SUSTAINABLE SUPPLY OF HIGH YIELDING KACIP FATIMAH (*LABISIA PUMILA*) IN MALAYSIA

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ABSTRACT

Labisia pumila, from the family of Myrsinaceae, also known locally as kacip fatimah, is an herbaceous plant commonly used in traditional medicine. It is one of the popular herbal species that are used by Malay women in childbirth. The water decoction of the root or whole plant is usually consumed before childbirth and is thought to induce and expedite labour. The herb is also used as a post-partum medicine as well as to treat flatulence, dysentry, dysmenorrhoea, gonorrhea and sickness in bones. Presently, most of the raw materials are sourced from the wild but the quantity and quality of the raw materials are uncertain to meet the current demand. Over exploitation of this species from the natural forest would endanger the species and without strict control, it will lead to the extinction of the species in the forest. A study by FRIM in 2017 reported that 87% of the raw materials used for traditional herbal preparation were harvested from the forest and only 17% were cultivated. Currently, L. pumila is not produced on any commercial scale. Several initiatives have been undertaken to plant the species for commercial use but they have been only limited, which cannot assume a sustainable supply of the raw material for industry. Therefore, planting on a large plantation scale is necessary as the raw material can be produced more efficiently and sustainably. Cultivation of this species can also be implemented on plantation basis either as single cropping or intercropped with other herbal species. This paper discussed on the aspects of i) propagation and nursery techniques and ii) cultivation of L. pumila based on organic farming. The information will help the interested parties such as plantation manager, planter, nursery and herbal industries in producing raw materials sustainably.

Key words: cultivation, high quality plants, nursery practices, propagation, organic, plantation

INTRODUCTION

Labisia pumila (Myrsinaceae) or Kacip Fatimah has long been recognized for its medicinal value and are widely available commercially as health supplements. It is one of the most popular and potent ingredient used in traditional herbal preparations or "jamu" for postnatal care. The species was reported having astrogenic properties (Institute for Medicinal Research 2002) and is used in treating flatulence, dysentery, dysmenorrhoea, gonorrhoea and sickness in bones (Burkill 1966). Its uses as a traditional herb for women appear to have some basis in relation to the total anti-oxidants content (Khairul et al. 2005; Mohamad Norhaiza et al. 2009; Ehsan et al. 2011). The research had indicated that there is a strong positive correlation between total phenolic content and antioxidant. *Labisia pumila* was not only has significant effects as antioxidant, but also research has indicated many benefits

to human's health such as for anti-aging, anti microbial, anti-obesity, osteoporosis, anti-cholestrol and to regain body strength for both women and men.

Recently, the use of natural product to maintain body health and treat illness is trending in Malaysia due to the increase in public awareness on herbal plant. As a consequence, the abundance of commercial products derived from the herbs either in the form of capsules or canned drinks can be seen in the market. *L. pumila* is one of the herbal plants that grasp a lot of attention from the public. Therefore, the identification of bioactive phytochemicals which contribute to the pharmacological properties was extensively carried out by several research institute and universities in Malaysia. At Forest Research Institute Malaysia, (FRIM) a study on selecting high quality planting materials has been conducted since 2009. A germplasm of *L. pumila* has been established with a total of 54 clones of *L. pumila* var. *alata* were screened for its total phenolic content in attempt to produce high quality planting materials (Farah Fazwa et al., 2012). Total phenolic content is in the group of plant secondary metabolites which useful in defence against oxidative stress from oxidizing agents and free radicals (Hossain and Shah, 2015). The clones with high total phenolic content were selected for further propagation process through macro and micropropagation (Farah Fazwa et al. 2018). From the selected clones, one elite clone of *Labisia pumila* was identified in 2012 namely as KFeFRIM01 (Farah Fazwa et. al 2014).

With the growing interest in *L. pumila* as a source of new pharmaceutical products and the increasing demand for herbal products in Malaysia, the demand for its raw materials is also increasing (Mohd. Azmi & Awang Noor 2001). A study by FRIM in 2017 reported that 87% of the raw materials used for traditional herbal preparation were harvested from the forest and only 17% were cultivated (Rohana et. al 2017). In another study conducted by University of Malaya found that about 50% of the raw materials used by the herbal industry in Malaysia were imported and majority came from China, India, Indonesia, Singapore and Thailand (Malaysia Department of Statistics, 1996). Uncertainty in raw material supply and lower price of the imported raw materials than the local one would be the ultimate concern under the production of raw materials. The price of herbs are varies depending on its origins, sources, volumes and form of the herbs (Mohd Azmi and Norini, 2000).

