International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume:03, Issue:06 "November-December 2017"

AN APPROACH TOWARDS CULTIVATION AND SUSTAINABILITY OF MEDICINAL PLANTS IN MALAYSIA

Farah Fazwa, M.A.

Forestry Biotechnology Division, Forest Research Institute Malaysia (FRIM)
Kepong, 52109, Selangor, Malaysia

ABSTRACT

Currently, plants with medicinal values have attracted enormous attention due to several reasons, such as for the rationale of biological diversity and economic contemplation. Most of the resources for these plants are obtained from the tropical natural forests. The present interest surge in herbal medicines all over the world (both developed and developing countries), has resulted in unregulated and exploitative harvesting of the raw materials from the natural forests. This will pose pressure to the ecosystem and threat of extinction of several valuable medicinal plant species. The logging activities and encroachment of the forests have also contributed to this problem. Therefore, cultivation of these valuable medicinal plants should be encouraged as it could avoid dependence of these materials from the natural forests. This is to ensure their sustainable supply to meet the health care needs of the present and future generations. For any cultivation program to be successful, adequate and regular supply of planting stocks should be available. Normal techniques of raising these planting stocks are from seeds. However, the dependence on seeds as source of planting materials is inadequate as seeds are difficult to obtain due to depletion of mother plants. Hence suitable techniques for mass propagation of these species have to be developed. This paper highlights the propagation and nursery techniques for the planting stock production, and the growth performance of some medicinal plant species that have been planted.

Keywords: propagation, planting stocks, nursery techniques, cultivation, plantation

INTRODUCTION

According to World Health organization (WHO), about 80% of the world population relies chiefly on traditional medicine, a major part of which involves the use of plant extracts or their active ingredients. Plants medicines are a necessity as pharmaceutical drugs are costly and unaffordable especially for those from the third world countries. On the other hand, in the

ISSN: 2455-6939

Volume:03, Issue:06 "November-December 2017"

developed countries, it serves as an alternative to using conventional drugs because it has less side effects. In view of the ever increasing demand of medicinal plant raw materials, one might ask the question where do these raw materials come from and/or are they available in the quantities required by the relevant industries.

Majority of these materials come from the wild collection. Supplies are in general are increasingly limited by deforestation from logging and conversion to plantations, agriculture and pastures. The condition is worsened with indiscriminate harvesting and over exploitation which are frequently destructive. This could/will ultimately lead to imminent extinction of many species. For example in the USA, about 60 million annually of goldenseal roots (*Hydrastis canadensis*) is collected, driving the species close to extinction. The American ginseng (*Panax quinquefolium*) is also at risk. In Malaysia it is reported that tongkat ali (*Eurycoma longifolia*) and tongkat haji samad (*Prismatomeris malayana*) are among the threatened species. The statistics showed that out of 422, 000 of flowering plant species worldwide, 72 000 species (17%) of them are used medicinally and out of this 21% are threatened (Govaerts, 2001; Bramwell, 2003 & Schippmann *et al*. 2006). To overcome this problem, suggestions on the sustainable use of plant resources and cultivation have been put forward, each has its own advantages and disadvantages.

Sustainable use of plant resources

The use of components of biological diversity, thereby maintaining its potential to meet the needs and aspiration of present and future generations (WHO guidelines on GACP 2003). Sustainable harvest to be the most important conservation strategy from the wild, given their contributions to local economies and their greater value to harvesters over the long term.

However, the major challenge for sustainable wild collection include; lack of knowledge about sustainable harvest rates and practices, undefined land use rights and lack of legislative and policy guidance. Wild collection also offers materials adulterated with unwanted, sometimes harmful plant species. Its harvest volumes are dependent on many factors that cannot be controlled and irregularity of supply is a common feature.

Cultivation

The cultivation processes of medicinal plants generally include planting materials, processing planting media, planting, maintaining plants, harvesting and post-harvest management. Depending on the condition of the land, the stages in planting management can include such activities as preparing the land, opening the land, constructing beds, and lime management. Maintaining plants include such activities as replacing dead seedling with healthy ones, weeding, fertilizing, irrigation, and management of insects, diseases and weed.

