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IS PLANTATION FORESTRY A WISE INVESTMENT? A PERSPECTIVE FROM MALAYSIA'S INITIATIVES

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Forest plantations are seen as a potential alternative to natural forest for timber supply. Leaders in forest plantation development include China, India, the Russian Federation, United States and Japan, which accounted for 65% of planted area in 2000. Other countries with increasing forest plantation development include Malaysia. Initiatives for large-scale forest plantation establishment in Malaysia started with an envisaged production of pulp, then second, an effort to augment timber supply with selected fast-growing species within 15 years, and third, to establish 375,000 ha of commercial forest plantation in stages. The first two initiatives ended up as failures due to shortcomings such as seed viability, mismatched downstream industry to the species planted and logistic unfeasibility. The third initiative looks promising as plantations are owned by the industry with the government providing loans and technical assistance. One industry has already entered its third rotation. Large hectarages of land are an advantage to have harvesting in perpetuity based on seven-year rotations. Choosing the right species that matches industry needs, improved planting materials and correct silvicultural practices are important factors, while having integrated downstream processing is an advantage.

Keywords: Forest planting, industrial wood, nutrient management, timber production, tree disease.

INTRODUCTION

Forest plantations have attracted both considerable attention and criticism in recent years, but timber from forest plantations will be an increasingly important source of industrial wood at present and in the future. A closer look can shed some light on questions about the potential of plantations to meet the demands for industrial wood products and thus their indirect role in conserving natural forest resources (Ahmad Zuhaidi et al. 2007). In fact, forest plantations have long been recognised as an essential part of strategic development plans for sustainable management of forest resources. The Ministry of Plantation Industries and Commodities Malaysia projected log supply from forest plantations at 16.7 million m^3 from 2016 to 2030, which exceeds the 14.0 million m^3 from natural forest (MPIC 2009). Besides global supply of wood, plantation forest establishment can improve environmental quality by mitigating land degradation, improving soil fertility and sequestering carbon.

The rationale behind the continual establishment of forest plantations started as early as in 1979 as indicated from a study by the Forestry Department of Peninsular Malaysia (FDPM) projecting dwindling log supplies from natural forests. Consequently, the government implemented a two-pronged strategy to (1) regulate and reduce annual log supply and (2) establish large-scale forest plantations, with the intention of protecting natural forests and to create a sustainable timber source supplying the industry. The Compensatory Forest Plantation Programme (CFPP) was initiated in the 4th Malaysia Plan (1981–1985) to establish 188,000 ha with the objective of supplementing and complementing log supply from natural forests. The state governments of Sarawak and Sabah in East Malaysia had similar programmes aiming to generate a continuous supply of timber through forest plantations. In Sarawak, 1 million ha of land has been earmarked for forest plantation establishment until 2020 while 300,000 ha of forest plantations will be established in Sabah.

Forest plantations have also been established to provide industrial timber in countries such as South Africa and the United Kingdom, which have small natural forest estates. Since the mid-1980s forest plantations have assumed greater importance as a source of wood in nearly every

country, whatever their forest cover, thus often taking pressure off natural forests and facilitating the provision of protective functions. Globally, the area under forest plantations has increased for the past two decades, and this trend is expected to continue. Countries such as Vietnam for example, recently announced plans to rehabilitate 5 million ha of forest land, of which about 3 million ha will be forest plantations (Nambiar et al. 2015). Other countries with continuing reforestation and afforestation programmes include Argentina, Brazil, Chile, China, India, Malaysia, Indonesia, Morocco, Thailand and Uruguay.

From 2005 to 2010, the global area under forest plantations had increased to 264 million ha (Otuba & Johansson 2016). China is a leading country with a planted area reaching 77 million ha (Dai et al. 2016). Other countries with significant areas of forest plantations are the United States with 77 million ha, the Russian Federation (17 million ha), Japan (10 million ha) and Canada (9 million ha; Otuba & Johansson 2016). In the southern hemisphere, reported figures for New Zealand and Australia are 1.5 and 1 million ha respectively. Vietnam, one of the countries in South-East Asia with rapidly expanding forest plantation hectarage, has 1.1 million ha of acacia plantations of which 0.5 million ha are *Acacia* hybrids (Nambiar et al. 2015). In Bangladesh, plantations make up 32% of the forest estate and are important for protection as well as production of firewood, but in India, despite the large area, forest plantations only make up 4.8% of the forest estate.