MATERIALS AND METHODS

Collection of *Labisia Pumila* Mother Plants

Mother plants of *L. pumila* can be collected from its natural habitat, purchase from nursery or from the middle man. The plants were pulled out from the forest floor carefully in order to avoid damages of the roots. After that all collected mother plants were tagged according to the origin, wrapped and placed in plastic bags before they were transported and replanted at the selected area. At this stage, the hardening process should be well monitored and maintained in order to achieve high survivality rate. After about one month of the hardening process, the plants are ready to be taken and used for propagation. Some of the plant parts that normally used for this propagation through cutting technique are leaf, petiol, stem and root.

Propagation and Nursery Application

Cuttings of *L. pumila* can be planted in either a mist propagation system with plastic enclosure or a non-mist propagation system. For the enclosed mist system, the frequency of misting is every hour with one-minute duration of spray. For the propagation of *L. pumila* by cuttings for commercial scale, the non-mist propagation system is recommended since it is easy, cheap to construct and does not require sophisticated facilities. It can be constructed using a wooden frame and plastic. Alternatively, to a concrete container, a fibre glass container or a water tank can be used with the top covered with a plastic sheet. The whole system should be covered with 80% shade where by the relative humidity is more than 80%. Black plastic netting can be used as shading material (Mohd Noh et al. 2006; Farah Fazwa et al. 2012). The non-mist propagation system is constructed based on Leakey et al. (1990). This propagator is basically an enclosed system with a volume of water below the rooting medium. The prepared container about 50 cm in height should be layered with stones, followed by gravel and water up to 15 cm followed by the rooting medium of 10 cm (e.g. cleaned river sand). The whole system should be water and air tight. The cuttings when planted should not touch the water to avoid rotting. The water from the bottom of the container provides moisture to the cuttings through capillary action. The water level should be maintained throughout the rooting period and should be topped up when necessary (Aminah 2009).

For mist propagation system, transparent plastic and 70% black netting were used to cover the concrete cutting bed. Sterile 100% river sand should be used as the propagation media. The size of sand particles used consisted of 24 percent 0.5 mm, 54 percent 2mm and 22 percent > 2 mm. The misting frequency was every hour with one-minute duration of misting.

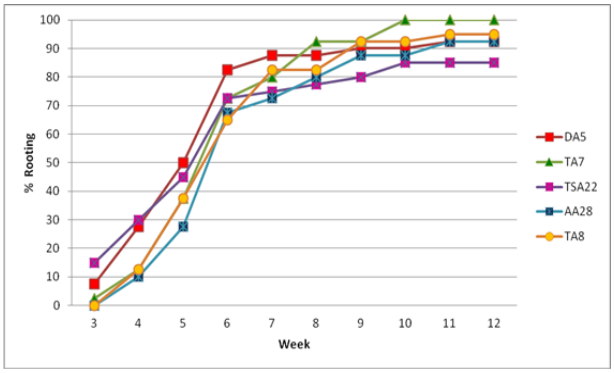
Preparation of Cuttings

Labisia pumila can be propagated using leaf, leaf and petiole, and stem (Aminah and Rozihawati 2004; Jane & Anak Peter 2012; Farah Fazwa et al. 2013, Syafiqah Nabilah et al 2014). For the purpose of mass planting for stock production, leaf cuttings are recommended since the leaves will grow again and can be sustainably used as cutting material. More cutting material can be taken from a single stock plant compared to using the stem where limited number of cuttings can be obtained. The cutting material used must be taken from healthy stock plants free from insect and fungal attacks. The leaf area suitable for cutting is recommended around 30–40 cm2 (Aminah et al. 2008). Two to three cuttings can be obtained from a leaf depending on its size. All cuttings prepared should be soaked in water prior to planting in the propagation system to avoid water stress and dehydration. For *L. pumila*, commercially prepared powdered hormone Seradix 1 (0.1% indole butyric acid-IBA) is recommended (Aminah and Rozihawati 2004). The base of each cutting should be lightly dipped in this hormone, particularly at the midrib where the roots will emerge (Farah Fazwa 2013; Norhayati 2013; Rozihawati 2005).

Planting of Cuttings in Propagation Bed

The prepared cuttings can be planted in the rooting medium. Rooting media that can be used are river sand, top soil, mixture of soil and sand, compost or peat depending on the material available at the propagation site. However, clean river sand is recommended for rooting of *L. pumila* since it is cheap and easily available (Aminah and Rozihawati 2004; Aminah et al., 2007; Rozihawati, 2008 and Farah Fazwa et al., 2013). The rooting medium should be washed with water and solar/steam sterilized to avoid any contamination from harmful organisms. This medium is then placed in the propagation system. Cuttings are checked every two weeks and those with lignified roots are potted while cuttings that do not root or with fragile roots are replanted into the rooting medium. These cuttings are reassessed until no new rooting occurs. Rooting period is within three to twelve weeks. Our trial for the mass propagation of five high yielding clones gave an average of 70% rooting with leaf cuttings, three months after planting on the rooting beds (Figure 1) (Syafiqah Nabilah et al 2013).