ISSN: 2455-6939

Volume:03, Issue:06 "November-December 2017"

Advantages of cultivation

- Provides reliable botanical identity
- Guarantees steady supply of raw materials
- Allows control post-harvest handling
- Can be easily certified organics
- Quality control can be assured
- The selection and development of genotypes with commercially desirable traits from the wild or managed populations may offer opportunities for the economics development of medicinal plant species as a crop
- Renders possible agreement between wholesalers and pharmaceutical companies on volumes and prices over time with growers
- Product standard can be adjusted according to regulations and consumer preferences

PLANTING STOCK PRODUCTION

Planting materials can be obtained from seeds, wildings, vegetative propagated materials such as cuttings, tissue culture plantlets, grafts, marcot and etc.

Source of planting materials

Seeds

Most of the species can be propagated by seeds. Seeds collected must be matured, fresh and free from pest and disease to ensure good germination. Germination beds can be constructed with size of 1m width and 15 cm deep and the length depends on the area available. Germination beds should be shaded with light intensity between 40 to 50% full sunlight for most species.

After the seeds are cleaned, they are sown in sowing beds in media of soil and sand in the ratio of 1:1 or 3:1. Small seeds can be distributed on the sowing beds while bigger seeds can be sown in rows to avoid overlapping among them. After sowing, the seeds should be covered with a thin layer of sowing media to avoid exposed parts from drying out.

Watering is carried out in the morning and late afternoon to keep the seeds moist. Weeding, insecticide and fungicide applications are made whenever necessary. The seedlings are ready for potting when one pair of leaves has developed.

ISSN: 2455-6939

Volume:03, Issue:06 "November-December 2017"

Wildings

One of the most reliable methods of getting planting stocks is through wildings collection. These wildings are from seeds germinated on forest floor underneath or around mother trees. High percentage of survival can be achieved if wildings are collected after the rainfall and the seedlings are still small about 3–5 cm tall. When collecting wildings, great care must be taken to ensure adequate amount of roots are removed for high survival rate. The use of sharp spades or similar tools is often recommended to avoid severe damage or breakage of roots during extraction process of the wildings. Wildings are usually kept moist in closed polythene with their root being wrapped with moist newspaper or tissue paper to avoid dehydration upon transporting to the nursery for potting. Leaves are trimmed to reduce water loss through transpiration and evaporation. Newly potted wildings have to be kept under shade and high humidity (e.g. in plastic tent) for three to four weeks before transferring them to transplanting beds. This process will help the wildings to recover from transplanting shock and to get acclimatise with normal growing condition in the nursery.

Vegetative propagation

Several methods of vegetative propagation can be used for propagation which includes cuttings, air layering, grafting and tissue culture. The most commonly used method by nurseries is through rooting of cuttings.

Vegetative propagation by cuttings

The cutting materials are taken from stock plants which can be raised in pots or on the ground. Light intensity 25–50% of full sunlight should be given to stock plants depending on species. The shade can either be natural e.g. canopy of trees in the nursery or artificial shading using the plastic netting. Basic maintenance such as watering, weeding, fertilizer, insecticides and fungicides applications have to be made to ensure healthy growth of the stock plants. Cutting back to produce new coppice shoots is necessary for continuous production of juvenile cutting materials for rooting (Hartmann *et al*. 1990).

