Convention of Nature (Oldfield et al. 1998), (IUCN, 2014). Red List classifies this species as vulnerable base on the reduction of at least 20% over three generations caused by levels of exploitation and declined in population (Hilton-Taylor, 2002).

Unlike most timber forest plantation tree species recommended such as *Hevea brasiliensis*, *Acacia hybrids*, *Khaya ivorensis*, *Tectona grandis*, *Azadirachta excelsa*, *Neolamarckia cadamba*, *Paraserianthes falcata* and *Octomes sumatrana*, the main challenge here is to meet the supply and demand for the timber industry as contrary to agarwood cultivation which is more specifically directed towards value added non-wood forest products such as for agarwood, oil and other health related products (Zakaria and Wickneswary, 1994; MTIB, 2007; Lim et al., 2010). The total acreage of forest plantation is estimated at 324,417 ha (Majlis Tanah Negara, 2012) and about 766 ha are reported cultivated with *Aquilaria* (Zahari, 2013). The expected wood

production cycle for timber tree species is about 15-20 years which is rather long whereby the criteria used are normally based on growth rates, planting stocks, species-site matching and market requirements as specified in the technical standard operating procedure (Ahmad Zuhaidi and Hashim, 2009; Ahmad Zuhaidi and Raymund, 2012). Management of *Aquilaria* is less intensive but required more specific regimes towards production of high valued non-wood products, whereby shorter gestation period is required upon achieving certain sizes for inducement and resin or agarwood production. Hence, this paper aims to share some growth performance and discuss new management aspects for domesticated trees of *Aquilaria malaccensis*.

2. Materials and Methods

A) Growth performance of *Aquilaria*

Site location

The plots are located at about 3° 14' N and 101 38 E with the mean daily temperature ranges from 27 to 30 C and an annual rainfall between 2000 to 2900 mm. They are established in F44 on May, 1997 and F53 on April 2009, at the lower slope of the lower ridge of Bukit Hari, Selangor Aspect is southerly and with an altitude of 200-220 m above sea-level. At both sites, the soil is of heavy clay loam granitic origin, reddish brown in colour with an average pH of 4.5. In F44, the trees were initially interplanted with *Azadirachta excelsa* at a planting distance of 3 x 3 m to study possible domestication in the open and growth performance with a fast growing tree while F53 was using monoculture cropping with a planting distance of 3 x 4 m. The trees were all planting with young potted seedlings obtained from the private nurseries and wildings collected at FRIM's ground.

Results and Discussion

Table 1. Occurrence of branching stems/leaders in seven years old *Aquilaria malaccensis* (%)

Stem Numbers/leaders	Numbers (%)
1	203 (62)
2	69 (22)
3	35 (11)
4	12 (4)
5	4 (1)
Total:	323 trees

Table 2. Mean annual increment (MAI), Mean Diameter and Height for different *Aquilaria* Species

Species	Age	MAI	Mean Diameter (cm)	MAI	Mean Height (m)
<i>A. Malaccensis</i> (FRIM)	5	2.8	14.0	2.0	9.8
<i>A. Malaccensis</i> (FRIM)	7	3.2	22.1	2.1	14.5
<i>A. Malaccensis</i> (FRIM)	13	1.4	18.3	1.1	13.8
<i>A. Malaccensis</i> (FRIM)	19	2.4	45.8	1.6	30.8
<i>A. Beccariana</i> (Sabah)	6	1.7	10.2	1.1	6.6
<i>A. hybrids</i> (Perak)	2	1.6	3.2	1.2	2.4
	3	3.8	11.4	1.8	5.4
<i>A.sinensis</i> (Selangor)	3	2.1	6.0	1.2	3.6
<i>A. crassna</i> (Cambodia)	6	2.1	12.6	1.3	7.8
<i>A.crassna</i> (Vietnam)	4	1.6	6.4	1.1	4.7

n=based on 100 trees/plot

MAI= Mean annual increment

a) Stem numbers

Normally a single straight clear bole stem is selected for inducement or inoculation of the species. However, due to poor genetic selections of the trees, multiple stems are obtained and this range from 1-5 stems (Table 1). However, for production and economics purposes, about 1-3 stems is recommended to be retained for agarwood production. The results obtained also indicate that there are almost 62, 22 and 11% % of the trees with 1, 2 and 3 stems respectively.

