GELAM CONSERVATION, PROSPECTS AND SILVICULTURE MANAGEMENT

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ABSTRACT

Melaleuca or better known as Gelam (in Malay) can be found in South East Asia and Australia. In Malaysia, Gelam forest is little known, and its numbers are declining due to human activities. A notable number of Gelam forests can be found in the East Coast of Peninsular Malaysia, but Gelam can actually live in other areas of Malaysia. Gelam is said to be extremely resilient, with excellent attributes like it can withstand frequent flooding, acid and low nutrient soils, and mild fires. Many types of Gelam has showy flowers that produce honey and leaves containing fragrant oils that contain a significant source of therapeutic phytochemicals that may lead to the development of beneficial drugs for human. In Australia and Indonesia, Gelam is well known for its medicinal purposes, and Gelam leaves are distilled to extract essential oil that is highly valuable not only because of its ingredients but, more importantly, it helps to accelerate economic development. For long, Gelam has been neglected in Malaysia and its commercial values are underestimated because not many studies have been conducted about its medicinal advantages and economic potential in Malaysia. The silvicultural systems employed for the production of essential oils from plantations fall broadly into two categories, which are high-cost but high-return (HCHR) systems and lower cost but also lower return (LCLR) system. LCLR system might likely be the best silvicultural system that can be adopted in Malaysia, where Gelam plantations must provide a multitude of services for sustainable development, such as inter-row cropping, rather than oil production alone. There are many Agarwood plantations in Malaysia because of its high economic value and Gelam also offers excellent potential to yield high profit. This paper contributes by providing an overview of Gelam conservation, economic prospects of Gelam’s essential oil-based products and Gelam silviculture management based on the authors’ experience.

Key words: Gelam, Melaleuca, Cajuputi, Gelam conservation, Silviculture management.

INTRODUCTION

There are about 300 species of Gelam (Melaleuca) distributed in Malaysia, South East Asia and Australia (Joseph, J. B. et. al., 2013). Gelam is a useful plant that can be used for many purposes, such as brushwood fencing, ornamental trees and shrubs for gardens and street planting. Gelam tree is pink or brown in color and has a uniform texture that can be used for wood carving, making cabinets and pieces of bark (Lim, S. C. et. al., 2006). Essential oils can also be extracted from biomass of Gelam like Melaleuca alternifolia, Cajuputi and Quinquenervia (Siska, S. et. al., 2020). In countries like Australia and Indonesia, Gelam is considered a useful tree, which are used as ingredients for medicine, balm, shampoo and insect repellant (Brophy, J. J. et. al., 1996).

Gelam can grow in extreme environments that are high in acid soil, saline soil, arid soil, water-locked soil and peat swamp areas where most agricultural crops and trees cannot grow (Sasaki, S. et. al., 1995, Cuong, C. V. et. al., 2015, & Hickley, K. I. et. al., 2017). Figure 1 shows the distribution of Gelam across South East Asia and Australia (Lum, S. K. Y., 1994). Based on Figure 1, subspecies cajuputi can be found in Southwest Australia and East Indonesia (Maluku and Timor Island) (Blake, S.T., 1968 & Bootle, K. R., 1983). Subspecies cunningiana grown in West Indonesia (Sumatera, West Juwa and South Kalimantan), Malaysia, Myanmar, Thailand and Vietnam. Subspecies plathphylla can be found in North Queensland/Australia and Northwest Papua New Guinea (Joseph, J. B. et. al.).

For honeybee breeders, Gelam forests are ideal for beekeepers to relocate bee hives because Gelam flower flourish throughout the year and can produce high-quality honey (Samat, S. et. al., 2016). Figure 2 shows a bee is looking for nectar from a Gelam tree. Many years ago, Gelam forests can be found across peninsular Malaysia, but today sizeable Gelam forests are hard to find. Unfortunately, Gelam forests were destroyed because of human activities like plantations and land conversions to commercial or housing areas. Today, sizeable Gelam forests are said to be found growing wildly in deserted and swampy areas between Kemaman...
Gelam trees can withstand drought, strong winds, and scorching temperatures. Gelam trees are also suitable as attractive landscape plants in gardens. Gelam trees shown in Figure 3 can reach heights of up to 15 to 25 meters (Joseph, J. B. et. al., 2013 & Nuyim, T., 1998). The leaves are 5 to 9 centimeters long green, thick, hard smooth, oval, or elongated with 5 to 7 longitudinal veins. The leaves of the Gelam tree resemble the leaves of the Acacia tree. When crushed, the leaves smell like tea trees.