The cuttings used are 5 cm in length to facilitate handling. Leaves of cuttings are trimmed to 15 to 30 cm^2 to reduce water loss and to allow photosynthesis to take place. For the species which are propagated from leaves like *Labisia pumila* (Primulaceae), 30–40 cm^2 leaf area is recommended. The base of cuttings is treated with commercially prepared hormone, Seradix 1 (0.1% indole butyric acid). The prepared cuttings can be planted in either mist propagation system with plastic enclosure or non-mist propagation system. For the enclosed mist system, misting frequency is every hour with one minute duration of spray. The non-mist propagation

ISSN: 2455-6939

Volume:03, Issue:06 "November-December 2017"

system is constructed based on Leakey *et al*. (1990). It is basically an enclosed system (a polythene frame) with a volume of water at the base of the propagator below the rooting medium. The water provides moisture to cuttings through capillary action. For propagation of most plants, cleaned river sand is a good medium. Light intensity of the propagation systems is to 15 to 30% of full sunlight depending on species while their relative humidity is more than 80%.

Cuttings are checked every two weeks and those rooted are potted while cuttings that do not root are replanted into the rooting media. These cuttings are reassessed until no more new rooting occurred. Rooting period is within three to twelve weeks depending on the species. Several species have been tried and about 70 to 90% success has been obtained depending on the species. Other Malaysian herbal species that can be propagated by cutting included *Labisia pumila*, *Phyllagytis rotundifoli*, *Pereskia sacharos*, *Andrographis paniculata*, *Ficus deltoidea*, *Orthosiphon stamineus*, *Piper longum***,** *Piper betle***,** *Tinospora crispa* and *Aquilaria malaccensis*.

Nursery practices for seedlings and rooted cuttings

Potting medium

Medium physically supports a growing plant, stores and supplies nutrients and water and air to the root systems. The better the media, the better will be development of a healthy fibrous root system and subsequently a better quality seedling is produced which will survive and commence growth quickly after field planting. The development of a healthy, fibrous root system needs a media with good physical properties.

Good potting medium should consist of a high percentage of organic matter, light in weight and is very well drained and aerated yet able to absorb and retain significant amount of water. Soil and sand mixture commonly used in nurseries is simply not appropriate for the development of good fibrous root system. Heavy and poorly drained soil medium will inhibit aeration, drainage and root growth. Organic matter helps resist compaction and retain water while still maintaining porosity for movement of air and root growth. Examples of organic matter that can be used as potting medium are peat, rice hulls, coconut and oil palm husk, sugarcane waste, sawdust, leaves and grasses, etc. Most organic matter other than peat and rice hulls should be composted prior to use to give good results. Composting improves physical properties and balances the ratio of carbon to nitrogen. Besides improving the texture of the potting media, organic matter will reduce the weight of the media in the container.

ISSN: 2455-6939

Volume:03, Issue:06 "November-December 2017"

Potting

Minimizing root damage is an important consideration when potting newly germinated seedlings or rooted cuttings. Germinated seedlings or rooted cuttings are kept in water before they are potted to avoid dehydration. Potted cuttings should be weaned in the propagations systems for 2 to 4 weeks (depending on species) before they are sent to the transplanting beds with 30% light intensity. These plants are gradually exposed to 50, 70 and 100% light intensity depending on the species. The base of transplanting beds may be constructed from concrete, gravels or plastic sheets to avoid roots penetrating to the ground and to reduce weed growth on the beds.

Maintenance of potted plants

Fertiliser application

Usually organic fertilizer is applied to the potted plants. The fertilizer can be obtained commercially or rotted dung of cow, goats, sheep and chicken can be used.

Watering

Water is very important for survival of potted plants. These plants will dry up very fast and will eventually die if no water is given. Manual watering is only practical for small nurseries. For large nurseries, sprinkler system, which operated automatically, is recommended. Watering can also be carried out using drip irrigation where each bag has an emitter. Watering is carried out twice daily in the morning and late afternoon except on rainy days. Watering frequency can be reduced if major component of the potting medium consisted of organic matter. Organic matter can improve the water holding capacity of the medium.

Root pruning

Regular root pruning should be carried out to avoid root penetrating into the ground. If the roots have already penetrated the ground, the plants may die if they are pulled out of the ground without careful handling.

Other maintenance includes weeding, insecticide and fungicide applications should be carried out whenever necessary. Regular inspection of planting stocks in the nursery will enable early detection of pests and diseases and hence proper measures can be taken.