The investment in forest plantations, which has always been relatively low in Malaysia, has recently grown in importance. The extent of forest plantations in Malaysia based on three main regions has been reported as: Sarawak, 380,000 ha (Abd Wahab 2012, unpublished); Sabah, 125,000 ha (Robert 2009); and Peninsular Malaysia, 113,810 ha (FPDSB 2018), which was nearly double the 64,630 ha reported by Krishnapillay in 1998.

Forest-based industries in the country have recognised that existing natural forests cannot continue to meet their raw material requirements, and investments in plantation programmes are expected to play a significant role in the coming years. Private investment in fast-growing plantations has grown in response to the growing demand for housing- and furniture-grade timbers, of which rubberwood, acacia and teak are most valued. Since 2000, plantation companies in Malaysia have promoted to investors tree planting schemes at low investment rates with expectations of high returns after as few as 20 years. Such tree plantations could certainly contribute to the supply of timber and other tree products and could help to increase forest cover in the country. However, for guaranteed success, tree investment programmes must be consistent with silvicultural and market needs, or risk failing to achieve their objectives. Market research and a sound business plan is crucial.

HISTORY OF FOREST PLANTATIONS IN MALAYSIA

Forest planting trials were established since the early 1920's in Peninsular Malaysia (Selvaraj & Muhammad 1980). These trials were established on small scale, mainly for research purposes or due to the availability of seedlings from nursery trials. Earnest efforts to establish forest plantations started in the 1950's after World War II with the intention of afforesting and reclaiming lands degraded due to mining and human resettlement after the war (Johari & Chin 1986). There were also teak and *taungya* planting trials in the northern states of Peninsular Malaysia.

The first large-scale commercial forest plantation emerged as a result of a proposed integration of the pulp and paper industry in Peninsular Malaysia (Freezailah & Fielding 1971). The five-year Pilot Plantation for Quick-Growing Industrial Tree Species assisted by FAO/UNDP was established in 1967. Tropical pine species including *Pinus caribaea and P. oocarpa*, and *Araucaria cunninghamii* and *A. hunsteinii* were the most planted for their long-fibre pulp and ability to thrive on poor soils. Early species trials showed promising growth for these species. A large-scale plantation followed in 1974 due to the favourable growth performance results from these pilot scales. However, planting efforts fizzled out after a few years because the envisaged pulp mill construction in Peninsular Malaysia did not happen (Johari & Chin 1986). Additionally, it was discovered that the species when planted at lower altitudes lacked the ability to naturally regenerate under local climatic conditions.

Subsequently a large-scale forest plantation project known as the Compensatory Forest Plantation Project (CFPP) was launched in 1982, following projections that Peninsular Malaysia would experience acute timber shortages for

domestic use by the year 2000 (Chong 1979). An area totaling 188,000 ha was set aside in stages for plantation establishment with fast-growing tree species. The project was partially financed through a loan from the Asian Development Bank. Initially, species such as *Acacia mangium*, *Paraserianthes falcataria* (batai) and *Gmelina arborea* were the main species planted but due to the poor performance and site-specific nature of the latter two species, other species were also selected for planting. These included the native species *Shorea leprosula*, *Dryobalanops aromatica*, *Hopea odorata*, *Dyera costulata* and *Endospermum malaccense*, and the exotics *Khaya ivorensis* (khaya), *Hevea brasiliensis* and *Acacia* hybrids.

TOWARDS WISE INVESTMENT IN PLANTATION FORESTRY

Forest plantations are generally more efficient in producing commercial timber than natural forests. Growth increments are far better at 20 m^3 ha^{-1} $year^{-1}$, management is easier, and the location of the plantations can be predetermined (Abdul Razak 1998). Plantations maturing in the next decade will be an important supplement to production from natural forests. The growing demand for industrial wood coupled with the necessary harvest limits on natural forest will enhance the economic role of plantations of fast-growing hardwood species.