The small yellow-cream flowers are elongated in the shape of a bottle brush; thus, it is also called as the ‘bottle brush plant’ as shown in Figure 4. There are also new leaves growing between the flowers while the fruit is round in the form of brown capsules in a dense cluster and can remain on the tree for several years (Wrigley, J. W. et. al., 1996). The fruit, as shown in Figure 5, will break to expose or spread its brown seeds. The trunk of the Gelam tree is thin and looks like it is twisted coated with a soft, thick skin that is...
brownish-white to gray and can peel in large pieces like sheets of paper, which is also often referred as paperbark (Abdullah, A. H. et. al., 2001).

Gelam has long been neglected in Malaysia and undervalued for its commercial potentials. Many people in Malaysia might have seen or know Gelam, but they are not aware that Gelam has various uses. In recent years, Gelam commercial values have been acknowledged by many and efforts to explore it, especially for medicinal purposes such as producing cajuput oil (Azwanida, N. N., 2015, Saima, S. et. al., 2017 & Saima, S. et. al., 2020). In Malaysia, the extract from leaves is used to treat muscle pain, stomach aches, and cholera (Yao, L. K. et. al., 2011). Figure 6 shows a famous balm among Malaysians that use Cajuput oil as its active ingredient. In Indonesia, Gelam leaves are used to treat wounds due to burns, stomach aches, cramps, skin diseases, wounds and various ailments and diseases (Zohdi, R. M. et. al., 2011, Syazana, N. S., 2011 & Raghunath, B. S. et. al., 2015). In Myanmar, Gelam leaves are known to be effective for gout treatment, while in Vietnam, the leaves are used to treat joint diseases.

**ECONOMIC PROSPECT OF GELAM**

*Gelam*, which is a tree species within the family of *Myrtaceae* has a vital prospect in Malaysia. It can be considered as a multipurpose tree because most of the tree parts are usable. In areas with abundant of *Gelam*, people have recognized their usefulness for a relatively long time. The trunk of *Gelam* tree is often used as a structural post, fuelwood, charcoal production, fence, platform, fishing rod, agricultural pole, and stake. Figure 7 shows *Gelam* trees cut and turned into an agricultural pole. The papery bark is
suitable to be used for roofing, boat-sealing, and dying material. Extract from Gelam leaves are perfect to be used as an ingredient in the production of medicinal products such as balm, shampoo, and insect repellent. Figure 8 shows Gelam leaves and the essential oil extracted from the Gelam leaves.

Gelam trees have excellent characteristics because it can grow in a wide range of conditions, including highly acidic, saline, arid, and water-locked soil, especially in swampy areas, as seen in Figure 9, where most crops and trees cannot rehabilitate and thrive. Its usefulness and its adaptability in unfavorable regions make Gelam tree highly potential tree species to be grown in plantations, especially in swampy areas, which are often abandoned. Gelam can be found in many regions in the western and eastern part of Malaysia. If Gelam can be commercialized like Agarwood (Gaharu), it has vast potential to be a source of income for those who live in coastal areas or landowners who have land with unfavorable soil conditions. They can try to utilize the abandoned Gelam forest or turn their land into acreage plantations, as shown in Figure 10. Examples of farms in Kuala Linggi have proven that Gelam can be an alternative to other crops in swampy areas. Therefore, Gelam can be promoted as a tree species that is suitable to be commercialized due to its usefulness, adaptability to unfavourable conditions and its potential to be used for medicinal purposes.
Figure 9: Gelam at swampy deserted area

Figure 10: Acreage plantation concept in Kuala Linggi

DISTRIBUTION OF GELAM

Gelam trees are well tolerant, grows without a problem under a range of environmental conditions associated with unfavorable growth such as flooded ground, high acidity, saline soil, and drylands, as shown in Figure 11. While it is known to be tolerant, it can co-exist next to brackish and saline water, it thrives best in peatlands, waterlogged lowlands, and flooded areas, particularly in swampy areas.

