Sustainable Forest Management and Development in Peninsular Malaysia

(Malaysia - International Tropical Timber Organisation Joint Project:
PD 185/91 Rev . 2 (F) - Phase II)

MANUAL FOR ESTABLISHMENT OF SEED PRODUCTION AREAS IN DIPTEROCARP FORESTS IN PENINSULAR MALAYSIA







Forestry Department
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A Manual on Grading of Nursery Seedlings

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MANUAL FOR ESTABLISHMENT OF SEED PRODUCTION AREAS IN DIPTEROCARP FOREST IN PENINSULAR MALAYSIA

1.0 INTRODUCTION

Sustainable forest management of moist tropical forest in Peninsular Malaysia depends very much on the retention of many virgin forest areas having most of the important valuable commercial timber tree species. It is here that most of the seed and/or seedling requirements needed for reforestation and rehabilitation can be secured in the future as most of the other areas become degraded through forest harvesting. Although planting stocks can be prepared from the collection of wildings and through vegetative propagation of some of the forest species, the bulk of the planting materials will still be the seeds. It must be stressed that most of the important dipterocarp and non-dipterocarp tree species are very difficult to propagate vegetatively through stem cuttings. Even with more favorable species many problems are still being experienced with rooted cuttings at the nursery phase.

Procurement of high quality forest tree seeds in large quantities is dependent upon the povision of forest areas set aside for seed production purposes where such procurement can be made economically and efficiently. Such forest areas are designated as seed production areas (SPAs). SPAs can be established either from existing virgin forests or partially logged-over forests containing sufficient stockings of almost matured trees of the target species. Additionally, for long-term perspective SPAs can be set up from conversion of open-pollinated progeny trials of the target species. Important requisites for the establishment of SPAs should be accessibility and security.

2.0 OBJECTIVES OF SEED PRODUCTION AREAS (SPAs)

To establish and manage SPAs of important commercial forest tree species in the Permanent Forest Estate in order to utilize seed resources for the afforestation and / or the rehabilitation of the logged-over and degraded forest areas.

3.0 WHAT ARE SEED PRODUCTION AREAS

A number of definitions have been given to seed production areas

(i) Seed production area is referred to a phenologically superior stand made up of vigorously healthy trees, upgraded by thinning to remove poorer phenotypes and treated and managed to cause abundant seed production. Seed stands are a stage prior to the formation of seed orchards (Tewari, 1994).

(ii) Seed production areas are stands specifically managed for seed production, often only as an interim measure until a more advances seed production program has been established (Eldridge *et al*, 1994). Such seed production areas can be stands specially plants for seed production or existing stands specially managed for seed production. They are very effective way of making available a seed supply of somewhat improved genetic quality.

(iii) A seed production area is management unit located in one seed zone within the natural forest. It is primarily managed to procure forest resource material of defined quality and sufficient quantity. Within seed production area one or several seed stands or seed collection species are located (Malaysian-German Technical Co-operation Project).

A seed/seedling orchard can also be looked at as seed production area in the true sense of its purpose.

4.0 SELECTION OF SPAs

4.1 Identification of species

Species should :-

- Have high commercial value
- Have seed/wildings of high current or potential value for reforestation/ rehabilitation
- Be found in almost distinct communities or clusters
- Have history of producing heavy flowering / fruiting

4.2 Identification of areas

(a) Seed production areas should be in the best natural forest area with good stocking, good health and almost half the rotation age. In view of this requirement, priority should be given to the following consideration :-

- Virgin forests;
- Accessible at present and future;
- Typical for the species selected;
- Of sufficient stocking in order to reasonably provide for cross pollination among neighbours over time and space.

(b) Where virgin forest areas are more difficult to reach, establishment of SPAs can also be considered in forest reserve areas that have been very selectively logged leaving adequate and matured residual stands of the target species. Such areas are usually accessible.

(c) Where seed production areas are to be established from planting ofseedlings of selected mother trees of good phenotypes, the areas need to be in the permanent forest estate suitable for the particular species or species mixture. Wherever possible establishment of such areas should be in very accessible locations in which the time taken to reach them will be very minimal.

5.0 ESTABLISHMENT AND MANAGEMENT OF SPAs

5.1 Establishment

5.1.1 Existing forests - natural stands

Establishment of SPAs can best be made in existing and accessible virgin forest areas. This constitutes *in situ* establishment. SPAs can also be established from planting of open pollinated progenies of selected trees from different species in areas chosen for the planting. This represents *ex situ* establishment.