A review of species suggests that *P. falcataria, Hevea* clones, and hybrids of *Acacia* are candidates with the lowest risk for short rotation plantation forestry. These genera, with the exception of *Hevea* clones, produce seeds that are easily stored for years without losing viability, thus making it easy to schedule nursery production. Trial plantings in FRIM's experimental plots at Bukit Lagong, Bukit Hari and FRIM research stations throughout Peninsular Malaysia indicate that *Shorea* spp. (including *Shorea roxburghii*, *S. leprosula* and S. *acuminata*), *D. costulata*, and *Endospermum diadenum* should prove to be reliable species in future plantation programmes for medium- to long-term rotations (30 to 40 years). Other candidates such as teak (*Tectona grandis*) and khaya are more sensitive to shallow, infertile and acidic soils and unlikely to grow fast enough to be a worthwhile investment. Native light hardwood species have yet to demonstrate promising growth. For many native species, including *Shorea* spp. and *Dipterocarpus* spp. the irregular production of recalcitrant seeds thwarts their effective use in plantation forestry. However, recent advances in plant propagation using stem cuttings mean that this obstacle may be overcome for such species.

Considering the high initial capital involved in plantation forestry establishment, clonal forestry (using genetically improved material) may play an important role in the success of an investment. The economic advantage is that clonal plantation yields a uniform product tailored to the requirements of the processing industry. The selected clone usually has fast growth rate, high wood density and high pulp yield, and is more profitable compared to seed-based planting. A word of caution however—clones must be properly tested because there may be differences in growth performance in variable environments. Mediocre or untested clones should be avoided. Testing should be conducted on major site types in the targeted planting environment. Half rotational testing gives a fairly reliable indication of performance, thus clonal development for short rotation planting can produce tested clones within five years.

A continuous research programme is required to support any effective plantation even if a good initial choice of planting species has been made. Research needs to be conducted locally to fill knowledge gaps and solve problems arising in local conditions. Research results should be made readily available to forest investors in the form of practical and accessible management recommendations. As such, long-term research cooperation between private forest plantation owners and research organisations is mutually beneficial.

In the early days, forest plantations in Malaysia were established through afforestation in areas left abandoned after agriculture or mining activities. Over the years, reforestation activities took place in clear-felled logging tracts where wood debris was burnt after high-value logs were extracted. Roots were left intact to decompose gradually. With the current awareness of the need to protect the environment, the practice of zero-burning and the utilisation of degraded sites—even tin tailings and BRIS soils—for forest plantation establishment is on the rise.

In continuing efforts to reduce pressure on natural forest and ensure a continuous supply of wood for the domestic timber industry, the Malaysian Government in 2003 launched another large-scale commercial forest plantation development phase with a new paradigm.

Under this programme, the Ministry of Plantation Industries and Commodities allocated MYR1.045 billion to be administered by the Malaysian Timber Industry Board (MTIB) over 15 years to develop 375,000 ha of forest plantations (25,000 ha year^{-1}) by the year 2020. From several promising species, eight were selected namely rubberwood (Timber Latex Clone or TLC), *Acacia* spp. (*A. mangium* and *A. auriculiformis*), teak, *Azadirachta excelsa* (sentang), *Khaya* spp. (*K. ivorensis* and *K.* senegalensis), *Neolamarckia cadamba* (kelempayan/laran), *P. falcataria*, and *Octomeles sumatrana* (binuang).