Figure 1: Rates of rooting of the five high yielding clones of Labisia pumila var. alata



Cuttings in the propagation system should be regularly checked and any dead cuttings should be immediately removed from the propagation system to avoid spreading of diseases. Cuttings should be sprayed whenever the lid of the propagator is opened to maintain the humidity in the system. The propagation bed should be cleaned, watered and rooting medium replaced with a clean one for every new batch of cuttings to be planted. The rooting medium from the previous cutting batch can be washed and sterilized before it can be used again. It is advisable to spray with anti-fungal agent on the rooting medium.

Potting Medium

Good potting medium should consist of a high percentage of organic matter, as light in weight and very well drained and aerated yet able to absorb and retain a significant amount of water. 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 husks, bagasse, sugarcane waste, sawdust, leaves and grasses. Most organic matter other than peat and rice hulls should be composted prior to use to give good results. Composting improves the physical properties and balances the ratio of carbon to nitrogen. The ratio of soil to organic matter for the potting medium is 1:1. Minimising root damage is an important consideration when potting newly rooted cuttings. Rooted cuttings are kept in water before they are potted to avoid dehydration. They are usually potted in polythene bags of 15 x 24 cm (6 x 9 in). Potted cuttings should be weaned in the propagation systems for two to four weeks before they are sent to the transplanting beds with 70-80% shade. Transplanting beds are where the potted rooted cuttings are kept before they are ready to be planted in the field. The beds can be constructed with concrete, gravel or plastic as the base to avoid roots penetrating to the ground and to reduce the need for weeding of the beds. The width of each bed is 1 m and the length is about 10 m depending on the space available. The distance between the beds is about 0.6–1 m to facilitate movement and daily maintenance work.

Maintenance of Potted Rooted Cuttings

Water is very important for survival of the potted cuttings. The cuttings 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, a sprinkler system, which operates automatically, is recommended. Watering is carried out twice daily in the morning and late afternoon except on rainy days. Watering frequency can be reduced if the major component of the potting mixture consists of organic matter. Organic matter can improve the water holding capacity of the medium (Aminah 2002). While in the transplanting beds, potted plants should be fertilized with organic fertilizer to ensure healthy growth of the rooted cuttings. Cattle or goat/sheep dung can be used as fertilizer. Regular root pruning should be carried out to avoid roots 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, and insecticide and fungicide applications which should be carried out whenever necessary. For L. pumila, organic insecticides and fungicides should be used such as the extracts of garlics. Regular inspection of planting stocks in the nursery will enable early detection of any pest attacks and hence proper counter measures can be taken.

Hardening Process

The potted cuttings are hardened in the nursery to reduce the shock of exposure to the planting environment. Usually the plants are ready to be planted in the field three months after potting when the new shoots and leaves have grown. Survival of the rooted cuttings after potting was 80%. This hardening process increases the chances of survival of the planting stocks after transportation. Potted plants in the transplanting beds are gradually moved to more exposed areas for hardening before field planting. The hardening process also involves gradually reducing the amounts of water and fertilizer given to the planting stocks. This process takes place over three to four weeks before the planting stocks are ready to be dispatched to the field. Almost 90% of healthy planting stocks 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 recovery.

Cultivation of *Labisia pumila*

The most important part of this cultivation is to ensure a constant and continuous supply of raw material to meet the growing demand from pharmaceuticals industry, food industry and traditional practices. This can be achieved if the species is cultivated in a plantation, as opposed to having the material sourced from the forest, which is unreliable. Therefore, a proper cultivation technique should be formulated and practiced. Before starting on any cultivation technique, it is important to know the plants' requirements and growth habits.

