



Establishment of *Aquilaria malaccensis* arboreta in Pahang and Selangor, Peninsular Malaysia

Lau Kah Hoo, Muhammad Alif Azyraf Azmi, Siti Fariezza Khairi Thaw & Lillian Chua Swee Lian

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Establishment of Arboreta and Strengthening Institutional Network for the Conservation of *Aquilaria malaccensis* in Peninsular Malaysia

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List of Acronyms and Abbreviations

CIRP	Christmas Island Rock Phosphate
CTSP	CITES Tree Species Programme
cm	centimetre
DBH	Diameter at breast height
DRC	Diameter at the root collar
FDPM	Forestry Department of Peninsular Malaysia
FRIM	Forest Research Institute Malaysia
g	gram
ha	hectare
KeTSA	Ministry of Energy and Natural Resources
kg	kilogram
km	kilometre
m	metre
MTIB	Malaysian Timber Industry Board
PL	Project Leader
RCBD	Randomized Complete Block Design
SSFD	Selangor State Forestry Department

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1. Introduction

The Forest Research Institute Malaysia (FRIM) was granted a project entitled “Establishment of Arboreta and Strengthening Institutional Network for the Conservation of *Aquilaria malaccensis* in Peninsular Malaysia” under the CITES Tree Species Programme (CTSP) between 2019–2022. The objective of the project was to enhance conservation activities for *A. malaccensis* through the establishment of an institutional network and arboreta. Three outputs were expected to be achieved at the end of the project which were (i) a network of institutions that is responsible for the conservation of *A. malaccensis*, (ii) established arboreta of *A. malaccensis* in selected states, and (iii) dissemination and sharing of the project results. This document was to report on item (ii), which was to establish an arboretum each in the states of Pahang and Selangor (to be known as the Pahang Arboretum and Selangor Arboretum) based on previous phenological and molecular studies conducted by FRIM. The activity comprised several stages (Figure 1) that involved a number of different agencies, staff, and resources. It also has to be highlighted that some challenges occurred along the process.

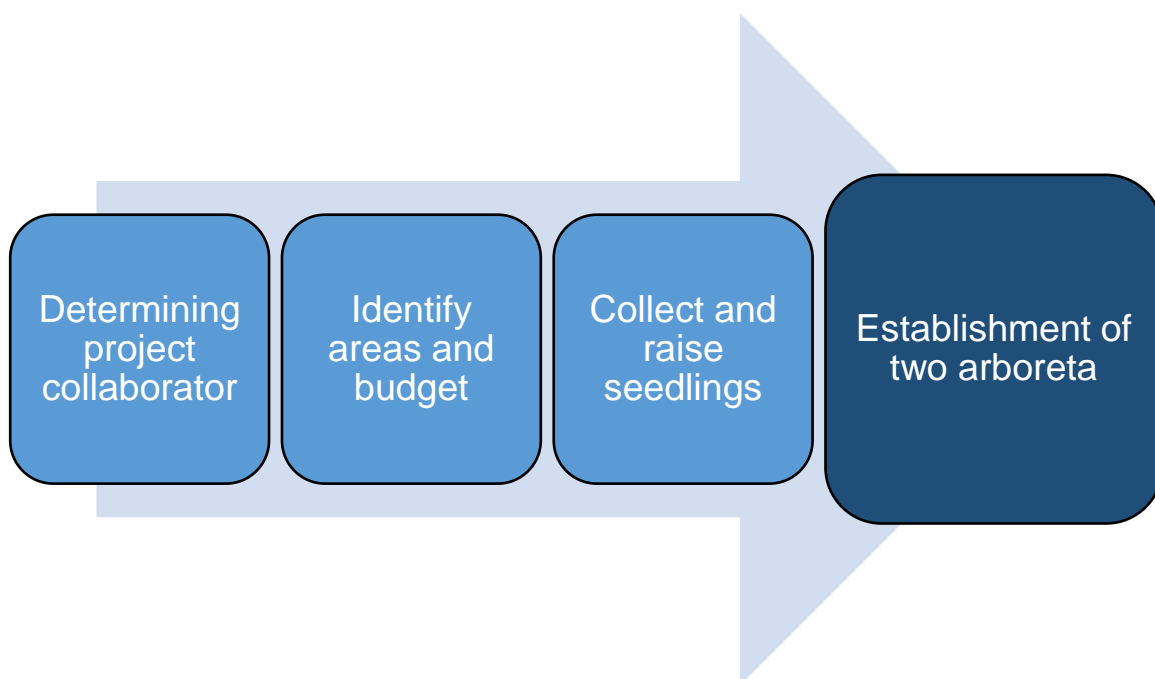


Figure 1. Work stages in the arboretum establishment.

2. Determining project collaborator

The initial CTSP project proposal was to establish an *A. malaccensis* arboretum each in the state of Selangor and Perak. In a meeting held on the 9 January 2018 in the office of the Ministry of Energy and Natural Resources (KeTSA) (then the Ministry of Water, Land and Natural Resources) between the Forestry Department of Peninsular Malaysia (FDPM), the Malaysian Timber Industry Board (MTIB), and FRIM, it was agreed that FDPM would be the project collaborator and the scope was to propose a suitable area in the state of Selangor for the establishment of the Selangor arboretum and to prepare the budget required.