In Malaysia, Gelam can be found spreading throughout many coastal areas of the east and west Malaysia. In degraded peat swamps, Gelam grows and spreads rapidly because of its tolerance to waterlogged and acidic conditions. Its speed of growth causes it to become established as pure forest species giving little opportunity for other species. On the edges of such areas, where permanent inundation conditions are dry, it will grow alongside other species. Gelam can adapt itself to unfavorable conditions better than other species, particularly in places where flooding occurs; Gelam will establish more freely in shallow areas where such secondary peat swamp forest is known as Gelam forest.

Gelam forest, which supersedes the primary forest, is quick to establish itself and dominates growth by not allowing other species to thrive, which includes other native species. This makes the land incapable of restoring itself to its natural conditions. Because of such nature, it is not recommended to grow in areas intended for restoration of forest species other than to limit its use for commercial forest plantations and acreage plantation. In the event of forest fires, Gelam is highly resistant to high temperatures, particularly the large and mature trees. In cases where forest fires are not intense, the papery bark provides insulation where the trees can survive. However, the root system will be burnt should peatland ground fires occur. Figure 12 shows the fire testing under controlled environment and supervision conducted at the Gelam plantation in Kuala Linggi.
In other countries, wide spreads of Gelam species have been observed, particularly in countries of Southeast Asia and Oceania, including Indonesia, Australia, Burma, Thailand, Vietnam, New Guinea, and on the islands of Borneo and Timor. Gelam can also be found in India and China. Although often associated with waterlogged tropical lowlands and peat swamps, Gelam has been found at altitudes more than 200 meters above sea level. It has been observed that while it is uncommon to certain geographic conditions, Gelam often survive under unfamiliar conditions.

**UTILISATION OF GELAM**

Gelam has a wide range of uses and values such as the following:

*Timber Posts, stakes, poles, and sticks*

In the early days, Gelam timber is of many uses to local people in the communities surrounding natural Gelam forests. The stems of Gelam were regularly used as stakes, poles, piles, timbers, and general construction materials. Gelam timber can also be used as biomass, which produces high-quality charcoal. Gelam timber is well adapted to anaerobic conditions and resilient to water damage. For smaller diameter size, it is used widely for the construction of boundary markers and perimeter fencing.
Leaves

Gelam leaves are considered to be the most valuable biomass of the species, due to its medicinal properties. On a broader scale, Gelam leaves are processed to produce Gelam oil - a non-toxic essential oil used as the core ingredient in a range of personal hygiene products. This may include medicated oil, shampoos, perfumes, soaps, and balm. Gelam oil is also widely used in traditional medicinal products for the treatment of respiratory symptoms such as coughs, colds, and as a general muscle relaxant. It has been studied that Gelam oil is a strong disinfectant against bacteria and can be used as termite and mosquito repellant. Gelam oil, which is also known as Minyak Kayu Putih in Indonesia, is considered a successful example of industrial agronomy. Currently, the majority of exported Gelam oil originates from Indonesia and Vietnam.

Bark

Along with a variety of uses, the ability to peel and roll Gelam bark into sheets has led to the usage of roofing material and a sealant material for boat building. It is also used in orchids propagation and nets for drying purposes. The bark of Gelam species is still used today in the construction of traditional houses in Papua New Guinea. It is used to line fernery baskets, for making bark paintings, and the cork from the bark has been used in pillows and mattresses (Bootle 1983). The bark of Gelam is used in parts of Malaysia as a luting material in boatbuilding (Lum 1994; Lim and Midon 2001).

Rehabilitation

Gelam is highly adaptable and hardy to a wide range of habitats and soils. They regularly thrive at sites that are extremely challenging for other native species to grow. Their adaptability, utility, and diversity in form see them listed ahead among the chosen species for land reclamation, with natural resource benefits including mitigation of salinity, waterlogging, and water and wind erosion. In Vietnam, Gelam forests are used for water quality maintenance. Acidic waters with low pH values are diverted into Gelam forest to raise the pH level before being used for rice cultivation. Biodiversity improvements, carbon sequestration, and potential to increase farmer’s income (e.g., through the production of related materials, essential oils, and bioenergy) are among the universal benefits of planting Gelam on degraded soil. Gelam wetland ecosystems also have their own specific high ecological value. At the same time, they are providing habitat to bees and for the provision of high-quality honey.

