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GELAM CONSERVATION, PROSPECTS AND SILVICULTURE MANAGEMENT

Dr Daing Nafiz
Faculty of Mechanical & Automotive Engineering Technology
Universiti Malaysia Pahang, 26600 Pekan, Pahang Malaysia
Email: daingnafiz@ump.edu.my

Johannes Esqander
Gelamekar Sdn. Bhd.
B036 Gelam Grove, Nusa Dusun Orchard Resort Kuala Linggi, 78200 Kuala Sungai Baru Melaka Malaysia
Email: gelamtree@gmail.com

Dr Ruhil Amal Azmuddin
Centre for Modern Languages,
Universiti Malaysia Pahang, 26600 Pekan, Pahang Malaysia
Email: ruhilamal@ump.edu.my

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, acidic 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.

Keywords: Gelam, Melaleuca, Cajuputi, Gelam Conservation, Silviculture Management.

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GELAM (MELALEUCA)

There are about 300 species of *Gelam* distributed in Malaysia, South East Asia and Australia. *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 has a uniform texture that can be used for wood carving, making cabinets and pieces of bark. Essential oils can also be extracted from biomass of *Gelam* like *Melaleuca.alternifolia, Cajuputi* and *Quinquenervia*. In countries like Australia and Indonesia, *Gelam* is considered a useful tree and they are used as ingredients for medicine, balm, shampoo and insect repellant.

Gelam can grow in an extreme environment like high acid soil, saline soil, arid soil, water-locked soil and peat swamp areas where most of agricultural crops and trees cannot grow. Figure 1 shows the distribution of *Gelam* across South East Asia and Australia. Based from Figure 1, subspecies *cajuputi* can be found in Southwest Australia, East Indonesia (Maluku and Timor Island), subspecies *cumingiana* grow in West Indonesia (Sumatera, West Jawa and South Kalimantan), Malaysia, Myanmar, Thailand and Vietnam and subspecies *plathphylla* can be found in North Queensland/Australia, Northwest Papua New Guinea.

For honey bee breeders, *Gelam* forests are an ideal place for beekeepers to relocate bee hives because *Gelam* flower throughout the year and can produce high-quality honey. Figure 2 shows a bee is looking for nectar from *Gelam* tree. Many years ago, *Gelam* forests can be found across peninsular Malaysia, but today sizeable *Gelam* forests are hard to find. Today, sizeable *Gelam* forests are said can be found growing wildly in deserted and swampy areas between Kemaman to Besut in Terengganu on the east coast of Peninsular Malaysia. *Gelam* forests were destroyed because of human activities like plantations and land conversions to commercial or housing areas. Figure 3 shows an example of *Gelam* that is grown in Kuala Linggi, Malacca, Malaysia.

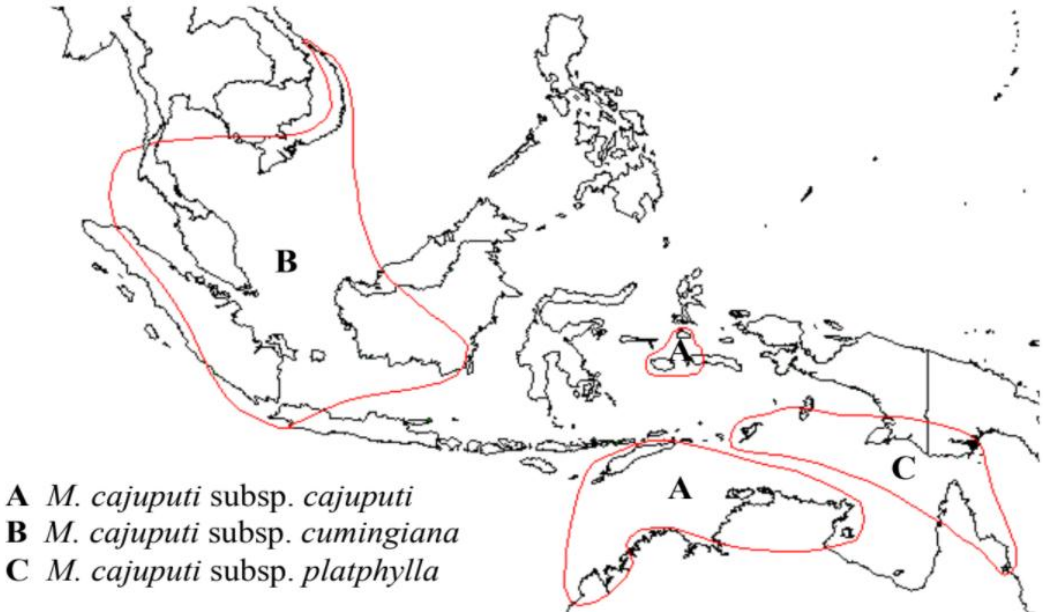

Figure 1 : Distribution of *Gelam* across South East Asia and Australia

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Figure 2 : A bee is looking for nectar from *Gelam* tree