In the *in situ* establishment of SPAs, a survey of good quality stands has to be made in accessible virgin forest areas. This is important in order to identify communities of the target species having similarity or dissimilarity in certain characteristics. Once an area (compartment (s)) has been identified, the establishment of the SPA can be effected in a similar manner following the method used for establishing a tree location map (Weinland *et al.*, 1998). The following procedure should be carried out :

i. Locate the starting point (SP) of the base line (BL) in the compartment.

ii. Establish parallel straight lines (SLs), 50 m apart from each other andperpendicular to the BL. The endings of the SLs are at the compartment boundary (see **Figure 1)**

iii. On each SL consecutive numbered pegs are planted at 20 m intervals commencing from the base line.

iv. With each SL at the center contiguous plots of 0.1 ha (50 x 20 m) intervals commencing from the base line

v. Within each 25 x 20 m sub-plot on either side of each SL potential seed trees of target species are searched and their positions determined from a selected reference corner of the sub-plot and sketched into the field recording sheet (see **Figure 3** and **Appendix 1**). Within each sub-plot selected trees are given consecutive numbering, e.g. SP1-01, SP2-01 are trees number 1 in sub-plots 1 (SP1) and sub-plot 2 (SP2), respectively. There will be a numer of a 25 x 20 m sub-plots for each SL. Numbering of sub-plots for each SL should commence from the BL running to the end of SL in one direction and to be continued from the BL running in the opposite direction until the end of the line.

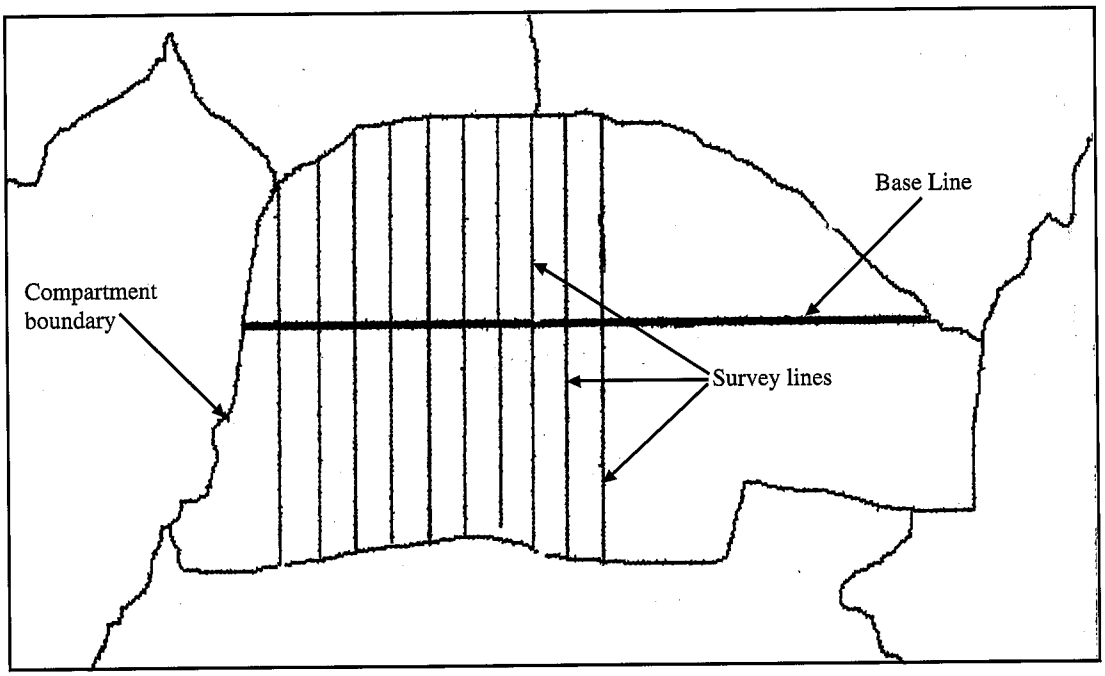

Figure 1: Sketch of a Compartment Showing the Base Line (BL) and the Survey Lines (SLs)