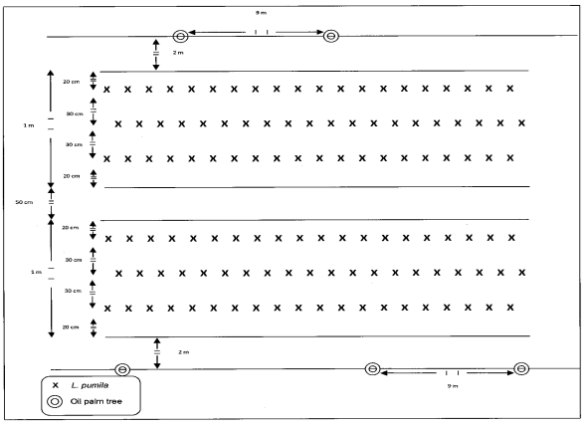
Site Selection

Prior to planting, the plantation site should be selected. *Labisia pumila* needs partial shade as a prerequisite for planting. It usually grows in shady lowland forest where there is ambient light, temperature, humidity and humus-rich soil (Mohd Jelani, Mohd Noh and Ahmad 2000). Since the natural forest is not available for commercial planting, the alternative is utilizing tree plantations such as forest plantations or agricultural plantations. The most readily available sites are agricultural plantations such as rubber or oil palm plantations. Mohd Jelani, Mohd Noh and Ahmad (2000) reported that L. pumila plants are suitable to be planted under oil palm, coconut and rubber plantations. This can be undertaken on a large scale for commercialization (Ab. Rasip and Ong 2001; Mohd Noh, Rezuwan and Md. Akhir 2006). Comparison of the two sites (forest plantations and agricultural plantations) showed that planting under oil palm plantation provided better condition for the growth of *L. pumila* because of the good shading of 60-65%. This species thrives in shady places and open sunlight can be harmful to its establishment and growth (Indu and Ng 1999). In cultivating *L. pumila* under an oil palm plantation, it is important to try to mimic the natural forest habitat for the plant's survival. In its natural habitat, L. pumila grows on humus-rich soil where the soil moisture is more than 60% with pH ranging from 4.0 to 5.0. This species is mostly found under closed canopy with about 25-35% light penetration and humidity more than 80%. It is recommended to use an older oil palm plantation since the closed canopy of the oil palm provides shade up to 65% with temperature around 24-28 oC and 80% humidity. Where the palm canopy is thin, additional shade should be constructed using oil palm fronds to ensure the L. pumila plants are not overexposed. Although the soil under the oil palm plantation is lacking in organic matter, it can be enriched with application of compost or other organic matter. The organic matter coupled with good irrigation will provide high soil moisture. The soil pH under the oil palm should be kept around 5.0 which can easily be maintained with organic fertilizer application. With proper site selection and amelioration under the oil palm plantation, a suitable condition can be provided for the L. pumila plants to grow. Another criterion to be fulfilled in selecting the plantation site is that L. pumila should be planted under organic farming. Therefore, the plantation site must be free from any inorganic chemicals such as chemical fertilizers or pesticides for at least ten years. This is the requirement if the L. pumila plantation is to be certified under the Malaysia Organic Farming System or SOM. If selecting a plantation that has been unattended for more than ten years would be an advantage for this purpose. Besides that, a system should be established to record the site history and layout of the plantation.

Site Preparation

Before the oil palm plantation site is ready for cultivation, the infrastructure of the site should be prepared such as having a reliable source of irrigation, an easily accessible road system and proper fencing to protect the *L. pumila* plants from wild animals. Planting of *L. pumila* under oil palm plantation is on raised/planting beds. Each bed must be constructed between two rows of oil palm trees. Although oil palm trees are planted in a triangular system, the diagonal view provides straight rows of oil palm trees. The planting bed is constructed between the two rows of oil palm trees. The space between the rows is about 8 m, therefore two rows of planting beds can be constructed in between the oil palm trees. The soil is tilled and ploughed before construction of the planting beds. During construction of the planting beds, root trenching must be done to cut the palm roots. If this is not done, the palm roots will invade the planting beds and form a root mass which will affect the growth of the L. pumila. Each bed is one-meter-wide and the length depends on the rows of the oil palm trees. The two beds are separated by a distance of 50 cm. During construction of the beds, organic matter (e.g. compost or peat) can be applied and mixed thoroughly with the soil. The planting beds should be covered with plastic mulching mats. Application of the plastic mats will control weed problem and retain soil moisture. The best planting distance of L. pumila is 30 cm X 30 cm using square planting or 30 cm x 30 cm x 30 cm as in triangular planting. To increase production, a plant can be inserted in the center of four plants in square planting. A 5-cm diameter hole should be made on the mat at each planting point. A diagram of planting is given in Figure 2.

Figure 2: Planting of Labisia pumila in triangular system



Planting Process

Planting material for the first batch can come from wild natural collection. The planting should be done in groups according to the type and provenance (source) of the plants. Proper recording must be done so that the planting materials are not mixed up. It is to ensure the performance of each provenance so that if needed for future collection, the high-performance source can be used. The first planting also acts as a source of planting material. For the first round, leaves from good individuals based on phenotype can be used for mass propagation. At the same time observations should be made to identify superior individuals for breeding purposes. Selection should be done based on phenotypic traits, such as good growth, health and high production of leaves. The selected individuals will then be placed in a gene bank. The gene bank will serve for future breeding and propagation. Each individual in the gene bank must be propagated to produce individual clones. The resulted ramets (clones) from the selected individual will then be placed in a clone bank. All the clones will be multiplied to make enough samples for a planting program. Each clone must be evaluated in terms of growth rate, health, production of leaves, and targeted chemical compounds. Those clones proved to be superior will be used for future planting programs. Following the first planting, subsequent planting should come from vegetatively propagated materials. Each planting must be properly recorded and labelled with the type of species, planting material or source and date of planting. For early planting, the raw material should come from mass selected sources from the plantation. This procedure will continue until proper clones are ready to be used.