Hardening process

When planting stocks are ready to be sent to the fields (at least 30 cm tall), they are hardened in the nursery to reduce the shock of exposure to the relatively harsh environment in the field. This

ISSN: 2455-6939

Volume:03, Issue:06 "November-December 2017"

hardening process increases the chances of survival of planting stocks after transportation. Potted plants on transplanting beds are gradually moved to more exposed areas for hardening before out planting. Hardening process also involves gradually reducing the amounts of water and fertilizer given to the planting stocks. This process will take over 3 to 4 weeks before planting stocks are ready to be dispatched to the field.

Grading of planting stock for planting

Healthy planting stocks that free from pests and diseases are selected for planting in the field. Weak and damaged planting stocks are either thrown away or kept in the nursery for possible rehabilitation.

AGRONOMIC AND PERFORMANCE OF SOME SELECTED MEDICINAL PLANTS

The medicinal plant species described below have been planted in research plots in Forest Research Institute Malaysia (FRIM) to see their growth performance.

Labisia pumila

Labisia pumila or locally known as "Kacip Fatimah" is a herb species that has phytoestrogenic activity which beneficial to women health. Naturally, kacip fatimah can easily be found in moist, well-drained lowland forests. However the species can also be planted in agricultural plantations such as rubber and oil palm. Between the two sites, oil palm plantation provides better condition for kacip fatimah plants growth since the oil palm trees provide good shading of 60–65%. Kacip fatimah plants thrive in shady places. Open sunlight can be harmful to the establishment and growth of kacip fatimah. Currently Forest Research Institute Malaysia (FRIM) has established many research plots and plantation integrated with rubber trees.

Field planting

Planting bed should have plenty of organic matter, e.g. compost or peat and it should be thoroughly mixed with the soil. Compost can improve the sandy soil composition, characteristic, water and nutrient holding capacity. In plantation it is recommended that composted oil palm mesocarp fibres be used due to as the material is cheap and can be easily obtained. The planting beds can be covered with plastic to control weeds and retain soil moisture. The planting distance of is 30 cm x 30 cm for square planting or 30 cm x 30 cm x 30 cm for triangular planting system. (Figure 1) (Farah Fazwa et al. 2015).

ISSN: 2455-6939

Volume:03, Issue:06 "November-December 2017"