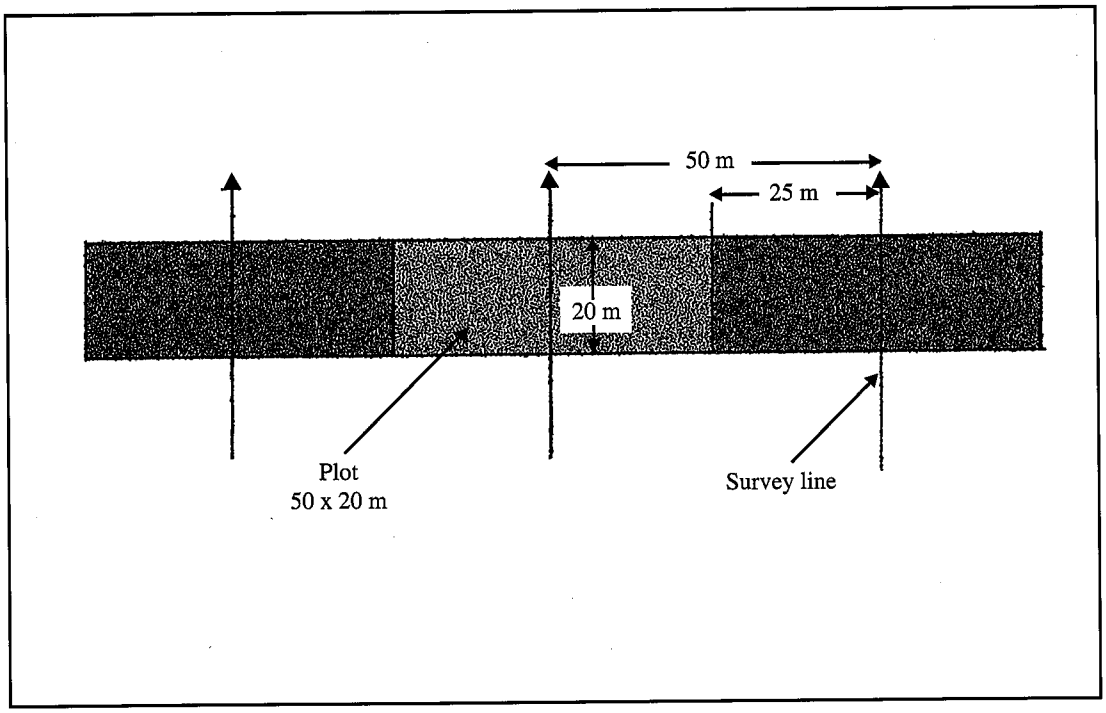

Figure 2: Arrangement of Survey Lines and Plots in the Compartment.

vi. The final numbering of the selected seed trees will be done for the compartment once the field tally exercise, followed by assessment of phenotypic qualities of the stand trees, have been completed.

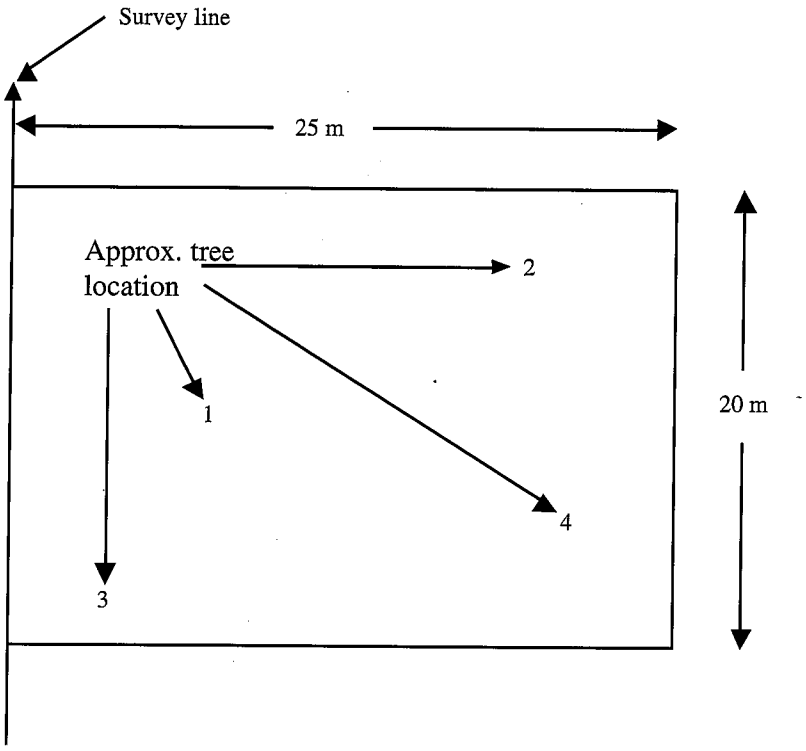

Figure 3: Sketching of Locations of Potential Seed Trees in a Sub-plot.

The phenotypic qualities of the individuals of target species are assessed morphologically and quantitatively. Potential seed/mother trees that have been identified will have their morphological external characteristic compared with several (say, five) adjacent trees of the same species. The qualitative assessment of the external traits of the potential mother trees should exceed the average values of the adjacent comparison trees. The traits to be used in selecting mother trees of a species should have substantial variation and hopefully highly heritable in nature. This is important for long term planning particularly if tree improvement program is contemplated in the near future. Important external traits that are normally assessed include the following:

Growth: The selected tree is more vigorous than the surrounding comparison trees of the same species; selected trees should be dominants or codominants, having height more than 15 meters.