Between February–June 2019, three meetings were held internally at FRIM with officers from the Forestry Biotechnology Division for the purpose of establishing the Perak arboretum. At that time, it was agreed that the Ecophysiology Branch under the Forest Plantation Programme of FRIM would assist in proposing a suitable area and preparing the cost needed to establish the Perak arboretum.

Collaboration was crucially needed as these two partners were able to furnish land for the project's use for the establishment of *A. malaccensis* arboretum, which was one of the project's main outputs. The success of the project would be gauged through the arboretum establishment for the purpose of *A. malaccensis ex situ* conservation approach.

3. Identify areas and budget

The discussion on the Selangor arboretum resumed after over a year since the project collaborators identification meeting held in 2018. The original purpose of the 2018 meeting was to gather information for the project proposal development. It was only after the project was approved on 1 February 2019 that execution of the project's activities could commence. On 17 September 2019, a presentation followed by a discussion with the FDPM was made in order to detail out the work plan. The Selangor State Forestry Department (SSFD) was approached by FDPM in November 2019, requesting the agency to propose a site for the arboretum establishment. Between January and December 2020, three meetings cum site visits were conducted at four sites in Selangor, namely the Sungai Lalang Forest Reserve, Kanching, Kundang, and Batu Arang (Figure 2). Upon visiting these sites, it was found that none of the sites was suitable due to unmet planting design and uncertainty of land status. According to SSFD, deciding on a suitable site for plantation was not easy nowadays, as land has become scarce in the state. Generally, for a site to be established as an *A. malaccensis* arboretum, the site had to be relatively safe from poachers with proper access roads and a clearly defined land status. Due to that and judging from the project's duration, it was decided that the site had to be changed and to be located in FRIM. Following that decision, a series of pre-site visits were made within the months of January and February 2021 to seek a suitable site, resulting in Bukit Hari, which was situated on the campus of FRIM as the possible site. Two internal meetings with Programme Heads from the Forestry Biotechnology Division, FRIM were immediately conducted between 12-13 April 2021 to seek approval to acquire a small area within a research plot at Bukit Hari to be developed as the Selangor arboretum.

Initial discussion regarding the Perak arboretum started in February–June 2019 with a site visit to the proposed site, the Bidor Research Station, FRIM, planned at the end of 2020, of which planting materials were expected to have reached the required quantity by then. At the commencement of the project, the Project Leader (PL) had anticipated some additional funds from another government-funded project but were not available at the time of the planting dates as setting the arboretum at the Bidor Research Station would require a high start-up and maintenance costs for planting as it is located on an ex-tin mining land. It was then after due consultation with several person-in-charge and the co-PL, in addition with the correct timing of the PL being invited as a co-worker in another ongoing project funded by FDPM – '*Membangunkan Strategi Pemuliharaan Dan Menambahbaik Kualiti Hasil Spesies Aquilaria Terpilih Secara Lestari Di Malaysia*' (Developing conservation strategies and improving the product sustainability of selected *Aquilaria* species in Malaysia) in February 2021 that it was decided that the Perak arboretum would be moved to Pahang (hence the Pahang arboretum). A site visit and a meeting conducted between February and March 2021 had garnered the needed approval to establish the Pahang arboretum.

As a comparison, the earlier proposed budget by SSFD was approximately US\$ 16,000.00 for the Selangor arboretum, and the proposed budget for the Perak arboretum at the Bidor Research Station was US\$ 54,000.00, including a 5-year maintenance package. Both estimations were made before the revised smaller scale of the arboreta that consisted of 442 seedlings in each arboretum in the current planting design. The shift of the location of both the arboreta to the FRIM campus in Selangor and the FRIM's Maran Research Station in Pahang did not adversely affect the scientific principles applied behind the arboreta establishment as the same planting design and protocol were implemented.



Figure 2. During one of the site visits to a proposed Selangor arboretum site with the Selangor State Forestry Department. Photo: Lau Kah Hoo.

4. Collect and raise seedlings

The site selection for seedlings collection was solely based on past genetic studies conducted by FRIM on 942 *A. malaccensis* samples collected from 35 natural populations in Peninsular Malaysia (Chua *et al.* 2016; Lee *et al.* 2022). These sites were chosen based on molecular evidence which showed that by preserving (either via *in situ* or *ex situ*) specific populations, it was hypothesised that the genetic diversity of *A. malaccensis* populations in Peninsular Malaysia could be conserved. In summary, the criteria for selection of collection sites were based on (i) genetic information generated from previous molecular studies conducted by FRIM, (ii) originated from natural populations in forest reserves, and (iii) healthy populations that produce ample seeds or seedlings with minimal anthropogenic disturbance. Therefore, between 2019–2021, 25 collection trips involving 37 visitations (Table 1) were carried out in the states of Kedah, Pulau Pinang, Perak, Selangor, Negeri Sembilan, Melaka, Johor, Pahang, Terengganu, and Kelantan with 17 district forest offices and ranger offices, two federal agencies, two state forestry departments, one botanic garden, and one private learning institution involved (Figure 3). The project (through FRIM) had obtained a 3-year forest entry permit (2019–2021) from FDPM to conduct and collect *A. malaccensis* seeds and seedlings from all forest reserves in Peninsular Malaysia. At the time of this report, a total of 3,059 seedlings had been collected and raised in the FRIM's nursery.