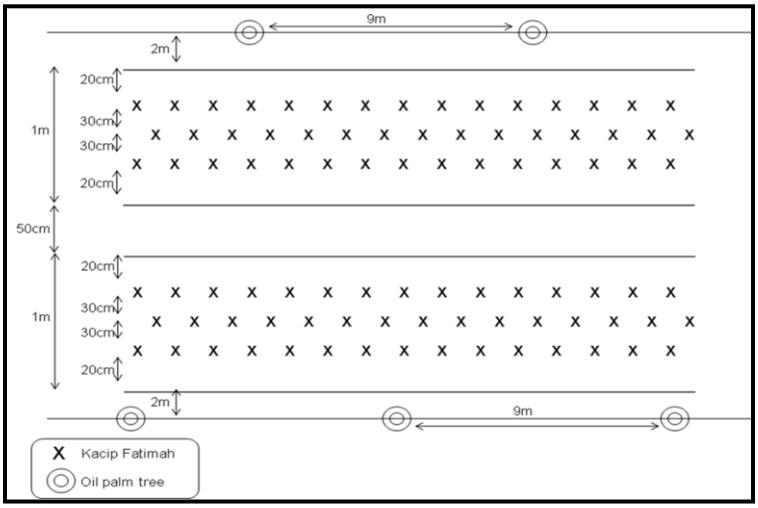

Figure 1: Planting design for *Labisia pumila* planted in oil palm plantation

In cultivating kacip fatimah, it is important to try to mimic the natural forest habitual in order for the plants to survive. In natural habitat, kacip fatimah grows on humus rich soil. Under this condition the soil moisture is more than 60% with pH ranging from 4.0–5.0. Kacip fatimah plants are mostly found growing under closed canopy with about 25–35% light penetration. Humidity of the areas is more than 80%. It is recommended to use older oil palm plantation since the closed canopy of oil palm provides shade up to 65% with temperature around 24–28 ^{o}C and 80% humidity. In the area where the palm canopy is thin, additional shade should be constructed using oil palm fronds to ensure kacip fatimah is not exposed to sunlight. Although the soil under the oil palm plantation is lacking in organic matter, application of compost or other forms organic matter would enrich the soil. The organic matter coupled with good irrigation system will provide high soil moisture to kacip fatimah plants. The soil pH under the oil palm should be kept around 5.0.

Maintenance

Irrigation is very important in any plantation of kacip fatimah. Many irrigation systems can be used such as drip irrigation, sprinkler and manual watering. Drip irrigation is the best option if kacip fatimah is planted using plastic mulching where the drip head is normally placed beside each plant and water will be supplied directly to the plant. This method will save water and energy. If kacip fatinah is to be grown as organic farming, only organic fertilizer is recommended for the planting of kacip fatimah. Process animal dung or composted organic material can be used for this purpose.

ISSN: 2455-6939

Volume:03, Issue:06 "November-December 2017"

To control weed, manual weeding is recommended as it is important to avoid competition from weeds. For large plantation plastic mulching is recommended. For pest and disease control, biological and mechanical methods are used. Besides that good cultural practice is recommended such as keeping the planting beds clean, free from debris of dead leaves and other fresh plant materials as these materials can become the source of pests and diseases.

Harvesting

Kacip fatimah is normally ready for harvesting nine months old after planting or when the plants are about 30–45 cm tall. Harvesting can be done by pulling the whole plant together with the roots or by cutting at the base of the plant. Cutting at the base of the plant will leave the rhizomes intact which will later coppices and produce new plants and this will reduce replanting cost for the subsequent crop cycles.

Citrus aurantifolia

Citrus aurantifolia or locally known as "Limau nipis" (Rutaceae) is found suitable to be planted in dry and moist season. The species can be planted at any soil types, preferably on sandy loam soil. FRIM has established limau nipis research plot in Maran, Pahang since 2006.

Field planting

The species is normally planted with a planting distance of 6 m x 6 m with a density of 270 trees ha^{-1}. The size of planting hole is 0.4 m x 0.4 m x 0.2 m and 10–12 kg organic fertilizer is applied in each hole.

Maintenance

Watering is required for the first 2 to 3 months after planting. In addition, application of organic fertilizer (cow dung) at the rate of 30–40 kg $tree^{-1}yr^{-1}$ is required for early growth development (1–3 years old) and then 40–60 kg $tree^{-1}yr^{-1}$ after three years of planting (Farah Fazwa et al. 2007). At early growth pruning and weeding are critical. Pruning is normally carried out by removing twigs, dead leaves, etc. Weeds are controlled manually and sometimes by using chemical control method.

If inorganic fertilizer is used, two types of fertilizer are recommended: $15N_2$:$15P_2O_5$:$6K_2O$:4MgO for growth and $12N_2$:$12P_2O_5$:$17K_2O$:2MgO to enhance fruiting. Fertilizer should be applied surrounding the trees and the type and frequency of the fertilization is as shown in Table 1.

ISSN: 2455-6939

Volume:03, Issue:06 "November-December 2017"

Table 1: Frequency and type of inorganic fertilizer for limau nipis

Tree Age (Year)	Type of fertilizer	Rate (kg tree^{-1}yr^{-1})	Time
1	Growth	0.3	3 times yr^{-1}
2	Growth	0.5	Beginning of rainy season
3	Growth	1.0	Before dry season
4	Fruit	1.5	Twice a year
5	Fruit	1.8	Beginning of rainy season
6	Fruit	2.3	4–5 months after harvesting
>6	Fruit	2.5	After harvesting

Growth performance

Based on pilot plantation in Maran, Pahang, the planted trees indicated the average plant height growth was 46.3 cm, ranging from 100 to 88 cm for 4 years after planting (2006–2010) as indicated in Table 2.