Stem form:

i) Straight stem.
ii) Stem cylindrical, circular in cross section, without excessive taper.
iii) Absence of spiral grain.
iv) Free from pronounced buttress and fluting.

Crown and branching:	i)	Narrow to intermediate in width.
	ii)	Not suppressed either from the top or from the sides any time.
	iii)	Light and spreading branches, which are either flat or moderately ascending.
	iv)	Dense mass of healthy foliage.
	v)	The selected tree should have no sign of attacks from insects, fungi or other pests.
Crown diameter:		The selected tree should have a narrow crown diameter. The diameter of the crown is estimated by projecting the outermost branches to the ground.
Resistance to disease and pests:		The selected tree should have no sign of attacks from insects, fungi or other pests.

The appraisal of the potential mother trees can be done by taking actual measurement of height, clear bole and diameter. For other characters scoring is done with the help of ocular estimates. Table in the **Appendix 2** illustrates the scoring form (ocular estimates) for selected mother trees. The selected mother trees should receive total scores exceeding the average for the site by a considerable amount.

The approved selected mother trees should be given identification marks in the form of two yellow bands of 5 cm width given 5 cm above and below the breast height. Each selected mother tree is then given a number designating the state, district, range and species. For example, J.N.J.l. MTTB-001 denotes Meranti Tembaga (*Shorea leprosula*) mother tree No.1 in Labis range within the North Johor district in the state of Johor. The important features of each mother tree recorded in a prescribed form such as shown in **Appendix 3**. Finally the location of the mother trees should be shown in a Tree Location Map.

Tree location maps showing the location of the selected tree in the stands should be prepared using a scale of 1:1000. A description of each site where the selected trees are found should be documented (see **Appendix 4**). In tropical rainforest areas where they are heterogeneous in nature, site evaluation should be given for each selected tree based on the following parameters:

- Topography: Whether flat, hilly, steep slope, medium slope or gentle slope;
- Aspect: Whether North, N-East, East, S-East, South, S-West, West, N-west;
- Soil: Whether sand, loamy sand, sandy clay, clay, clay loam, silty clay, silty loam, silt, pH;
- Stand: Whether natural, open, thin, dense; and
- Wind Exposure: Whether protected, exposed or intermediate.

The selection intensity should not be too high at the start of the establishment. For many of the dipterocarp species that occur in the district communities, nothing less than four (4) trees to the hectare should be selected. Selected trees should not be less than 50 meters from each other in order to avoid running the risk of selecting individuals from the same parentage resulting in the possibility of the undesirable imbreeding phenomenon. Relatedness among individual trees quite often result in these trees not producing viable seed in good quantities or not producing seed at all. Should there be individual trees with superior traits occurring in less than 50 meters from each other provisional selection should be made on them. These selected individuals should be examined for their genetic relatedness using isoenzyme analysis technique. The distribution of the selected mother trees is very important depending on the reproductive biology and the pollination

mechanism of the target species. On the other hand, care should also be taken not to leave too few seed trees per hectare for seed production. Pollen vectors on dipterocarp tree species, particularly those insects that have localized foraging behavior, may find difficulty to effect the more desirable cross-pollination if the trees are too few and far apart.

The size of a seed production area will be determined by the maximum number of trees for the target species that can be selected. The size and number of seed production areas in a seed zone will primarily be determined by the seed demand for the target species. The area should not be too small that it becomes uneconomical. If the area is too big it may become unmanageable. For reasons of cost and productivity, an area of less than 5 ha may be considered not suitable for commercial production of seed. However the size will also depend on the original area covered by the species, and the resources available for effective management of the area.

5.1.2 Planting of seedling of selected mother trees – Conversion of open-pollinated progeny trials

Seed production areas can also be set up by thinning a progeny trial. For this purpose, open-pollinated seeds of different dipterocarp species, are collected from selected phenotypes from different origins (provenances). Taking an example of a species, such as Meranti Tembaga (*Shorea leprosula*) different distinct stands of this species should be identified within the whole state. During mast flowering period, these stands should be inspected and selection of good phenotypes be carried out based on the desirable characteristics mention in **5.1.1** above. These selected stands and the selected phenotypes should be followed with other dipterocarp species, simultaneously as selection is being done on Meranti Tembaga. Seed from each of the selected phenotypes of different dipterocarp species should be collected and their identities carefully recorded and kept in a Seed Register.

In the nursery, sowing of seed in the sowing beds and subsequent transplanting of seedlings should be done with great care in order to distinguish them by their respective mother trees. In order to minimize variations in seedling growth resulting from environmental factors, it is important to ensure uniform growing conditions within the nursery are provided. The same nursery procedures should be applied to other selected species. Collection of data relating to the germination and growth rates of seeds and seedlings from different mother trees, by species and locations, should regularly be carried out until the seedlings are ready for field planting.