Honey Production

Bees love the nectar from the flowers of Gelam trees. Gelam honey is well known for its topical properties and contains therapeutic phenolic acids. Figures 13 and 14 show the stingless beehives surrounded by Gelam trees. Figure 15 shows the stingless bee honey collected from the stingless beehives. Gelam flowers assist directly with honey production by providing nectar and pollen in sufficient quantities to stimulate brood-rearing. The honey from these species is variously described as light to dark amber in color, with intense flavor and odor and of low moisture content. Their pollens are generally described as being a good source of protein utilized by bees in building up colonies, Figure 16 shows an example of commercialized Gelam honey sold by a stingless beekeeper.

Figure 13 : Stingless bee hives surrounded by matured Gelam trees
Figure 14 : Stingless bee hives surrounded by young Gelam trees

Figure 15 : Stingless bee honey collected from the stingless bee hives

Figure 16 : Commercialised Gelam honey sold by stingless beekeeper
PROPAGATION

Gelam can be grown in a range of ways, including from seed, from small saplings removed from natural habitats and through transplantation of large trees, which also proves to have a high survival rate.

Generative

Mass propagation is usually by seed, which germinates in moist, warm conditions with no pretreatment required. Seed should be sown under shade (optimum temperature for germination is 25–30 °C) on a sterilized medium and covered very sparingly with inert material (e.g., peat moss, sand). Soil needs to be prepared simply upon which Gelam seeds are simply distributed. The area needs to be watered gently and then covered with transparent plastic to maintain humidity. Germination should be completed after two weeks. Once underway, however, they grow quickly, and it takes between 3–4 months for the seedlings to reach plantable size.

There are two ways of producing container-grown seedlings commonly applied in the propagation of melaleucas: (a) the two-stage system where seeds are first sown into germination trays or beds and the seedlings later be transplanted or (b) the linear system where seeds are sown directly into separate individual containers for germination. In this system, seedlings are transplanted from the germination trays or beds at the second leaf-pair stage to polybags filled with a potting mix ratio of 1:1:1:3 (sand, compost, cocopeat, and topsoil). Once plants have become established, as shown in Figure 17, they can be removed to polybags containing the potting mix.

Vegetative

Along with propagating saplings for transplantation, sprouts can be taken directly from areas where natural Gelam forest are abundantly found. These can be extracted by hand and temporarily transplanted into temporary plastics bags. It is recommended, however, that saplings are taken from non-flooded areas as those already established in the more favorable flooded conditions have a lower survival rate on transplantation. By using this method, the total time before final planting, as shown in Figure 18 can be reduced to 2-3 months. However, if done during rainy season, transplanting can be immediate, without the need for temporary planting in plastic bags.

Gelam does not need to be transplanted onto raised beds or soil mounds as it has been found that under both allocated and non-raised transplanting sites, survival rates are similar. Raising the soil level, therefore, increases both preparation time and additional costs. Furthermore, raising beds may produce unstable soil structure and lower the survivability of the plants.

Under natural circumstances, Gelam is a pioneer species that proliferate after incidents of forest fire and has a high ability to rapidly colonies the vacant land. While some trees propagate from the natural dispersal of seed, others originate from damaged roots and broken trunks but thrive equally, increasing in height by up to 2 meters per year.

In terms of pests and diseases, Gelam is vulnerable to very few, except for some insects which utilize the outer bark of the tree trunk. Because of its natural durability, the care and maintenance of Gelam plantations are entirely natural and require minimal care and attention. During the first three years of growth, weeding once or twice per year and ensuring that land is protected from forest fires may prove sufficient. In addition to this, trees displaying slow or stunted growth can be removed to allow better growth for the remaining species. Nevertheless, in the event of growing for Gelam oil, the tree height is not essential and can be controlled to allow easier access to the leaves. Gelam can also be propagated vegetatively from stem cuttings and grafts to ensure the genetic integrity of cultivars.

Figure 17: Seedling development starts with germination of the seed
Figure 18: Transplantation from polybag to plantation and maintenance of Gelam trees
SILVICULTURE AND MANAGEMENT

Gelam is used for a range of landscape, wood, and non-wood purposes. The silvicultural system implemented will depend on the end-use of the planting. However, it is clear from the lack of information and studies is known about optimal stand establishment, tending, and conventional systems for Gelam silviculture and management in Malaysia.