Collected seeds or seedlings were immediately sowed in the FRIM's nursery after the staff had returned from trips (Figure 4). Polybags and sowing containers were prepared in advance to save time and minimise stress on the seedlings. The medium that was used in the polybags was a 3:2:1 ratio of soil, sand and compost respectively. Potted seedlings were placed under 70% shade and watered once a day. Watering would be reduced to once in two days during the rainy season to avoid pests and disease outbreaks. All polybags were labeled with a living collection number and grouped in batches. Pesticides were only applied during serious pest outbreaks. A full inventory of the seedling stocks was carried out every 2–3 months to ensure that the seedlings supply from each population was sufficient to be planted. This was due to mortality from pests attack and diseases, and hence decline in seedlings' quantity of certain populations might occur.

Table 1. List of field works conducted for planting materials collection.

No.	Visitation dates	State
1.	15–19 April 2019	Kedah
2.	10–12 June 2019	Melaka
3.	10–12 June 2019	Negeri Sembilan
4.	20 June 2019	Selangor
5.	24–28 June 2019	Kelantan
6.	24–28 June 2019	Terengganu
7.	8–12 July 2019	Pahang
8.	8–12 July 2019	Johor
9.	15–17 July 2019	Pulau Pinang
10.	5–7 August 2019	Perak
11.	13–16 August 2019	Pahang
12.	13–16 August 2019	Johor
13.	7–11 October 2019	Kelantan
14.	7–11 October 2019	Terengganu
15.	21–23 October 2019	Pulau Pinang
16.	25–29 November 2019	Kedah
17.	16–18 December 2019	Pulau Pinang
18.	20–24 January 2020	Pulau Pinang
19.	20–24 January 2020	Perak
20.	28–31 January 2020	Johor
21.	10–14 February 2020	Pulau Pinang
22.	10–14 February 2020	Perak
23.	24–28 February 2020	Pahang
24.	24–28 February 2020	Negeri Sembilan
25.	24–28 February 2020	Johor
26.	9–13 March 2020	Pulau Pinang
27.	9–13 March 2020	Perak
28.	29 June–3 July 2020	Kelantan
29.	3–7 August 2020	Pahang
30.	3–7 August 2020	Terengganu
31.	24–28 August 2020	Pahang
32.	24–28 August 2020	Johor
33.	1–4 September 2020	Perak
34.	28 September–2 October 2020	Terengganu
35.	5–9 October 2020	Johor
36.	24 March 2021	Pahang
37.	22–23 November 2021	Kuala Lumpur



Figure 3. In one of the field trips with the state forestry department to collect planting materials. Photo: Muhammad Alif Azyraf Azmi.



Figure 4. Seedlings of *Aquilaria malaccensis* were immediately sowed upon returning from the field. Photo: Lau Kah Hoo.

5. Establishment of two *Aquilaria malaccensis* arboreta

The site selection for the Pahang and Selangor Arboretum was based on the genetic distance and Bayesian clustering analysis that *A. malaccensis* populations in Peninsular Malaysia could be divided into three regions, namely northern, southern and eastern regions of the peninsula (Lee *et al.* 2017). The three regions should be regarded as distinct plant material transfer zones for the species. While the ultimate objective of the arboretum is for genetic diversity conservation, it could also act as an experimental plot for testing plant material transfer guidelines, association studies and provenance trials (Lau *et al.* 2022a). Hence, it was only logical that the arboretum was established in these two areas, representing the southern and eastern regions. Other than that, the site had to be also relatively safe from poachers with proper access roads and a clearly defined land status, as stated above. The establishment of the two arboreta was based on the “Guidelines for the establishment of *Aquilaria malaccensis* arboretum in Peninsular Malaysia” (Lau *et al.* 2022b) produced under the project.

5.1 Pahang Arboretum

5.1.1 Site description

The Pahang Arboretum, which is situated in the Maran FRIM Research Station, is located in Ulu Luit, Maran, Pahang. The station is next to the Betong Forest Reserve. The distance between the city of Kuala Lumpur and Maran is about 200 km. Accessibility is easy as the

station is connected to major cities through the East Coast Expressway. The station is made up of 50 ha of hilly terrain where the gradient ranges between 2°–35°. The soil type where the arboretum is situated is of the Bungor series. The arboretum sits at an elevation of 45 m above sea level. The station was established in 2000 after securing the land title from the state government of Pahang, with the aim to become a pharmaceutical products development centre.