Numbering of the seedlings according to their mother trees should be strictly adhered to in order to retain their identities, For example, MTTB1.1,....,MTTB1.N1, MTTB2.1,....,MTTB2.N2, denote seedlings numbers 1 to N1 and 1 to N2 for selected mother tree No.1 and No.2, respectively. Only graded seedlings should be used in the field planting. This means that only healthy and vigorous seedlings which are free from any defects be used for planting. All important information on nursery activities should be kept in a Nursery Register.

In carrying out field planting, the silvicultural requirements of the species for the sites must be given serious consideration. (The ideal site will of course where the species will produce abundant seed. This can be done by observing seed production of the species on a range of sites).

In order to accord regular maintenance and other important management practices, it is desirable to locate the planting sites in most accessible locations where the traveling time to reach the planting sites can be reduced to very minimal. In addition, the areas selected must have security of tenure; thus, it is important to locate the planting sites in logged-over forests within the Permanent Forest Reserves.

The Planting of seedlings from selected mother trees of each target species can be done in any of the following designs:

- In row plots – in which each row represents progenies of each selected mother tree (see Figure in **Appendix 5**); there will be **n** rows of seedlings representing **n** selected mother trees of each species. These **n** rows representing **n** selected mother trees may be replicated if there is enough seedlings available.

- In either square or rectangle plots – where seedlings of a selected mother tree of a species are planted in each square or rectangular plots, or within each plot are planted seedlings of all the selected mother trees of a species (see Figure in **Appendix 6**). In the latter situation, the identities of seedlings by their mother trees must be clearly located on the ground as well as on the plot layout plan. The plots will be replicated according to the variability of the planting sites and more importantly on the availability of the seeding material.

- With proper consideration of the planting design incorporating the statistical requirements, seed production areas established from the open-pollinated progeny trials will yield not only high quality seeds but also important genetic information of the selected mother trees. In order to achieve this goal continuous collection of growth data is very much needed. It is therefore important to have properly designed data recording formats such as shown in the **Appendix 7**.

The planting of seedlings of **Shorea** spp. can be done at a spacing of 10 m x 10 m. Heavy and selective thinning will be carried out so that the trees of the best form and vigor can be retained while at the same time a wide spacing is opened up to allow full crowns and good seed crops to develop.

In the preparation of planting lines, strips of 3 m wide planting corridors are cleared at intervals of 10 m. Planting lines, located in the middle of the planting corridors, are aligned in an east-west direction in order to accord the planted seedlings maximum exposure to sunlight. All vegetation along the planting corridors ranging from herbaceous undergrowth to all trees must be removed and stacked on the adjacent uncleared areas and left to degrade naturally. Bamboo and Bertam (*Eugeissona triste*) are to be poisoned if they are found growing in the planting corridors.

At 10 m intervals along each planting line, planting holes will be dug to a depth of 3-5 cm deeper than the height of the polybags containing the seedlings. Before planting 200 gm of ground magnesium limestone (GML), 100g of 15(%N):15(%P_2O_5):15(%K_2O)+TE (Trace elements) are sprinkled into the hole after removing the plastic polybag. The seedling is placed in the middle of the hole after removing the plastic polybag. Finally the hole is covered with soil and the soil is firmed by foot to ensure seedlings is firm in the ground. Planting of seedlings must be done during the rainy season. After completion of planting, the position of each seedling in the field must be recorded and a map generated. This map must be kept safely as it will be needed to facilitate subsequent measurement and data collection.

The fully established planting of seedlings from selected mother trees of a species, such as described above, actually constitutes an open-pollinatted (half-sib) progeny test which can give a lot of important genetic information regarding the selected mother trees. The establishment of such seed production areas is important from the long term planning perspective. From these established seed production areas improved seed quality and in sufficient quantities can be achieved.

5.2 Management

5.2.1 SPAs from existing natural forests

Thinning of competing vegetation around selected seed trees

Selected seed or mother trees should be provided with sufficient growing space in order to allow the trees develop full and vigorous crowns needed for seed production. To achieve this goal it will be necessary to remove all competing trees and other vegetation within a radius of 30-50 meters from each of the selected seed tree. Poor phenotypes, with deformed bole, short height, weak growth and unhealthy trees should be removed. Wherever possible retain only trees with vigorous growth, having good clear bole, straight stem, free from knots, fluting and buttressing, free from disease and insect attack, having wider branch angle and producing higher yields of seed. Felling of these trees should be done in such a manner that will not damage the seed trees. After thinning operations are completed, undergrowth should be checked.