Harvesting

In plantation, the planted trees start fruiting at the age of 2–3 years for trees planted using air layers (marcot). The properly managed plantation is in the position to yield 20–25 kg fruits tree^{-1}yr^{-1} with an economic life span of about ten years.

Aquilaria malaccensis

Aquilaria malaccensis or locally known as "Karas" (Thymelaeaceae) is the major source of agarwood, resinous heartwood, used for perfume and incense. The resin is produced by the tree in response to infection by foreign bodies. The most popular species in Malaysia that are generally associated with agarwood trade are *A. malaccensis* and *A. hirta*. The species is widely distributed in countries such as Bangladesh, Bhutan, India, Indonesia, Malaysia, Myanmar, Philippines, Singapore and Thailand. The trees occurred in various habitats such as rocky, sandy or calcareous, well-drained slopes and ridges and land near swamps. Sometimes, the species can grow at latitudes up to 1000 m with an average daily temperature of 24–32 ^{o}C and annual rainfall of between 2000–4000 mm yr^{-1}.

Field planting

ISSN: 2455-6939

Volume:03, Issue:06 "November-December 2017"

In plantation the plant is usually planted by seedlings obtained through wildings or raised seedlings. The planting stocks can also be prepared using propagation via juvenile cuttings, with or without hormone. They normally grow well under full sunlight and planting is recommended during raining or wet seasons. The planting distance used is 3 m x 3 m or 4 m x 4 m (equivalent to 1111 or 625 trees ha^{-1}) and in the form of square planting pattern. The plants can be planted either as a monoculture or inter-planted with other high quality timber trees.

Maintenance

For optimum growth, some basic fertilizer such as rock phosphate or other main nutrients is necessary. The amount of fertilizer applied as in the following Table 2 for the first five years is recommended (Ahmad Zuhaidi *et al*. 2008).

Table 2: Recommended fertiliser rate for early of *Aquilaria malaccensis*

Time (months)	Amount (g)	Application	Treatments
0	100	Planting holes	CIRP (rock phosphate)
6	100	50 cm radius	circle weeding, NPK
12	100	50 cm radius	circle weeding, NPK
18	200	Below edge of canopy	circle weeding, NPK
24–60	200	Below edge of canopy	circle weeding, NPK

The karas plantation is relatively free from any major pest and diseases. However extra care must be taken to ensure good hygienic surrounding and healthy conditions of the trees during their early growth. Regular weeding, pruning and inspection are also required.

Growth performances

In a 67 years old experimental plot at FRIM, the mean diameter and height of 38.2 cm and 26.7 m respectively was obtained (Lok & A. Zuhaidi 1996). In another study, a trial was set up to examine the growth performance of karas in an open condition with a planting distance of 3 m x 3 m and was inter-planted with *Azadirachta excelsa*. The results indicated that after 6 months, both *A. malaccensis* and *A. excelsa* attained a similar high survival rate of 93% with an average height of 86.2 cm and 114.4 cm respectively (Lok *et al*. 1999). Recent assessment carried out on the ten years old stand showed that the mean diameter and height was 15.6 cm and 9.7 m respectively.

Harvesting

ISSN: 2455-6939

Volume:03, Issue:06 "November-December 2017"

Research into the formation of agarwood is still on-going and reports on the natural age of the trees for the formation of agarwood are not consistent. For example, Chakrabarty *et al*. 1994 reported that infected trees were found to produce resin from the age of 20 years onwards. La Frankie (1994) suggested that only 10% of mature *Aquilaria* trees with diameter ≥ 20 cm and above can produce agarwood while Soehartono (1997) suggested that trees with age ≥50 years old produce the best yields of agarwood. Hence, uncertainty exist about the size/age of trees when they reach reproductive maturity has cause various speculation that the current practice of harvesting adult trees is likely to be detrimental to the viability of the natural population. The current inducement technique for gaharu production on *Aquilaria crassna* suggests that as early as 4–6 years old cultivated trees are able to produce agarwood (Zuhaidi *et al*. 2008).