To implement the programme, on 13 February 2006 MTIB set up a Special Purpose Vehicle (SPV) named Forest Plantation Development Sdn. Bhd. (FPDSB) with the following main functions: (1) promote the establishment of forest plantations for future timber supply, (2) manage the disbursement of soft loans, carry out auditing process of the plantations and provision of technical support, (3) create a proper trading centre for timbers produced by man-made forests. Once successfully implemented, every 25,000 ha of land planted is expected to produce 5 million m^3 of timber (200 m^3 ha^{-1}). To attract and encourage private sector participation in the forest plantation programme, they are provided with fiscal incentives such as soft loans payable after 15 years and investment tax allowance. Following the increase in allotted soft loans where disbursements per ha for rubberwood increased from MYR8000 to MYR10,000, and from MYR6000 to MYR8000 for forest species, the targeted area for planting was reduced to 130,000 ha. Once successfully implemented, every 25,000 ha of land planted is expected to produce 5 million m^3 of timber (200 m^3 ha^{-1}).

In Peninsular Malaysia, forest plantations must be developed on state or alienated (privatised) land with prior approval from state forestry departments, and not on Permanent Reserved Forests (PRFs), which are gazetted for conservation and water catchment. In Sabah, approved areas are in zones for Industrial Tree Plantation (ITP) under the Sustainable Forest Management License Agreement (SFMLA) while in Sarawak, areas with a License for Planted Forest (LPF) can be developed. Sabah and Sarawak allocated 545,000 and 1 million ha respectively for forest plantation development. Since the programme launch in 2006, a total of 113,810 ha of forest plantations have been established in Peninsular Malaysia, of which rubberwood and other forest species comprise 78,479 and 35,331 ha respectively (FPDSB 2018). Since 2004, Sabah established more than 125,000 ha largely with *A. mangium, P. falcataria, Eucalyptus grandis*, *E. deglupta, E. pellita* and *N. cadamba* while a total of 349,394 ha has been planted in Sarawak.

The need for soil and nutrient management

Plantation forests in Malaysia have largely been established on soils with poor fertility. Unlike rubber and oil palm plantations, fertiliser is not a major input in plantation forests because the long gestation period requires minimal planting costs. Fertilising is carried out only to boost initial tree growth.

When the first 'systematic' forest plantation of exotic species was established in Peninsular Malaysia, little was known about species adaptation and survival under local conditions. Few problems were encountered with early plantation trials but subsequent plantings were unsatisfactory. Growth rates were not as expected and in some parts of the country, the trees showed symptoms of ill health (Freezailah & Fielding 1971). There were also cases where young, healthy trees developed symptoms of ill health as they aged. Among the causative factors diagnosed were nutritional disorders, poor site adaptation and to a lesser extent, diseases. According to Koslowski (1970), the ill health phenomenon discovered in *Pinus* plantations in Malaysia was attributed to nutrient deficiencies compounded in some cases by competing weeds. Phosphorus (P) deficiency was the dominant contributor while insufficient nitrogen (N) supply also limited tree growth. At the nursery stage, a correlation between unhealthy seedlings and needle blight disease susceptibility was found for various species of *Pinus*. The disease was caused by the fungus *Nigrospora* followed by four other secondary fungal invaders. Affected seedlings were distinguished by browning and death of the lower needles at the early stage and terminal bud attack later on. Nursery trial treatment results were unexpected—affected seedlings showed little response to fungicide but periodic fertiliser applications to an extent prevented the disease (Freezailah & Low 1986).

Malaysian soils in general have low available P due to high P fixation. In the compensatory plantation, a nutrient retranslocation study carried out on a two-year-old stand of *A. mangium* and *K. ivorensis* revealed high retranslocation for

P, most significantly for *A. mangium* with 78 % retranslocated (Wan Rasidah et al. 1998). P was returned to the tree even at the leaf yellowing stage while N and K were also retranslocated but at a much lower percentage. Ben and Harwood (2016) reported that fertiliser application increased growth of *Acacia* hybrid in the first three years of establishment, but by the fourth year wood volumes were similar for fertilised and unfertilised trees at 100 m^3 ha^{-1}. Notably, fertiliser input led to poorer stem form and early branching, necessitating pruning.