Application of fertilizers

Selected seed trees that have been relieved from competition with the surrounding trees and vegetation should be give liberal applications of ground magnesium limestone (GML), at the rate of 500 gm per annum with perhaps small amounts of trace elements. The fertilizers should be applied around the trees at 100 cm from the tree radius.

The type of fertilizers to be used should be guided by results of the soil analysis obtained for the sites.

5.2.2 SPAs established from open-pollinated progeny trials

Enumeration/Measurement Activity

First enumeration/measurement will be carried out 3 months after planting in order to determine the growth status and number of dead seedlings. The planting lines should be cleared. Second enumeration/measurement will be carried out 6 months after the first enumeration. At this stage crown opening and clearing of planting lines will also be carried out. This will be followed by a third enumeration/measurement at 6 months after the second enumeration/measurement. Subsequently, the fourth enumeration/measurement will be done 12 months after the third enumeration. For the following subsequent years, enumeration/measurement will be carried out annually.

Thinnings

It will be desirable to carry out a number of thinnings in order to remove those seedlings of each selected mother tree that are below average performance in terms of the traits assessed and at the same time to provide the necessary growing space for the final number to be retained. In some instances, there may be justification to also remove selected mother trees from being included in the established seed production areas if they are found to be below average of all the selected mother trees in the traits assessed.

Application of fertilizers

During the first year, each of the planted seedlings should receive 200 gm of ground magnesium limestone (GML) together with 100 gm of 15(%N):15(%P_2O_5):15(%K_2O) plus trace elements (TE). During the second year the rate of application will be 100grams of15:15:15 + TE and 50 grams of rock phosphate dust to be ring applied at about 20 cm from the plant base. In the third year each plant should receive 150 gm of 15:15:15 + TE together with 100 gm of rock phosphate, also to be ring applied at about 30 cm from plant base.

Weeding and canopy opening

Depending on the nature of planting sites, weeding will invariably be required in order to release the planted seedlings from severe weed competition. During the first five years of establishment, at least 2-3 weedings will be needed annually. The actual frequency of weeding will have to be closely monitored.

As the seedlings will be planted under canopy cover it will be important to open up the canopy when the plants are found to be receiving in sufficient light from above. Opening of canopy should be done judiciously so as to avoid too strong lighting of the young planted tree initially.

5.3 Phenological Activity

Studies that involve continuous observation and recording of morphological development of shoots, floral buds development and maturity of fruits and seed are important in the planning of seed collection activities and also help the nursery management to make the necessary early preparation in order to receive the collected seed when the time comes. Information collected from phonological observation is also useful in helping meaningful forecast to be made.

Reliable forecasting of seed maturity through these phonological observations will greatly assist in organizing trained tree climbers to carry out seed collection. Collected information on the phenological activities of the seed trees provides useful forecast on the time of floral initiation so that related activity of fertilizer application can be carried out in order to enhance heavy duty fruiting.

Often time phonological phenomenon is related to certain prevailing weather patterns occurring within a certain period. In general, flowering trees from the tropical area fall into the following categories (Marzalina et al., 1995):

- Species that flowers throughout the year. This enables different developmental phases (floral buds, flowers, fruits) to be observed in trees of these species at one particular time.

- Species that are not seasonal in their flowering but flowering is uncertain from tree to tree or from branch to branch.

- Species that flower heavily but blossom only when surrounding situations are favorable. This causes the species as a whole to flower and blossom simultaneously in all areas.

- Species that are seasonal in their flowering. This situation is often due to the reaction of the species to the rainy or dry season as well as the temperature conditions at a certain particular time.

As a guideline, important data to be collected in phenological studies are the following:

- Month – To indicate which month the observations were made;
- Date – Date to indicate which month the observation were made
- Tree number
- Phenological Observations – Using codes to facilitate developmental stages

  1 = No phonological difference
  2 = Tree producing new leaf shoots
  3 = Formation of floral buds
  4 = Majority of flowers blooming
  5 = Floral petals falling
  6 = Development of early fruit stage
  7 = Development of young fruits
  8 = Developed mature fruits
  9 = Fruits falling

- Density of fruit production

  5 = The whole canopy branches heavy with fruits
  4 = 3/4 of the canopy loaded with fruits
  3 = Only half of the canopy branches bearing fruits
  2 = Only 1/3 canopy branches bearing fruits
  1 = Very sparse fruiting of the canopy