Orthosiphon stamineus

Orthosiphon stamineus or locally known as "Misai kucing" (Lamiaceae) is a shrub that grown along the forest edges, roadsides and wastelands. Currently the species are being planted in many home gardens because of its elegant flowers. The species can easily be planted on many soil types including Bris and alluvium soils and survived well in well-drained soils with full sunlight.

Field planting

The recommended planting distance for the plant is 1.5 m x 0.45 m with a population density of 14 800 trees ha^{-1}.

Maintenance

For Bris soils, the recommended fertilizer regime is 10 ton ha^{-1} of chicken dung three days before planting and should be repeated every six months. For regular applications of organic fertilizer, kokei (NPK 10:10:10) at the rate of 1000 kg ha^{-1} every six months is recommended. For the plantation on Alluvium soils, 5 ton ha^{-1} of chicken dung is recommended to be applied three days before planting and should be repeated every six months. As for the regular applications of organic fertilizer, kokei (NPK 10:10:10) at the rate of 500 kg ha^{-1} every six months is suggested (Zaharah, A. 2005).

Irrigation of the plantation is depending on the soil type and water resource. As for commercial scale planting, it is recommended that a sprinkler system to be used to reduce high labor cost. Weeding is critical during early planting however at the maximum growth, close canopy limit weed growth and therefore, reduces the need for weeding. It is also recommended that plastic mulch can be used to control weeds in big plantation.

ISSN: 2455-6939

Volume:03, Issue:06 "November-December 2017"

The plantation of misai kucing is found to be not significantly susceptible to diseases but it is quite prone to insect attacks. If planting of misai kucing were during the dry season (Jan–June), the plantation will require 40–50% shade. However the shade is not required for plantation established on alluvium soils.

Growth performance

Misai kucing grows well in mineral soil with an average height of 12.67 cm in three months as compared to other soil types. The growth performance of misai kucing planted on different soil types is as indicated in Table 3. It is also indicated that they grow poorly sandy and well-drained soil such as Bris, sand-tailing and sandy soils (Rozita *et al*. 2009).

Table 3: Growth performance of *Orthosiphon stamineus* planted on different soil types

Soil type	Plant height (cm)
Mineral	12.67
Peat	9.83
Sandy	10.17
Tin tailing	7.85
Bris	6.75

Harvesting

Harvesting of misai kucing can be done manually where the first harvest is normally done at ten weeks after transplanting. It is important to note that harvesting can be carried out when the plant is about 30 cm tall measured from ground level to the shoot tip. The recommended harvesting cycle is at an interval of every two weeks.

CONCLUSION

In the production and utilization of medicinal plants, quality assurance has always been the focal points. There is an upsurge in the need to improve the traceability and safety of the natural products. The increasing reliability in the production and collection practices of these species is also meant to contribute to the increasing acceptance of these commodities. Therefore sustainable production of these materials should be aimed to meet the quantity required by the industries involved. Hopefully with clonal materials obtained through selection and breeding, the cultivation of the medicinal plant species will be successful just like our rubber and oil palm plantations.

ACKNOWLEDGEMENTS

The authors are grateful to the staff of Herbs and Tree Improvement Branch of Forest Research Institute Malaysia (FRIM) for their assistance in this study.