b) Early and present growth performance

One of the first attempts to cultivate *A. malaccensis* in Malaysia occurred in 1928 (Lok & A. Zuhaidi 1996). However, due to high mortality rate, inadequate maintenance and lack of silvicultural understanding of the species caused the original population

density of 833 ha⁻¹ to reduce to 31 ha⁻¹ by 1995. However, several attempts have been carried out to domesticate this species. However, due to the lack of trials plots for samplings and statistical analysis, the results obtained showed that *A. malaccensis* is fast growing during early growth age at five years old stands with mean annual increment diameter and height of 2.8 cm and 2.0 m respectively (Table 2). This growth increment results was also found to be similar in other exotic species of *A. crassna* and *A. sinensis*.

Figure 1. (Left to Right) Five years old stand, fruits and flowers of *Aquilaria malaccensis*



Figure 2. (Left to right) 19 years old stands of *Aquilaria malaccensis* at FRIM and Agarwood collected from induced cultivated trees.



B) *Aquilaria* domestication and cultivation

All species of *Aquilaria* are an important source of agarwood. Similar to other forest tree species, *Aquilaria* is best raised and easily planted through seedlings (Zuhaidi et al., 2015). This can be obtained through wildings or raised seedlings with supply easily obtained from private nurseries. The first step is to look for mother trees and start the collections nearby. Subsequently, the species can also be propagated by cuttings and tissue culture (Aminah et al., 2007). For raised seedlings, propagation must take place when seed is mature and must be done immediately once the fruit has ripened and exposed as most *Aquilaria* seeds have a short viability period. As such, good planning, proper time management and modern nursery practices must be observed. As observed, *Aquilaria* seedlings can be produced in large numbers and used in large plantation programme such as the Agarwood Project in Gopeng, Perak.

These trees were also cultivated in farm, home garden and established for reforestation and afforestation projects in the hill forests and other marginal soil lands. *Aquilaria* can be grown on marginal land and under a wide range of soil conditions which must be well drained. They are fast growing trees, hardy and in areas with adequate moisture, can achieve 10 cm DBH within 4

to 6 years. *Aquilaria* has also been cultivated by intercropping with other forest trees such as rubbers, teak and any short term cash crops such as bananas, corns, pepper, pineapples, and lemon grass in many Southeast Asia countries.

Figure 1. Propagated seedlings of *Aquilaria malaccensis* successfully raised from seeds and ready for *ex-situ* cultivation

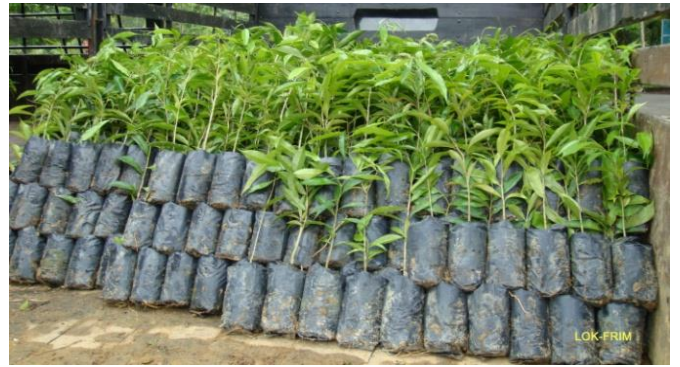


Figure 2. Young cultivated trees growing on hill forest in Selangor



Figure 3. Intercropping of *Aquilaria* with pepper. Intercropping can provides some shade for the young *Aquilaria* seedlings and cash returns



C) Management practices and domestication considerations

1. Propagation techniques

This species is easily planted and domesticated by seedlings and can be obtained through either wildings or raised seedling in the nurseries. The seedling is hardy, easily transported but hardening processes are required for adaptation to the site.

2. Land preparation

From the growth data and species trials, *A. malaccensis* and other promising species of *Aquilaria* can be domesticated from the wild. The species grows well under full sunlight although some early light shade is recommended. The species is shade tolerant during seedling stage and are known to regenerate freely under mother tree. However, there must be minimum soil disturbance during clearing and with planned planting activities during wet seasons.