Maintenance

In order for the *L. pumila* plants to grow well, good agricultural practices should be applied. Amongst the basic requirements are watering, fertilizer application, weed control, pest and disease control, and suitable light (50-60% shades). Labisia pumila performance is thriving best under shade house (60-70% shades) with the production of 160 g per plant (22.1 ton ha-1) fresh weight (Mohd Noh et al 2004). Low light intensity is another requirement for good performance of *L. pumila* where at 5% PAR it gave highest growth of stem diameter (5.9 mm) in stem cuttings and 5.5 mm in leaf cuttings (Rozihawati et al 2005).

Irrigation

Being herbaceous in nature, *L. pumila* plants require a lot of water (approximately 1.5 litre per day). Therefore, a proper irrigation system needs to be in place where by optimum amount of water is supplied to the plants. The water source is important. Clean uncontaminated water must be used for watering *L. pumila* to ensure the plants grow healthily. There are many irrigation systems that can be adopted for planting *L. pumila* such as drip irrigation, sprinkler, flooding, and hand watering. For a start, it is sufficient to use manual hand spraying for watering the *L. pumila* plants. Water wastage can be controlled but this method is labor and time consuming. Another option is to use water sprinklers. This system is good for open soil planting. However, if plastic mulching mats are used, water sprinkler system is not recommended because much water will be wasted if it falls on the plastic mats. Instead drip irrigation is the better option. In drip irrigation, the drip head is placed beside each plant and water will be supplied directly to the plant. This method will save water and energy. A raised water tank is sufficient to provide free flow of water and hence will cut down the need for energy to pump water as in a sprinkler system. The only issue with this method is that the initial cost of establishing the drip irrigation system is high due to the large number of pipes and drip heads needed. In large-scale plantation (0.2 – 1.0 ha), a consistent water supply is important for plant growth. It is uneconomical to plant *L. pumila* under irrigation of using tap water. It is important to source for a cheaper and reliable water supply. The proposed option is to construct two to three tube wells to provide a consistent water supply for the plants. Prior to the construction of the tube wells, an electricity supply should first be installed in the oil palm plantation. The electricity is needed to run a water pump that will be used to pump water from the tube wells up to the water tank. The tank provides as a free flow of water to the *L. pumila* plants in the drip irrigation system.

Fertilizer

Only organic fertilizer is recommended for the planting of *L. pumila*. There are many organic fertilizers available in the market. To reduce cost, self-made compost can be used to replace commercial fertilizer which is 50% cheaper (Eg. 1 kg of compost cost MYR 1.00, while 1 kg of commercial fertilizer cost about MYR 2.00). If fresh plant parts are used as compost, it will increase the nitrogen competition between microbes and the *L. pumila* during the decaying process. This will hinder the uptake of nitrogen by

the *L. pumila* plants which will show nitrogen deficiency symptoms such as poor plant growth and pale green or yellow leaves. Stems may also turn yellow and spindly. In order to avoid this, the plant materials must be composted or decayed before use as compost. Compost is specially recommended to be used in the cultivation of *L. pumila* in sandy soil. As mentioned earlier, compost as organic material can improve the sandy soil composition, characteristics, and water and nutrient holding capacities. In general, every 1 percent of organic matter content, the soil can hold 16,500 gallons of plant-available water per acre of soil down to one foot deep. Currently, the organic material used for *L. pumila* cultivation is from composted oil palm leaves collected from more than 10 years unattended oil palm plantation, fruits, vegetables and cow dung. For commercial cultivation, large amounts of organic composts are needed to enhance the plant growth. It is proposed to use composted oil palm mesocarp fibers as the material is cheap and can be obtained easily from a nearby palm oil mill. Composted mesocarp needs to be applied during the planting bed preparation where it is then rotovated into soil. Two tonnes of composts are required for one hectare of planting field.

Weed Control

Competition from weeds will affect the growth and quality of L. *pumila* plants. Weeds can be detrimental if not properly controlled. Manual weed control is recommended as no weed killers or herbicides are allowed in *L. pumila* planting. To avoid competition from weeds, plastic mulching mats are recommended. Occasionally, weeds can be found growing in the planting holes but they can be pulled out manually. Daily inspection and removal of weeds at the early stage of *L. pumila* cultivation are recommended.