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Appendix 1

TREE LOCATION FIELD RECORDING SHEET

TREE LOCATION TALLY				
Date	Compartment No:	Survey Line No:	Bearing (°)	Page No:
	Survey Line Number:		Left sub-plot	Right sub-plot
Plot No.	Left	Right	Tree No. & Species	Tree No. & Species
			1: 2: 3: 4: 5:	6: 7: 8: 9: 10:
			1: 2: 3: 4: 5:	6: 7: 8: 9: 10:
			1: 2: 3: 4: 5:	6: 7: 8: 9: 10:
			1: 2: 3: 4: 5:	6: 7: 8: 9: 10:
			1: 2: 3: 4: 5:	6: 7: 8: 9: 10:
			1: 2: 3: 4: 5:	6: 7: 8: 9: 10:
			1: 2: 3: 4: 5:	6: 7: 8: 9: 10:

Base Line

Appendix 2

SELECTED MOTHER TREE-SCORING FORM
(Oscular estimates)

A. VIGOUR	B. FORM	C. CROWN
a. Total height 0 – Shorter than the shortest 1 – Intermediate 2 – Equal to the tallest 3 – Taller than the tallest b. Bole height 0 – Shorter than the shortest 1 – Intermediate 2 – Equal to the tallest 3 – Taller than the tallest c. Diameter 0 – Shorter than the shortest 1 – Intermediate 2 – Equal to the tallest 3 – Taller than the tallest	a. Bole straightness 0 – Less straight than the poorest 1 – Intermediate 2 – Equal to the straightest 3 – Better than the straightest b. Tapering 0 – More than the most tapering 1 – Intermediate 2 – Equal to the less tapering 3 – Lest than the least tapering c. Shape (cross section) 0 – Less circular than the poorest 1 – Intermediate 2 – Equal to the best 3 – Better than the best d. Fluting 0 – More fluted than the poorest 1 – Intermediate 2 – Equal to the least fluted 3 – Less than the least fluted	a. Natural Pruning 0 – Not as good as the poorest 1 – Intermediate 2 – Equal to the best pruned 3 – Better than the best pruned
D. PESTS	FRUITING*	Total point scored:
0 – More than the worst infested 1 – Intermediate 2 – Equal to the least infested 3 – Less than the least infected	0 – Less bearing than the poorest 1 – Intermediate 2 – Equal bearing as the best 3 – Heavier than the best	Scored and approved as a selected mother tree by; Name: Designation: Date:

*If assessment is done during the fruiting period

Appendix 3

PLUS TREE INFORMATION SHEET

Forest Reserve: _____ District: _____

Compartment Number: _____ State: _____

Date of Selection: _____ Selection approved by: _____

Tree No.	Species Code	Tree Height (m)	Height of 1st Branch (m)	Height of 2nd Branch (m)	* DBH (cm)	Ratio of branch diameter main stem	Branch angle to main stem	Crown form	Stem straightness	Pruning ability	Dominance	Fruit production
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)

* DBH - diameter of branch height

Appendix 3 (cont'd)

GUIDELINE FOR FILLING COLUMNS IN THE PLUS TREE INFORMATION SHEET

Column	Notes	Information
1	Tree No.	Record the number of the tree
2	Species code	Name of the tree species. Example: Meranti sarang punai SHORPAR Meranti rambai daun SHORACU Meranti tembaga SHORLEP Meranti kepong SHOROVA Meranti seraya SHORCUR Meranti pa'ang SHORBRA Meranti Bukit SHORPLA Jelutong DYERCOS
3	Tree Height	Height of the tree measured in meters
4	Height of 1st Branch	Height measurement of clear bole in meters
5	Height of 2nd Branch	Height measurement of clear bole in meters
6	Diameter of Breast Height	Measurement of bole diameter at breast height in centimeters
7	Ratio of branch diameter to main stem	Record the diameter of the first branch divided by diameter of stem bole. Use the following code system: 1 = < 10%; 2 = 10% < 20%; 3 = 20% < 30%; 4 = 30% < 40%; 5 = 40% < 50%; 6 = 50% < 60%; 7 = 60% < 70%; 8 = 70% < 80%; 9 = 80% < 90%;
8	Branch angle to main stem	Use the following codes: 1 = 900; 2 = 700; 3 = 500; 4 = 300;
9	Crown form	Use the following codes: 1 = Round; 2 = Spreading; 3 = Open 4 = Hanging; 5 = Oval; 6 = Cylinder 7 = Conical
10	Stem straightness	1 = Very straight till the canopy 2 = Slightly straight till canopy 3 = Top portion near the canopy not straight 4 = Unsatisfactory stem condition 5 = Main stem forking
11	Pruning ability	1 = Very good 2 = Fair 3 = No pruning ability
12	Dominance	In comparison with the surrounding trees 1 = Very dominant 2 = Fair 3 = Less dominant
13	Fruit production	Assessment during fruiting period 5 = Whole canopy fruiting heavily 4 = 3/4 of the canopy branches heavily fruiting 3 = Only half of the canopy bears fruits 2 = Only 2/3 canopy branches bear fruits 1 = Very scarce fruiting