3) Lining and holing

This is no different from other forest plantation. It is an important aspect as this will assist in the planting direction, systematic lining and spacing with respect to the site conditions. Planting holes should be flexible and avoid any water-logged, rocky, big stump and boulders.

4) Planting pattern and spacing

Unlike other plantation grown species, a small square planting is recommended for *Aquilaria* cultivation with spacing of 2 x 2 at 1020 trees per acre and 2.5 x 2.5 m at 653 trees per acre depending on the objectives of the trials or programmes. However, no large planting distance are required if monoculture is to achieve the purpose but intercropping with short term cash crops are allowed in wider spacing.

5) Pruning and inducement techniques

Similar to other timber tree species, pruning for *Aquilaria* is necessary to promote optimum growth and determine the number of branches to be retained for tree with multiple stem branches although a single straight stand is recommended during inducement selections. Pruning can be carried out within 3-6 months whereby first pruning is called corrective pruning to shape the tree with balanced canopy-stem ratio favourable for so-called wood production. It can also be a continuous process at least during the first three years of the tree when the desired tree height or form is achieved. No thinning is required.

With the current interest in plantation of *Aquilaria*, research into the most suitable age for inducement and the conditions in which higher grades of agarwood are produced are needed. However, as a prerequisite rule, trees at age four to five and reaching a diameter of 10 cm should be ready for any inducements.

6) Other silvicultural treatments

Tending and Weeding

Tending should be carried out during and after planting by removing any unwanted weeds or saplings and pruning by removing multiple branches or stems, which may interfere with the seedlings / stands growth. However, as a general rule, multiple stems of more than three are not encouraged as this may impede tree growth. Weeding must be carried out during planting (if any), establishment, cleaning and large pole and tree size stages. Normally, in open planting, circle weeding within a 1 m radius should always be removed and uprooted if possible. These weeding practices are recommended to be done every quarterly until the canopy closed at the expected stand age of 3-4 years. Other dense creepers and herbaceous weeds, which should also be removed gradually, include climbers (*Mikania sp.*), vines, lalang and plants.

Fertilizer application using basic fertilizer such as rock phosphate (CIRP) in the planting hole during planting is needed. This is because fertility in most soil types is low and in certain areas the soil may be deficient in certain nutrients for optimum plant growth (Paramanathan, 1995). The amount of fertilizer is almost similar to other forestry practices but close monitoring is required. As a general rule, during first year a low organic fertilizer is recommended with NPK ratio of 8:8:8 + TE with about 100g/sapling and thereafter any inorganic fertilizer of 12:12:12 + TE with each application of only about 100g-200 g after second to fifth year. The frequency of application depends on the conditions and growth of the tree.

7) Pest and diseases:

Aquilaria are susceptible to various pests and diseases. Care should be taken to ensure good hygienic surrounding conditions of the saplings and trees during nursery, early growth and at the site. No serious incidence has been reported except larvae attack by *Heortia vitessoides* belonging to the Hymenoptera group, scale insects, stem borers, pink disease on the stem and branches, wood borers and in some cases root *Fusarium* wilt problems (. Fungicides such as Bourdeaux Mixture, copper oxychloride and Mancozeb, systematic pesticides such as Furadan G or any active ingredient containing parathion of Class IV can be applied wherever necessary.

Conclusions

The demand for cultivation of *Aquilaria* tree and agarwood is predicted to increase with the depletion of the natural resources. There is also a great concern for more conservation and preservation efforts through domestication and good management practices for *Aquilaria* in order to sustain production of agarwood for all protected *Aquilaria* species. Use of agarwood is no doubt an important commodity similar to timber products. In this aspect, more management skills should be developed with integrated strategy for conservation of *Aquilaria malaccensis* and other species for large *in-situ* and *ex-situ* cultivation. Cultivated *Aquilaria* requires no thinning, pest resistant, smaller planting distance with higher tree intensity, can be intercrop with short term cash crops, less labour intensive and minimum establishment cost but give promising economic returns. Although the species is fast growing, adapt well to the local environment conditions and availability of inoculum for inducements, care must be taken to enhance good growth during early stage. Availability of selected genetic planting materials and proper application of silvicultural aspects should be recommended. It is expected that this high valued tree crop would contribute significantly to the income of the planters and in the development of a new forest plantation.

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