Plantations for wood production

Most interest in growing Gelam for wood production is on difficult sites for tree growth where the adaptive traits of the Gelam provide them a competitive advantage over other tree crops. It is mainly Gelam native species that are grown for this purpose. An essential advantage over other tree crops under cultivation in this harsh environment for tree growth is that they can be established successfully without expensive and environmentally damaging soil mounding. Mounding is required to cultivate alternative species, and this exposes the acid-sulfate soils. Species of our native Gelam are known to survive a fluctuating water table, including prolonged seasonal inundation and severe acidity. Other essential advantages in this environment are abilities to withstand intense weed competition and dry-season fire. Practices that include proper site preparation, fertilization when required, and intensive weed control pay dividends in the cultivation of Gelam. Figure 19 shows intensive site preparation by plowing, the addition of a nitrogen/phosphorus/potassium (NPK) fertilizer, and manual tending are known to be beneficial to the establishment and early growth of Gelam plantations where growth rates are relatively reasonable.

Plantations for production of essential oils

The silvicultural systems used to produce essential oils from plantations represent an intensive, high-cost but high-return system (large scale plantation) and a less intense, lower cost but also a smaller return system (acreage plantation). This second case is a representation of silvicultural systems used in developing countries where Gelam plantations can provide a multitude of commercialized for sustainable development, such as inter-row cropping and honey production, rather than oil production alone, as is the case with the Kuala Linggi plantation.

RECOMMENDATIONS AND LIMITATIONS

Growth and management of Gelam in the form of economic forest plantations to provide mainstream and downstream products is an approach to forestry and farming with a bright future. Nevertheless, the current results of the study show that trees will differ in size and characteristics depending on their geographic location. Consequently, this will affect the quality and yield of cajuput oil and
timber. It is, therefore, necessary to increase the current amount of study for the right silvicultural system, especially in the selection and development of required species to increase the growth and yield to meet the needs of the market. Attention needed to be given to a wide range of factors such as the development and selection of quick-growing species, and the effect of species type on yields of cineol from leaves. It is also necessary to study, in greater detail, the potential for producing medicinal and other by-products. Figure 20 shows samples of extracted oil from multiple species of Gelam essential oil from Gelam plantation in Kuala Linggi. In combination with timber, honey production, intercropping, and Gelam oil harvesting, this can increase the economic value of Gelam. The most significant limitation to the broader growth and plantation of Gelam is the risk and potential damage through a forest fire. At all plantation sites, it is necessary to take preventative measures to mitigate the risk and protect the investment of the plantation. The immediate future for the Gelam Essential oil and honey industry looks very promising in Malaysia, where demand consistently exceeds supply. However, significant constraints due to lack of official quality standards will potentially lead to adulterated oils of variable composition, efficacy or clinical trials to support claims of medicinal benefits, and low yields and quality variation in oils from natural stands and plantations. If plantations are to be more productive on a sustainable basis, tree improvement programs are needed to enhance biomass production and oil traits. Extensive research is also necessary to determine optimal silvicultural methods for oil production without depleting soil nutrients. Prospects for broader exploitation of carefully selected Gelam species appropriate for intended use both within and beyond their zones of natural occurrence appear promising. When considering the introduction of a Gelam species to a location for the first time, plant risk analysis procedures should be applied commercialized.

OPPORTUNITIES

Reasonable growth rates in the face of deplorable environmental conditions for plant growth and a broad range of uses are among the desirable attributes of the Gelam species regularly deployed in reforestation, land reclamation, amenity, and landscape plantings and for production of essential oils. With a predominance of species occurring in arid and semi-arid regions, it is possible to select species which can be tolerant of a wide range of unfavorable conditions such as infertile soils, poorly drained sites, continuous and periodic inundation, coastal exposure, fire, acidity, salinity, and both high and low soil pH. Gelam is largely outbreeding, often with heritable and highly variable commercial traits (e.g., growth characteristics and oil concentrations). This will provide a massive opportunity for the tree breeder where there is an excellent opportunity for species selection and breeding to improve oil yields and oil qualities in the establishment of Gelam plantation. These species all have distinctively different chemical variants, of which several types found is suitable for commercial exploitation. It is vital to select the suitable species that will reliably provide the required oil as well as the ability to coppice well so that oil yields are maximized.

CONCLUSIONS

Even though its' commercial values are often undermined, Gelam can grow well in extreme conditions. Gelam is suitable to be commercialized as “economic crop”, because it has good potential to support the lives of rural farmers through downstream production of essential oil and quality honey. Gelam honey and Gelam essential oil demonstrate good results in antioxidant, anti-inflammatory and anti-microbial tests. Therefore, Gelam honey and Gelam essential oil have huge potential to be used in both modern and traditional medicinal applications.
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