5.1.2 Planting design and layout

The planting layout uses a *Randomized Complete Block Design* (RCBD) so that all the seedlings in an experimental unit would receive the same treatment (Figure 5). The planting interval was 4 m × 4 m, hence an area of approximately 0.7 ha (including buffer plants) was required to establish an arboretum consisting of nine populations with 40 seedlings from each population. Every experimental unit is composed of one seedling per population, and the entire planting design is comprised of 40 experimental units (replicates). This resulted in 360 seedlings being used. Apart from that, another 82 seedlings (which can be derived from the same populations or different populations of the 360 individuals) were planted as a buffer along the perimeter of the plot. The buffer acts as a separator from the surrounding vegetation. The design uses a monoculture approach where only *A. malaccensis* was planted without intercropping. Colour codes indicate the origin of the seedling (see 5.1.4).

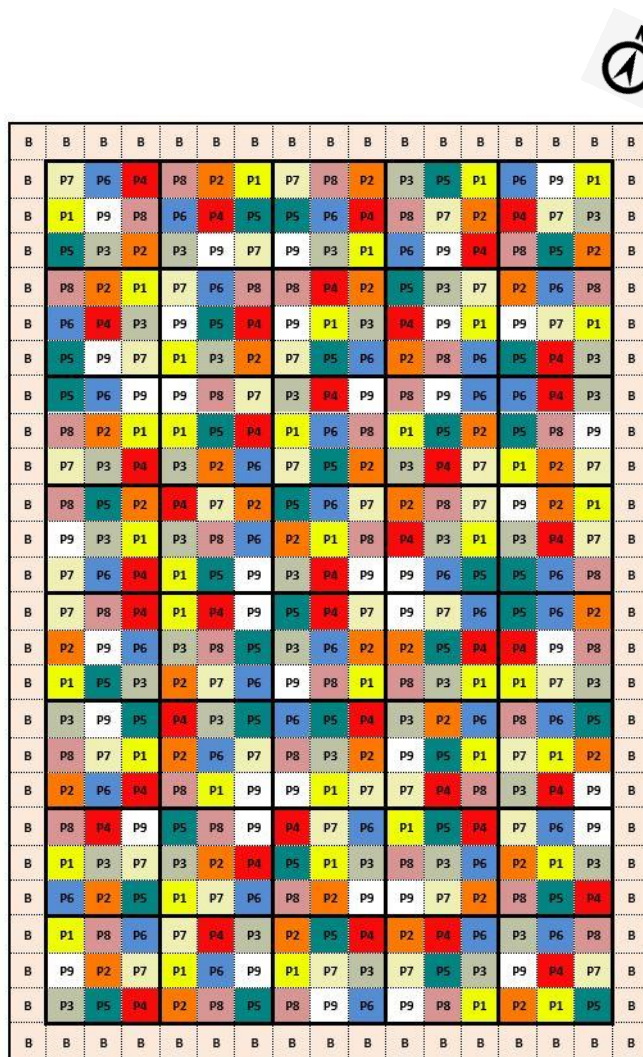


Figure 5. Layout, north direction and planting design in the Maran Research Station, FRIM.

5.1.3 Site preparation for planting

A site survey was conducted on 25 February 2021 with research officers from the Natural Products Division, FRIM. Boundary demarcation was done on 20 and 21 April 2021 by a team of FRIM staff using standard mapping equipment to ensure precision. A temporary string was first tied along the arboretum's perimeter of 68 m × 104 m to mark the boundary. The application to clear the site was submitted on 24 June 2021, and it was only on 19 July 2021 that the site clearing commenced. Land clearing was sourced out to a local contractor and it took more than one month to be completed. No terracing was needed at the site.

5.1.4 Planting stock production

Planting materials used in the arboretum were from either seedlings germinated from seeds or the collected wildings. In order to meet the planting design requirement of nine populations, the population from the Penang Botanic Gardens (PBG2) was replicated. Colour codes indicate the origin of the seedlings. The number in parenthesis denotes the number of seedlings. Seedling ages varied as planting materials used were collected during different fruiting seasons (Table 2).

Table 2. Details of the seedlings' origins, quantity planted and year of collection in Pahang Arboretum.

	Population	Year
P1	Gunung Jerai (Kedah) (40)	2019
P2	Penang Botanic Gardens 1 (Penang) (40)	2015, 2019
P3	Universiti Teknologi PETRONAS (Perak) (40)	2015, 2016, 2018
P4	Chabang Tongkat (Kelantan) (40)	2019
P5	Gunung Tebu (Terengganu) (40)	2019
P6	Merchang (Terengganu) (40)	2019, 2021
P7	Mont Kiara (Selangor) (40)	2014
P8	Sungai Udang (Melaka) (40)	2019
P9	Penang Botanic Gardens 2 (Penang) (40)	2014, 2015, 2018, 2019
B	Buffer from any population (82)	2011, 2014, 2015, 2016

5.1.5 Planting operations

Planting lines, alignment and planting holes preparation were carried out in the week of 6–10 September 2021. These were done by FRIM staff, except for planting holes preparation where locals were hired. Wooden poles of 1 m height were used to mark the planting holes and each was coloured to distinguish different populations. To ensure accuracy during distribution to each planting hole, the same colour code was painted on the side of the polybag accordingly. The planting hole has a dimension of 30 cm (width) × 30 cm (depth). Approximately 1 kg of compost soil and 50 g of Christmas Island Rock Phosphate (CIRP) were added to each of the planting holes to enhance the soil quality. Of utmost importance during planting was to ensure that the soil encapsulating the root ball was intact at all times when the polybag was being opened, and carefully put into the planting hole. Planting only started on 13 September 2021 and the arboretum of 0.7072 ha was successfully established on 16 September 2021 with a total of 442 seedlings planted. (Figure 6).