Figure 3 : *Gelam* that are grown in Kuala Linggi

Figure 4 : Small yellow cream flowers are elongated in the shape of a bottle brush

Figure 5 : Fruit is round in the form of brown capsules in a dense cluster

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Figure 6 : Balm that use cajuput oil as active ingredient (Photo from tigerbalm.com)

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 20 meters. 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. If crush, 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. 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.

Gelam has been long 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 many uses. In recent years, *Gelam* commercial values have been acknowledged by many and efforts to explore *Gelam* commercial values, especially for medicinal purposes like producing cajuput oil or also known as eucalyptus oil. In Malaysia, the extract from leaves is used to treat muscle pain, stomach aches, and cholera. 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. 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 were 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 is 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* has 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 shown in Figure 9, where most of crops and trees cannot rehabilitate and thrive. Its usefulness and its adaptability in unfavorable regions made *Gelam* be 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 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 proved that *Gelam* can be an alternative choice 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 in drugs.

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Figure 7 : Gelam were cut and made as agricultural pole

Figure 8 : Essential oil is extracted from Gelam grown in Kuala Linggi leaves

Figure 9 : Gelam at swampy deserted area

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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 owing to 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.

Figure 11 : Gelam are grown at peatland in Kuala Linggi

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Figure 12 : Fire testing under controlled environment and supervision

Gelam forest, which supersedes the primary forest, is quick to establish itself and dominates growth by not allowing other species to thrive, include other native species. This makes the land incapable of restoring itself to its natural conditions. Due to this 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, in particular 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 in excess of 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 anaerobiotic 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

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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.

Figure 13 : Stingless bee hives surrounded by matured *Gelam* trees

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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

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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 bee hives surrounded by *Gelam* trees. Figure 15 shows the stingless bee honey collected from the stingless bee hives. *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.

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 can abundantly be 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, although if done during the 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 more or less similar. Raising the soil level, therefore, increases both preparation time and additional costs involved. Furthermore, raising beds may produce unstable soil structure and lower the survivability of the plants.

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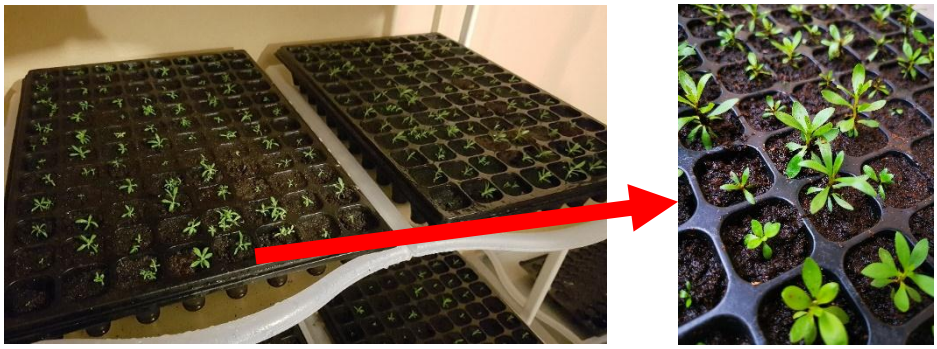

Figure 17 : Seedling development starts with germination of the seed

Figure 18 : Transplantation from polybag to plantation and maintenance of *Gelam* trees

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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. As a consequence 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.

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 in places such as the Mekong Delta of Vietnam. 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 tend-ing 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 for the production of 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 services

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Figure 19 : Intensive site preparation by plowing

Figure 20 : Samples of extracted oil from multiple species of *Gelam* plantation in Kuala Linggi

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

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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. 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.

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 distinctly different chemical variants, of which of 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

Gelam has a wide range and variety of uses, both to local people and on the open market, and is capable of growing well and adapting to a range of geographic areas and conditions. Centre for Economic Policy Research Malaysia has also determined that *Gelam* is suitable as an "economic crop," and therefore, commercial plantation and where harvesting is permitted and not in conflict with current forestry legislation. *Gelam* also has a high potential to support the lives of the farmers, especially those in secondary and degraded swamps.

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