Pest and Disease Control

As in weed control, no chemical-based pesticides are allowed in *L. pumila* planting. Even traces of chemicals in pesticides can affect the quality of *L. pumila* plants. There are many techniques other than chemical control that can be adopted for pest control such as biological, mechanical and cultural pest control. Biological control of pests in agriculture is a method of controlling pests (including insects, mites, weeds and plant diseases) that relies on predation, parasitism, herbivory, or other natural mechanisms. While, mechanical control is the management of pests by physical means such as the use of a barrier (e.g. screens or row covers), trapping, weeding or removal of the pests by hand. It may also involve changing the physical conditions in a given area, for example, changing the temperature to make an area unfavorable for pests. Simple modification of a pest's environment or habitat often proves to be effective in pest control which is categorized as cultural pest control. As a group, the tactics employed are usually known as cultural control practices because they frequently involve variations of standard horticultural, silvicultural, or animal husbandry techniques. Since these control tactics usually modify the relationships between a pest population and its natural environment, they are also known, less commonly, as ecological control methods.

Sanitation

Good sanitary practices can avoid pest and disease outbreaks. The planting beds must be kept clean free from debris of dead leaves of *L. pumila* and other fresh plant materials. These materials can lead pests and diseases outbreak. Weeds can also be a host for many pests and diseases such as snails that regularly feeding on kacip Fatimah by chewing up the leaves. This action leaves irregularly shaped holes on *L. pumila* leaves. Normally, the holes were like being punched out and not eaten from the edges of the leaves. Grasshopper also one of the pests that cut and tear off leaves due to their eating habit. Since grasshoppers are polyphagous insects, *L. pumila* can be one of their food sources. Therefore, the planting beds should be weed free. Regular inspection should be carried out to monitor the signs and symptoms of pest and disease attacks on *L. pumila* plants. If any disease is noticed, the affected plant or plant parts have to be removed from the planting site. If possible all these materials are collected and burnt. This is to avoid further infection or outbreak. Similarly, with pest attack, if any pest is found on the plant, it should be removed and killed immediately. It must not be allowed to multiply until it becomes too hard to control.

Pesticide Application

No chemical pesticides are used for *L. pumila* cultivation. In the event of a pest outbreak, biological based pesticides are applied to control the pests. For example, in controlling caterpillars, BT insecticide is effective. Self-prepared biopesticides such as pepper leaf extract can be used to control fungal diseases and neem extract to control insect pests. Studies conducted at FRIM have shown that many of the Malaysian essential oils were biological active (Ling et al. 1998; Zaridah et al. 2003) which may contribute to repellency effects. For *L. pumila* cultivation, the contract farmers can use garlic and betelnut (sireh) extracts for pest and disease control. Garlic has insect repellent (Arun et al. 1996) and betelnut fungicidal properties. Other than that, the mixtures of chilies and lemongrass water decoction in garlic extracts were also recommended to be used by spraying it onto the *L. pumila* plants.

Harvesting

Labisia pumila plants are ready for harvesting when they are nine months old or when they are about 30-45 cm tall (Aminah and Farah Fazwa 2012). Harvesting can be done by pulling out 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 coppice and produce new plants. This process is recommended when using improved materials or when there is not enough planting material for replanting. Once the *L. pumila* plants are harvested, they should be immediately washed with clean tap water and dried to prevent microbial contamination. The plants should be properly packed and labelled. Each batch should be recorded with the name of the species, source, planting date (or batch) and time of harvesting. The plants must be placed in a cool condition. This is to keep the *L. pumila* plants as fresh as possible (within 2 days) before being transported to the extraction facility. Our study reported that L. pumila planted under old oil palm plantation can produce 2.6 tonnes of fresh material per hectare after nine months of planting (38 plants ≈ 1 kg of fresh weight). This is referring to a total of 100,000 plants planted in bed triangular system in a size of 1-hectare plot.

Conclusion

Labisia pumila can be propagated via leaf cuttings as described in this paper. This species can be cultivated commercially either as single cropping or intercropped with oil palm, coconut and rubber. It can also be planted on a small scale by rural communities as a source of income. In Malaysia, currently *L. pumila* were listed as top five of herbal species that have been identified to be planted by small holdings and big corporations as a new income generation as outlined in National Key Economic Area (NKEA). Such a project could generate rural employment and help lessen urban migration of the youths in the country. By venturing in this business, it is anticipated that standard of living of smallholder could also be enhanced in terms of per capita income. Furthermore, one of the strategies for new agriculture outlined in East Coast Economic Region (ECER), the government encourage the main player to sustain the production of planting materials in a shorter period of agricultural cycle.

REFERENCES

Abd Rahman Rohana, Siti Zubaidah, Ariff Fahmi, Abu Bakar, Nik Zanariah, Hin Fui Lim, Marzalina Mansor, Jean-Marc Roda, Mohd Shahidan Mohd Arshad, Rosdi Koter, Pin Kar Yong, Nor Azah Mohamad Ali (2017). Socio-economic background of herbal industry in Peninsular Malaysia. Agricultural Science and Technology Information, FRIM, Selangor.