Figure 6. The Pahang Arboretum located in Maran Research Station, FRIM. Photo: Siti Fariezza Khairi Thaw.

5.1.6 Maintenance and protection

Replacement for seedlings can be carried out up to three years after first planting. Planted seedlings are not to be pruned or thinned as in other normal plantation environments for them to be fully grown. No fertilizers were applied as the arboretum also serve as a growth performance plot for different populations of seedlings. Pesticides are not to be applied regularly except when there is a pest or disease outbreak. There was no fire history in the station but standard prevention measures such as no open burning and smoking are allowed in or near the arboretum area.

5.1.7 Establishment costs

The costs incurred from the project for the establishment of the Pahang Arboretum can be itemized in Table 3. Worker costs were paid by FRIM which were estimated to be US\$ 3,662.00 involving 17 personnel for work done from 6–10 September and 13–17 September 2021.

Table 3. Establishment costs for the Pahang Arboretum.

Item	Cost (US\$)
Seedlings collection trips and nursery materials	2,080.93
Site clearing and preparation	2,732.02
Planting materials (poles, iron netting, top-soil, fertilisers & coco fibre)	1,822.68
Total	6,635.63

5.1.8 Constraints and challenges

The establishment of the arboretum had met some constraints, as well as challenges. The original proposed site was in Bidor, Perak (Perak arboretum) but needed to be changed due to a costing issue. The entire work involved in establishing the arboretum was carried out during the Covid-19 pandemic which caused many delays in carrying out the planned activities. These were due to a series of Movement Control Orders, areas lockdown (Ulu Luit was involved) and travel restrictions imposed throughout 2020–2021. Within the arboretum itself, as the Maran Research Station is surrounded by villages and fragmented forests, wild and grazing animals would sometimes encroach into the station and disturbed the planted seedlings. To mitigate this problem, regular checks and repairs on torn fences were carried out.

5.1.9 Next steps

Each planted seedling has an individual tag and recordings were done on an Excel data worksheet. A full inventory was carried out one month (October 2021) after the seedlings were planted to record growth and mortality. For growth performance, height, diameter at the root collar (DRC) and diameter at breast height (DBH) of the seedlings are to be measured once every two months. To date, data collection had been done for the months of December 2021, February 2022 and April 2022. To avoid growth performance bias, planted seedlings are not fertilized, pruned or manipulated in any manner. However, weed removal is still required and would be carried out whenever necessary. Many more leisure and research activities could be carried out in the future after the planted seedlings have been established (Lau *et al.* 2022a).

Preliminary results from the inventory and growth performance data collected have shown that as of April 2022, 29 seedlings had died, average height growth of 10.1 cm, average DRC growth of 0.07 cm, and average DBH growth of 0.02 cm (Figure 7).