Importance of pest and disease management

In any large-scale tree planting, disease incidence is not uncommon, and management plans for pest and disease control should be well laid out. Cases of forest plantations failing to establish due to serious pest and/or disease attacks especially during the early phase have been documented (Wingfield 1999). According to Lee (2014), very few disease problems were experienced with *A. mangium* when it was first introduced as plantation species in Malaysia and it was even promoted as robust and easy to grow. However, with time, problems started to emerge. Heart rot disease in *A. mangium* was first discovered in Sabah (Gibson 1981) and in the 1980s became widespread in plantations, affecting timber quality and yield (Hashim et al. 1990, Lee et al. 1988, Zakaria et al. 1994). A decade later, the emergence of red root rot (associated with *Ganoderma philippii*) caused high mortality to mature *A. mangium* plantations in Peninsular Malaysia (Ito 1999, Lee 2000). Plantations between 10 and 14 years old reported more than 40% mortality in severely infected areas (Lee 2000). The most recently reported threat to *Acacia* spp. is vascular wilt disease (associated with *Ceratocystis* fungus), which was first found in 2005 in Indonesia, and now affects significant areas of plantation in Sabah, and parts of plantations in Johor and Pahang of Peninsular Malaysia (Lee 2017). Young plantations have been most affected (Mohd Farid et al. 2017) and a high mortality rate was reported in Sabah, forcing the company to abandon *A. mangium* in favour of other fast-growing species such as *Eucalyptus* spp. (Lee 2017). To date, no effective method is available to control this disease.

With the exception of rubberwood, diseases affecting other tree species have not been widely reported and have not been studied in depth. *Ceratocyctis* is also known to cause mortality of *Eucalyptus pellita* but whether it is the same species attacking *A. mangium* has yet to be confirmed.

FOREST PLANTATION RESEARCH AND DEVELOPMENT

In an effort to expand and diversify the existing list of tree species for recommended for forest plantations, planting trials have been conducted that assess the silvicultural and management regime requirements for each species. In Setul Forest Reserve, Negeri Sembilan, a model *N. cadamba* plantation was established in 2006 on 120 ha of land with elevation ranging from 80–250 m above sea level (Ahmad Zuhaidi 2012). Results from that study indicate that the species requires continuous and high soil moisture for good growth.

In a joint private–government sector initiative, a 20 ha pilot plantation of a native tree species, *D. costulata* was established in Kemasul Forest Reserve, Pahang under a Memorandum of Understanding between Staedtler (M) Berhad, FRIM and Pahang State Forestry Department. At 15 years after planting, open-grown trees performed well with the 833 and 625 stems ha^{-1} planting densities reporting a high calculated Periodic Annual Increment in diameter of 1.1 cm, while survival rates of over 45% were reported for planting densities of 400, 625, 833 and 1,111 stems ha^{-1}. The variability of 15-year-old stand are shown in Figure 1. Data collection and monitoring were discontinued for trees planted under closed canopy, which suffered high mortality. Subsequently, planting under open conditions yielded a mean annual volume of 6.23 m^3 ha^{-1} $year^{-1}$, diameter at breast height (DBH) of 21.5 cm, and total height of 12.55 m. Monitoring will continue for the open-planted trees in that trial planting until a stand age of 20 years to obtain one rotation's worth of cumulative growth data.

At the FRIM Research Station in Segamat, Johor, *D. costulata* planted at an initial density of 833 stems ha^{-1} achieved a mean annual volume of 11.32 m^3 ha^{-1} $year^{-1}$ 13 years after planting (Faridah A, personal communication). Soil quality and agroecological factors may have contributed to the vastly greater growth performance of the trees in Segamat compared with Kemasul stands. Nevertheless, the timber yield of *D. costulata* was comparatively lower than that of indigenous fast-growing meranti (*S. roxburghii*) planted at this

Figure 1 Open-grown *Dyera costulata* with initial planting densities of 833 (left) and 625 stems ha^{-1} (right) had higher and lower survival rates respectively, 15 years after planting

station. The species is currently being evaluated for future commercial planting programmes.

FRIM and ASIA PRIMA Sdn Bhd are collaborating on a research project investigating alternative techniques for re-establishing *A. mangium* plantations following harvest of a previous rotation. The first rotation of an *A. mangium* plantation established in Kemasul, Pahang in the 1990s was harvested with the next rotation establishment method was planned. Existing regrowth of wildings from the first rotation trees were selectively thinned under various thinning regimes to establish the second rotation plantation. This approach eliminated the cost of acquiring planting materials.