REFERENCES

1. AHMAD ZUHAIDI, Y., LOK, E. H. & AMINAH, H**.** 2008. Cultivation and management of *Aquilaria malaccensis* for agarwood (gaharu) production. Pp. 59–68 in Mohd Yunus Zakaria, Nazir Khan Nizar Khan & Mohd Yusoff Baharom. (Eds.) Prosiding Persidangan Gaharu Kebangsaan 2007: Kearah bekalan gahryu yang berterusan (11.9.2007) JPSM 2008 Kuala Lumpur.
2. FARAH FAZWA, M.A., ISMAIL, H., MOHD NOOR, M., AB RASIP A.G., LOKMAL, N. 2007. Financial assessment of *Citrus hystrix* (Limau purut) grown on plantation scale: A preliminary analysis. The Planter 83 (980): 719-724
3. FARAH FAZWA M.A. 2015. Maintenance of *Labisia pumila* at nursery and method of plantation. Paper presented at Plant Improvement Workshop, 26-27 Mei 2015, Bukit Bakar FR, Machang, Kelantan, Malaysia.
4. CHAKRABARTY, K., KUMAR, A. & MENON, V. 1994. Trade in Agarwood. TRAFFIC India and WWF India, New Delhi.
5. GOVAERTS, R. 2001. How many species of seed plants are there?. *Taxon* 50:1085–1090.
6. HARTMANN, H. T., KESTER, D. E. & DAVIS, Jr. F. T. 1990. *Plant propagation-Principals and Practices*. 5th. Edition. Prentice-Hall International Editions. Englewood Cliffs, New Jersey. 647 pp.
7. LA FRANKIE. 1994. Population dynamics of some tropical trees that yield non-timber forest products. *Economic Botany* 48(3): 301–309.
8. LEAKEY, R. R. B., MESEN, J. F., TCHOUNDJEU, Z., LONGMAN, K. A., DICK, J. McP., NEWTON, A. C., MATIN, A., GRACE, J., MUNRO, R. C. & MUTHOKA, P. N. 1990. Low technology techniques for the vegetative propagation of tropical trees. *Commonwealth Forestry Review* 69:247–257.
9. LOK, E. H. & ZUHAIDI YAHYA, A.. 1996. The growth performance of plantation grown *Aquilaria malaccensis* in Peninsular Malaysia. *Journal of Tropical Forest Science* 8 (4): 573-575.
10. LOK, E. H., CHANG, Y. S. & AZIAH, M. Y. 1999. Early survival and growth in field trials *Aquilaria malaccensis* (karas) and *Azadirachta excelsa* (sentang). *Journal of Tropical Forest Science* 11 (4):853–854.

ISSN: 2455-6939

Volume:03, Issue:06 "November-December 2017"

11. ROZITA, A.**,** WAN RASIDAH, K.**,** TUMIRAH, K. & ROSAZLIN, A. 2009. Effects of different soils and nitrogen fertilizer on the growth of *Orthosiphon Stamineus*. Pp 259–266 in Zulkefli, M., Che Fauziah, I., Goh, K. J., Rosazlin, A., Jeyanny, V., Umi Kalsom, M. S., Zulkefli, H. (Eds.). Proceedings of the Soil Science Conference of Malaysia 2009: Soil Health: Preserving Resources for Sustainable Agriculture, 13–15 April 2009, Kuala Terengganu.
12. SCHIPPMANN, U., LEAMAN, D. & CUNNINGHAM, A. B. 2006. A comparison of cultivation and wild collection of medicinal and aromatic plants under sustainability aspects. Pp. 75–95 in Bogers, R. J., Craker, L. E. & Lange, D. (Eds.) Medicinal and Aromatic Plants. Springer, Netherlands.
13. SOEHARTONO, T**.** 1997. Overview of trade in gaharu in Indonesia. In: Report of the Third Regional Workshop of the Conservation and Sustainable management of Trees. Hanoi, Vietnam. WCMC IUCN/SSC.
14. WHO (World Health Organisation). 2003. WHO guidelines on good agricultural and collection practices (GACP) for medicinal plants. Geneva, Switzeland.
15. ZAHARAH, A. 2005. Misai Kucing. In Musa Yaacob, Muhamad Ghawas Maarif & Mansor Puteh (ed). Planting of medicinal and aromatic plants. Pp. 57-62. Serdang: Malaysian Agricultural Research and Development Institute.