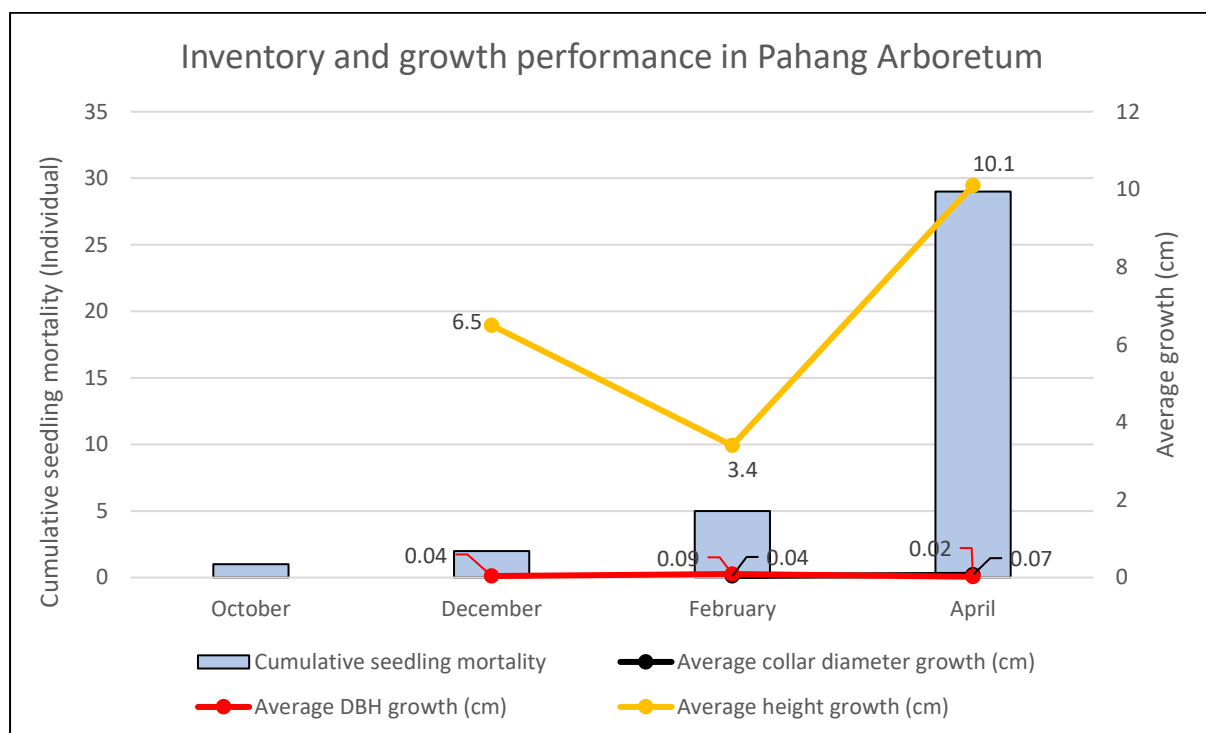


Figure 7. Inventory and growth performance in Pahang Arboretum.

5.2 Selangor Arboretum

5.2.1 Site description

The Forest Research Institute Malaysia was founded in 1929 (then known as the Forest Research Institute of the Forestry Department, Peninsular Malaysia) and became a full-fledged statutory body in 1985. In 2012, FRIM received its freehold land title from the State Government of Selangor. The Selangor Arboretum, which is situated in F52 Bukit Hari, FRIM, is located in Kepong, Selangor. Bukit Hari is a small hill located next to the Kepong Botanic Gardens. The hill comprises many research plots that had been planted with various plant species on an experimental basis. The Institute itself sits on a 544.3 ha site next to the Bukit Lagong Forest Reserve. The distance between the city of Kuala Lumpur and Kepong is about 16 km. Accessibility is convenient as the Institute is connected to many major highways and

municipal roads. The arboretum lies in a hilly terrain where the gradient ranges between 25°–30°, at an elevation of 140 m above sea level. The soil type where the arboretum is situated is of the Tai Tak series.

5.2.2 Planting design and layout

The planting layout uses a *Randomized Complete Block Design* (RCBD) so that all seedlings in an experimental unit would receive the same treatment (Figure 8). The planting interval was 4 m × 4 m, hence an area of approximately 0.7 ha (including buffer plants) was required to establish an arboretum consisting of nine populations with 40 seedlings from each population. Every experimental unit is composed of one seedling per population, and the entire planting design is comprised of 40 experimental units (replicates). This resulted in 360 seedlings being used. Apart from that, another 82 seedlings (which can be derived from the same populations or different populations of the 360 individuals) were planted as a buffer along the perimeter of the plot. The buffer acts as a separator from the surrounding vegetation. The design uses a monoculture approach where only *A. malaccensis* was planted without inter-cropping. Colour codes indicate the origin of the seedling (see 5.2.4).

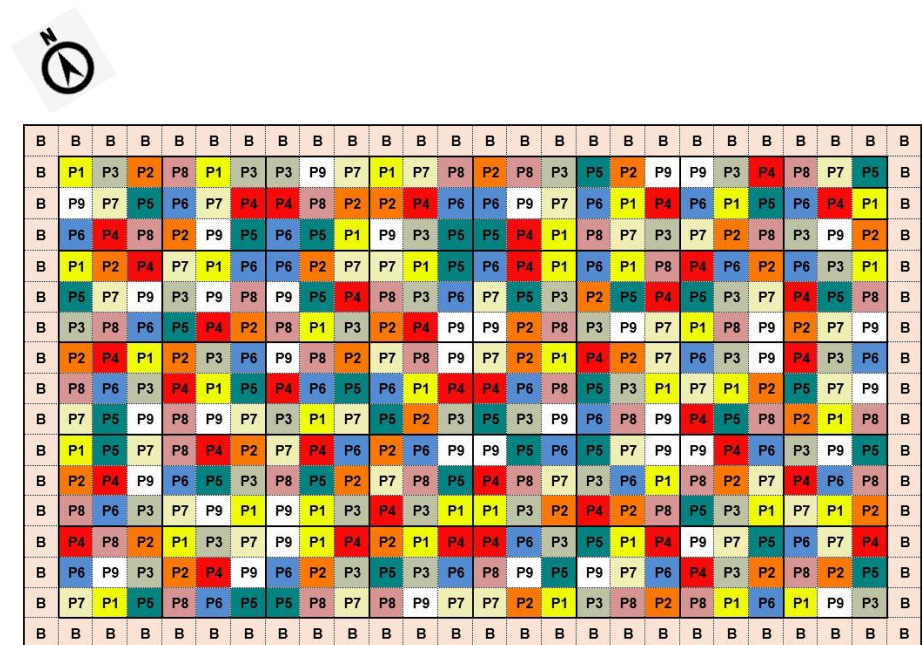


Figure 8. Layout, north direction and planting design in Bukit Hari, FRIM.