CONCLUSIONS

The commercial planting of timber species under plantation conditions with intensive silvicultural support, improved planting materials, proper site matching and clear management objectives remains a profitable long-term investment comparable with other plantation commodities in Malaysia such as rubber. Sabah Softwood Berhad's experience establishing plantations of the fast-growing *P. falcataria* currently in their third rotation, and in the management of *Eucalyptus* (both the hybrid and *E. pellita*) are evidence of successful ventures into forest plantations. Also, the success of forest plantation programmes using *Pinus radiata* in New Zealand and Australia, and *Eucalyptus* in Brazil is indisputable as they lead the world market in the supply of temperate softwood. The timely advancements in clonal forestry technology using genetically improved material will play an important role in the success of investments in forest plantations.

REFERENCES

Abdul Razak MA. 1997. Prospects for forest plantations in Malaysia—potentials and challenges. Pp 1–6 in Ahmad Zuhaidi Y et al. (eds) *Proceedings of the Seminar on Commercial Cultivation of Teak, Sentang, Acacia and Hevea for Timber*. 9 January 1997, Kuala Lumpur.

Ahmad Zuhaidi Y. 2012. Evaluating the growth performance of four year-old *Neolamarckia cadamba* in Malaysia. *The Planter* 88: 100–107

Ahmad Zuhaidi Y, Hashim MN & Ahmad Fauzi S. 2007. Commercial forest plantation programme in Malaysia: the future wood supply. Pp 218–222 in Gan KS et al. (eds) *Proceedings of the Conference on Forestry and Forest Products Research: Balancing Economic and Ecological Needs*. 27–29 November 2007, Kuala Lumpur.

Bon P & Harwood C. 2016. Effects of stock plant age and fertiliser application at planting on growth and form of clonal *Acacia* hybrid. *Journal of Tropical Forest Science* 28: 182–189.

Baskaran K, Noor Mahat M, Norini H, Ab Rasip AG, Ahmad Zuhaidi Y & Mahmud AW. 1998. Viability of planting teak and sentang in Malaysia. Pp 23–33 in Ahmad Zuhaidi Y et al. (eds) *Commercial Cultivation of Teak, Sentang, Acacia and Hevea for Timber*. Proceedings of the seminar, 9 January 1997, Kuala Lumpur.

Chong PW. 1979. The growing domestic demand for timber and its influence on forest management. *Malayan Forester* 42: 376–399.

Dai J, Welham C, Cao L & Cao F. 2016. Sustainable production in subtropical hybrid poplar plantations. *Journal of Tropical Forest Science* 28: 190–204.

Forest Plantation Development Sdn Bhd. 2018, 16 January. *Minutes of Meeting: Physical Progress of Forest*

Plantation Development Programme (2). Ministry of Primary Industries and Commodities, Putrajaya.

Freezailah CY & Fielding JM. 1971. *The Development and Results of the Pilot Plantation Project and Prospects for the Future*. FO:SF/MAL/12. Working Paper No.18. FAO, Rome.

Freezailah CY & Low CM. 1986. Some preliminary observations on the attack and control of a fungal (*Pestalotia* sp.) disease on seedlings of *Pinus caribeae*. *Malayan Forester* 31: 15–19.

Gibson Ias. 1981. *Seed Source Establishment and Tree Improvement - Sabah, Malaysia*. FAO/UNDP-MAL/78/009, Forest Mycology Consultant's Report No. 3. FAO, Rome.

Hashim MN, Maziah Z & Sheikh Ali A. 1990. The incidence of heart rot in *Acacia mangium* Willd. plantations: a preliminary observation. Pp 54–59 in Appanah S, Ng FS. & Roslan I (eds) *Malaysian Forestry and Forest Products Research*. Proceedings of a Conference on Forestry and Forest Products Research. 3–4 October 1991, Forest Research Institute Malaysia, Kepong.