Ab. Rasip, A.G. and Ong (2001). Growth Performance of Tongkat Ali in Forest Farm Plantation. Paper presented at *Forest Research Institute Malaysia,* Kepong, Selangor, July 24-25, 2001.

Aminah, H. (2009). Effect of Potting Media and Watering Frequencies on The Growth of *Dyera costulata* (Jelutong), Malaysian Forester (2002): 22–27. *Poster for Invention/Innovation Awards in Malaysian Technology Expo (MTE),* PWTC, Kuala Lumpur, February 19-21, 2009.

Aminah, H and Rozihawati, Z. (2004). Planting stock production of *Labisia pumila* by cuttings: Multipurpose trees in the tropics: Assessment, growth and management. Paper presented at Arid Forest Research Institute, Jodhpur, India, November 22–25, 2004).

Aminah, H., Naimah, C.L., Mohd Zaki, A. and Lokmal, N. (2007). Rooted leaf cuttings of *Labisia pumila*. *Journal of Tropical Medicinal Plants,* 2007: 593-599.

Aminah, H. Naimah, C.L. Mohd Zaki, A. & Lokmal, N. (2008). Rooted leaf cuttings of Labisia pumila. *Journal of Tropical Medicinal Plants*, 9(1): 101-104.

Burkill, I.H. A. (1966). A dictionary of the economic products of the Malay Peninsula. Kuala Lumpur: Ministry of Agriculture and Cooperatives.

Ehsan, K., Hawa, Z.E.J. & Sahida, A. (2011) Phenolics and flavonoids profiling and antioxidant activity of three varieties of Malaysian indigenous medicinal herb *Labisia pumila* Benth. *Journal of Medicinal Plant Research* 2011: 1200-1206.

Farah Fazwa, M.A., Ab Rasip A.G., Maideen, H. & Mohamad O. (2012). Selection among two varieties of *Labisia pumila* that yield high phenolic contents for establishing plant stock and further cultivation. *Journal Tropical Medicinal Plants*, 13(1).

Farah Fazwa, M.A., Norhayati, S., Syafiqah Nabilah, S.B. & Mohd. Adi Faiz, A.F. (2013). Evaluation of rooting ability of five superior genotypes of *Labisia pumila var. alata* on sand media. *Proceedings of Soils Science Conference of Mala*ysia 2013: 329-333.

Farah Fazwa, M.A., Norhayati, S., Syafiqah Nabilah, S.B., Mohd Zaki, A. & Mohd Asri, L. (2014). Establishment of Four Clonal Trial Plots of Labisia pumila. Poster presented at *The 13th Symposium Malaysian Society of Applied Biology* 2014. 8-10 June 2014.

Farah Fazwa, M.A., Norhayati, S., & Syafiqah Nabilah, S.B. (2018). Mass production of elite clone KFeFRIM01 (*Labisia pumila* var. *alata*) using in vitro propagation for sustainable supply of high-quality planting materials. End of Project report NKEA research grant scheme (NRGS) 2018.

Indu and Ng. (1999). Labisia pumila. Herbs, the Green Pharmacy of Malaysia. Kuala Lumpur. Vimpress. Jamia. "Investigation of Labisia pumila: A Malay traditional herb for pregnant women". *PhD Dissertation*, University of London, 1999.

Institute for Medical Research. (2002). Estrogenic and androgenic activities of kacip fatimah (*Labisia pumila*). Malaysian Herbal Medicine Research Center. Kuala Lumpur: Ministry of Health Malaysia. pp.8.

Jane Diane Anak Peter Ah-Came (2012). Vegetative Propagation of *Labisia pumila* Roxb. by Rooting of Cuttings. *MSc. Dissertation*, Universiti Malaysia Sarawak, Sarawak. 2012.

Khairul, F.K., Nurul Haniza, M. & Zhari, I. (2005) Antioxidative properties of various extracts of *Labisia pumila* (Kacip Fatimah)". *Proceedings of the Seminar on Medicinal Plants 2005*, Institut Penyelidikan Perhutanan Malaysia (FRIM), Kepong, Kuala Lumpur 2005:306-312

Leakey, Mesen, Tchoundjeu, Longman, Dick, Mcp, Newton, Matin, Grace, Munro, and Muthoka. (1990). Low Technology Techniques for the Vegetative Propagation of Tropical Trees. *Commonwealth Forestry Review*, 1990: 247–257.

Ling S.K., Khozirah S., Rasadah M.A. & Nor Azah M.A. (1998). Lipoxygenase inhibitory activity of selected plant extracts and essential oils. *Journal of Tropical Forest Products*, 4(2):199-206.

Malaysia Department of Statistic. (1996). Import and export of medicinal plants for pharmaceutical uses in Malaysia.