5.2.3 Site preparation for planting

A site survey was conducted on 12 and 14 April 2021 with research officers from the Forestry Biotechnology Division, FRIM. Boundary demarcation was done on 28 April 2021 by a team of FRIM staff using standard mapping equipment to ensure precision. A temporary string was first tied along the arboretum’s perimeter of 68 m × 104 m to mark the boundary. The application to clear the site was submitted on 7 September 2021, and it was only on 10 November 2021 that the site clearing commenced. Land clearing was sourced out to a local contractor and it took more than two months to be completed. Mild terracing was done on selected parts of the arboretum to reduce the slope.

5.2.4 Planting stock production

Planting materials used in the arboretum were from either seedlings germinated from seeds or the collected wildings. In order to meet the planting design requirement of nine populations, the population from the Penang Botanic Gardens (PBG2) was replicated. Colour codes indicate the origin of the seedlings. The number in parenthesis denotes the number of seedlings. Seedling ages varied as planting materials used were collected during different fruiting seasons (Table 4).

Table 4. Details of the seedlings' origins, quantity planted and year of collection in Selangor Arboretum.

	Population	Year
P1	Gunung Jerai (Kedah) (40)	2019
P2	Penang Botanic Gardens 1 (Penang) (40)	2015, 2019
P3	Universiti Teknologi PETRONAS (Perak) (40)	2015, 2016, 2018
P4	Chabang Tongkat (Kelantan) (40)	2019
P5	Gunung Tebu (Terengganu) (40)	2019
P6	Merchang (Terengganu) (40)	2019, 2021
P7	Mont Kiara (Selangor) (40)	2014
P8	Sungai Udang (Melaka) (40)	2019
P9	Penang Botanic Gardens 2 (Penang) (40)	2014, 2015, 2018, 2019
B	Buffer from any population (82)	2011, 2014, 2015, 2016

5.2.5 Planting operations

Planting lines, alignment and planting holes preparation were carried out between 14 January 2022 and 8 February 2022 concurrent with the ground clearing work to avoid further work delay. These were done by FRIM staff, except for planting holes preparation where locals were hired. Wooden poles of 1 m height were used to mark the planting holes and each was coloured to distinguish different populations. To ensure accuracy during distribution to each planting hole, the same colour code was painted on the side of the polybag accordingly. The planting hole has a dimension of 30 cm (width) × 30 cm (depth). Approximately 1 kg of compost soil and 50 g of Christmas Island Rock Phosphate (CIRP) were added to each of the planting holes to enhance the soil quality. Of utmost importance during planting was to ensure that the soil encapsulating the root ball was intact at all times when the polybag was being opened, and carefully put into the planting hole. Planting only started on 7 February 2022 and the arboretum of 0.7072 ha was successfully established on 17 February 2022 with a total of 442 seedlings planted (Figure 9).



Figure 9. The Selangor Arboretum located in F52 Bukit Hari, FRIM. Photo: Lau Kah Hoo.

5.2.6 Maintenance and protection

Replacement for seedlings can be carried out up to three years after first planting. Planted seedlings are not to be pruned or thinned as in other normal plantation environments for them to be fully grown. No fertilizers were applied as the arboretum also serve as a growth performance plot for different populations of seedlings. Pesticides are not to be applied regularly except when there is a pest or disease outbreak. There was no fire history in the station but standard prevention measures such as no open burning and smoking are allowed in or near the arboretum area.

5.2.7 Establishment costs

The costs incurred from the project for the establishment of the Selangor Arboretum can be itemized in Table 5. Worker costs were paid by FRIM which were estimated to be US\$ 1,590.00 with 19 personnel rotated for work done between 14 January to 17 February 2022.

Table 5. Establishment costs for the Selangor Arboretum.

Item	Cost (US\$)
Seedlings collection trips and nursery materials	2,080.93
Site clearing and preparation	4,830.59
Planting materials (poles, iron netting, top-soil, fertilisers & coco fibre)	1,822.68
Total	8,734.20

5.2.8 Constraints and challenges

Sites identification for the Selangor arboretum took slightly longer than expected due to several reasons. This was mainly due to difficulties in finding the right area in the state of Selangor. The proposed sites were either too small, had unclear land status or were located adjacent to future development areas. Even after it had been decided that the arboretum would be located on the FRIM campus, many discussions, negotiations and papers work needed to be done for approval. The delay in work progress was due to several factors; the Covid-19 pandemic, difficulties in selection of contractors by the contract awardee, machinery breakdown, unfavourable weather, and absence of workers due to bees attack.