Ito S. 1999. Annex 8: Incidence and severity of root disease at *Acacia mangium* plantations in the Multi-Storied Forest Management Project. In: *Integrated Report on the Multi-Storied Forest Management Project in Malaysia (1991–1999)*. Forestry Department Peninsular Malaysia, Perak State Forestry Department, Japanese International Cooperation Agency, Kuala Lumpur.

Johari B & Chin TY. 1986. Review of plantation experiences in Peninsular Malaysia. Pp 213–242 in *Proceedings of the Ninth Malaysian Forestry Conference: Forest Our National Heritage*. 13–20 October 1986, Kuching.

Koslowski TT. 1970. *Physiological Implications in Establishment and Growth of Quick-Growing Species in Malaysia*. FO:SF/MAL/12. Technical Report No. 2. FAO, Rome.

Landsberg JJ. 1977. The Biophysical Environment. Pp 65–96 in Nambiar EK & Alan G (eds). *Management of Soil, Nutrients and Water in Tropical Plantation Forests*. ACIAR Monograph No. 43. Australian Centre for International Agricultural Research (ACIAR), Canberra.

Lee SS. 2017. Ceratocystis wilt: a threat to Malaysian forest plantations. Pp 3–6 in Wan Rasidah K et al. (eds) *Penyakit Layu: Risiko dan Ancaman Terhadap Perladangan Acacia mangium di Malaysia*. Prosiding Bengkel Penyakit Layu. 11–12 January 2017, Temerloh.

Lee SS. 2014. Lamenting the state of mycology and forest pathology in Malaysia. *Journal of Tropical Forest Science* 26: 443–445.

Lee SS, Teng SY, Lim MT & Razali AK. 1988. Discoloration and heart rot of *Acacia mangium* Willd.—some preliminary results. *Journal of Tropical Forest Science* 1: 170–177.

Mohd Farid A, Syazwan SA, Wan Muhammad Azrul WA, Patahayah M, Mohd Salleh S & Abriza MZ. 2017. Penyakit layu disebabkan kulat *Ceratocystis* di ladang *Acacia mangium* di Malaysia dan ancamannya kepada pokok hutan dan pokok pertanian terpilih. Pp 21–24 in Wan Rasidah K et al. (eds) *Penyakit Layu: Risiko dan Ancaman Terhadap Perladangan Acacia mangium di Malaysia*. Prosiding Bengkel Penyakit Layu. 11–12 January 2017, Temerloh.

Ministry of Plantation Industries and Commodities (MPIC). 2009. *NATIP: National Timber Industry Policy 2009–2020*. MPIC, Putrajaya.

Nambiar EK, Harwood CE & Kien ND. 2015. *Acacia* plantations in Vietnam: research and knowledge application to secure a sustainable future. *Southern Forests* 77: 1–10.

Otuba M & Johansson K. (2016). Understorey plant diversity under seven tropical and subtropical plantation species. *Journal of Tropical Forest Science* 28: 107–111.

Selvaraj P & Muhammad AB. 1980. *A Checklist of Plantation Trials in Peninsular Malaysia*. Research Pamphlet No 79. Forest Research Institute Malaysia, Kepong.

Wan Rasidah K, Van Cleemput O & Zaharah AR. 1998. Nutrient retranslocations during the early growth of two exotic plantation species. Pp 133–136 in Schulte A & Ruhiyat D (eds) *Soils of Tropical Forest Ecosystems: Characteristics, Ecology and Management*. Springer-Verlag, Berlin.

Wan Rasidah K, Van Cleemput O & Zaharah AR. 1999. Soil nitrogen dynamics in the early establishment phase of a forest plantation in Peninsular Malaysia. *Journal of Tropical Forest Science* 11: 100–110.

Wingfield MJ. 1999. Pathogens in exotic plantation forestry. *International Forestry Review* 1: 163–167.

Zakaria I, Wan Razali WM, Hashim MN & Lee SS. 1994. *The Incidence of Heartrot in Acacia mangium Plantations in Peninsular Malaysia*. FRIM Research Pamphlet No. 114. Forest Research Institute Malaysia, Kepong.

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