Mohd Azmi and Awang Noor. (2001). The Utilization and Conservation of Medicinal Plants in Malaysia: An Overview. In: Towards Bridging Science and Herbal Industry, Proceeding of the Seminar on Medicinal and Aromatic Plant edited by Chang, Y.S., Mastura, M. & Zainon, A.S. Institut Penyelidikan Perhutanan Malaysia (FRIM), Kepong, Kuala Lumpur, 2001:101 – 111.

Mohd Azmi, M.I. & Norini, H. (2000). Supply and Demand of Medicinal Plants: A Preliminary Study in the Northern States of Peninsular Malaysia. In Proceedings of the Seminar on Medicinal and Aromatic Plants, 12-13 September 2000, FRIM, Kuala Lumpur.

Mohd Amzad Hossain & Muhammad Dawood Shah. (2015). A study on the total phenols content and antioxidant activity of essential oil and different solvent extracts of endemic plant Merremia borneensis. *Arabian Journal of Chemistry*, 8 (1): 66-71.

Mohd Jelani, Mohd Noh, and Ahmad. (2000). Propagation and Cultivation of Potential Herbal Crops' – To Meet The Need and Demand of the Industry. *In herbs an international conference exhibition, Malaysia Agricultural Research and Development Institute*, Serdang, Selangor, Malaysia, 2000.

Mohd Noh J., K. Rezuwan, & MD A. Hamid. (2004). Performance of Kacip Fatimah (*Labisia pumila*) production under shade house. *International Symposium on Greenhouses, Environmental Controls and In-house Mechanization for Crop Production in the Tropics*, 710: 2004.

Mohd Noh, Rezuwan, and Akhir Md. (2006). Performance of Kacip Fatimah (*Labisia pumila*) Production under Shade House." In IS on Greenhouses, Environment Controls & Inhouse Mechanization for Crop Production in the Tropics and Sub-tropics, edited by Rezuwan, Ibni Hajar Rukunuddin and Nor Raizan, 710. *Acta Horticulture*, 2006.

Noorhaiza, M., Maziah, M. & Hakiman, M. (2009). Antioxidative properties of leaf extracts of a popular Malaysian herb", Labisia pumila. *Journal of Medicinal Plant Research* 3: 217-223.

Norhayati, S., Farah Fazwa M.A, Syafiqah Nabilah S. B., Mohd Zaki, A. (2013). Production of *Labisia pumila* var. *lanceolata* through stolon part for future planting stock". Poster presented at *Conference of Forestry and Forest Products (CFFPR) 2013*, Hotel Sunway Putra, Kuala Lumpur, November 11-12, 2013.

Rohana A. R, Ariff Fahmi A. B., Nor atiqah, M. F., Marzalina, M. (2017). Value Chain of The Herbal Industry In Peninsular Malaysia. Project Evaluation and Monitoring (PEM) 2017, Forest Research Institute Malaysia (FRIM).

Rozihawati Z., Aminah, H., Nor Azurawati M.S. & Farah Fazwa M.A. (2004). Effect of Indole Butyric Acid (IBA) on Rooting Stem Cuttings of *Labisia pumila* (Kacip Fatimah) in Mist Propagation System. Poster presented at the *Malaysian Science & Technology Congress*, Palace of the Golden Horses, Seri Kembangan, Selangor, October 5-6, 2004: 617-622.

Rozihawati, Z., Azmy, M. and Aminah, H. (2005). Vegetative Propagation of Labisia pumila Through Stem Cuttings. Institut Penyelidikan Perhutanan FRIM 2005: 368-373.

Rozihawati, Z. (2008). Production of planting stock from Kacip Fatimah (*Labisia pumila* (Bl.) F. Vill & Neves) through cuttings. MSc. Theses, Universiti Putra Malaysia, Serdang. 2008.

Syafiqah Nabilah, S.B., Farah Fazwa, M.A., Norhayati, S., & Mohd Zaki., A. (2013) Production of Quality Planting Stocks from Five Selected Clones of *Labisia pumila* var. *alata* Through Leaf Cuttings. *Proceedings of the International Symposium on Tropical Forest Ecosystem Science and Management* 2013: 276-280.

Syafiqah Nabilah S. B., Farah Fazwa M. A., Norhayati S., Mohd Zaki A. and Mohamad O. (2014) Propagation of five high yielding clones of *Labisia pumila* var. a*lata* and evaluation of their growth performances at nursery stage. *International Journal of Agricultural Science Research* 3(7): 121-125.

Zaridah M.Z., Nor Azah M.A., Abu Said A. and Mohd. Faridz Z. (2003). Larvicidal properties of citronella (*Cymbopogon nardus*) essential oils from two different localities. *Tropical Biomedicine* 20(2):169-174.