5.2.9 Next steps

Each planted seedling has an individual tag and recordings were done on an Excel data worksheet. A full inventory was carried out one month (March 2022) after the seedlings were planted to record growth and mortality. For growth performance, height, diameter at the root collar (DRC) and diameter at breast height (DBH) of the seedlings are to be measured once every two months. To avoid growth performance bias, planted seedlings are not fertilized, pruned or manipulated in any manner. However, weed removal is still required and would be carried out when necessary. The first data collection had been carried out in May 2022. Many more leisure and research activities could be carried out in the future after the planted seedlings been have established (Lau *et al.* 2022a).

Preliminary results from the inventory and growth performance data collected have shown that as of May 2022, 15 seedlings had died, average height growth of 6.12 cm, average DRC growth of 0.05 cm, and average DBH growth of 0.06 cm (Figure 10).

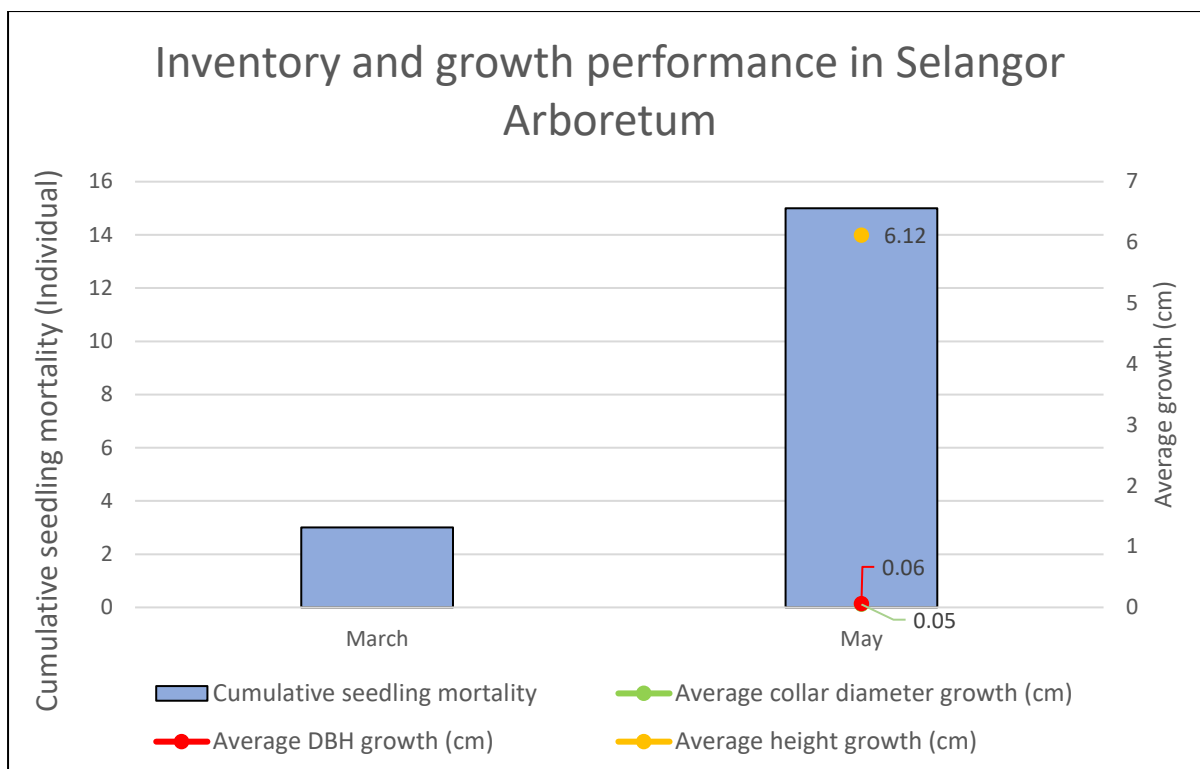


Figure 10. Inventory and growth performance in Selangor Arboretum.

6. Lessons learned

Alternative or backup plans need to be included at the research planning stage. The delay in site determination could be mitigated by listing several alternative sites during initial meetings with respective land managers. This could avoid longer time spent to find a second (or third) site should the first site be found not to be suitable.

7. Conclusion

The establishment of the two arboreta is an important milestone in achieving the objective of genetic diversity conservation of the species *A. malaccensis* in Peninsular Malaysia, through an *ex situ* approach. The entire process was a collective of initiation, effort, and perseverance from various agencies. Each agency had played its role well and provided full cooperation to FRIM as the project's implementer. Furthermore, with illegal harvesting continuing to threaten the remaining natural stands, the establishment of the two arboreta is a valuable repository of the species' genetic resources. It is envisaged that the two arboreta will hold various research potential beyond fundamental studies, such as genome-wide association studies. Planters will benefit from further studies on tree improvement and breeding programmes aimed to develop high-yield variety in view of the potential of *A. malaccensis* being Malaysia's commodity species in the future. In addition, these arboreta are ready to be used as a teaching facility for tree dendrology, specifically on *A. malaccensis*. With fresh finances and time allocated in the future, it is hoped that additional arboreta could be established at other selected locations for better representation.

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