Appendix 4

S.P.A INFORMATION SHEET

State: _____ District: _____

Forest Reserve: _____ Compartment: _____

Latitude: _____ Longitude: _____

Altitude: _____ Site Condition: _____

Site Condition: _____

Soil type: _____

Forest Type: _____ Dominant Species: _____

Year of Establishment: _____

Registration Number: _____

Management Activities:

	Date													Remarks
General Investigation														
Measurement														
Weeding														
Fertilizer Application														
Pesticide Application														
Others														

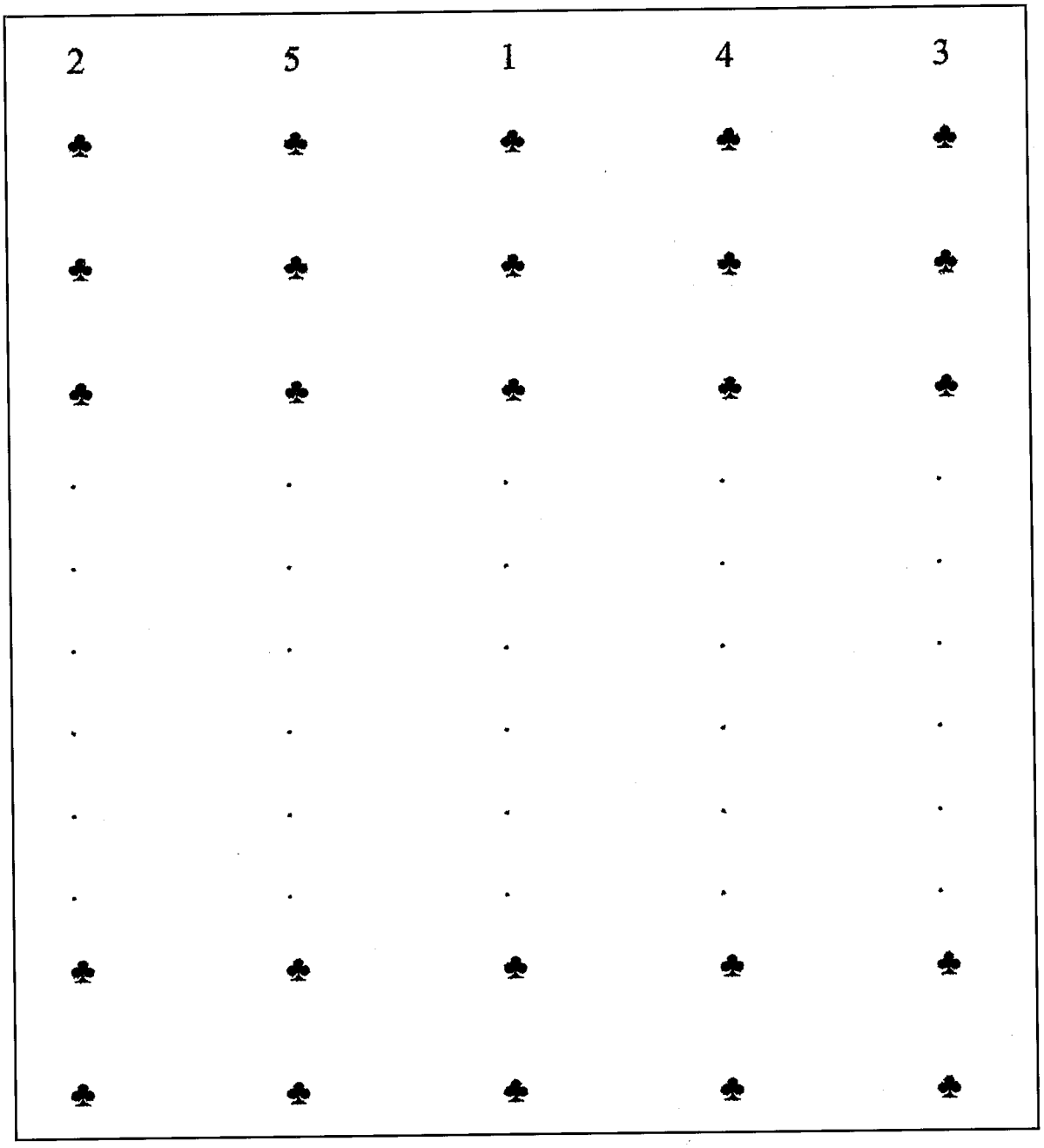
Location Map:-

Recorder: _____

Date: _____

Appendix 5

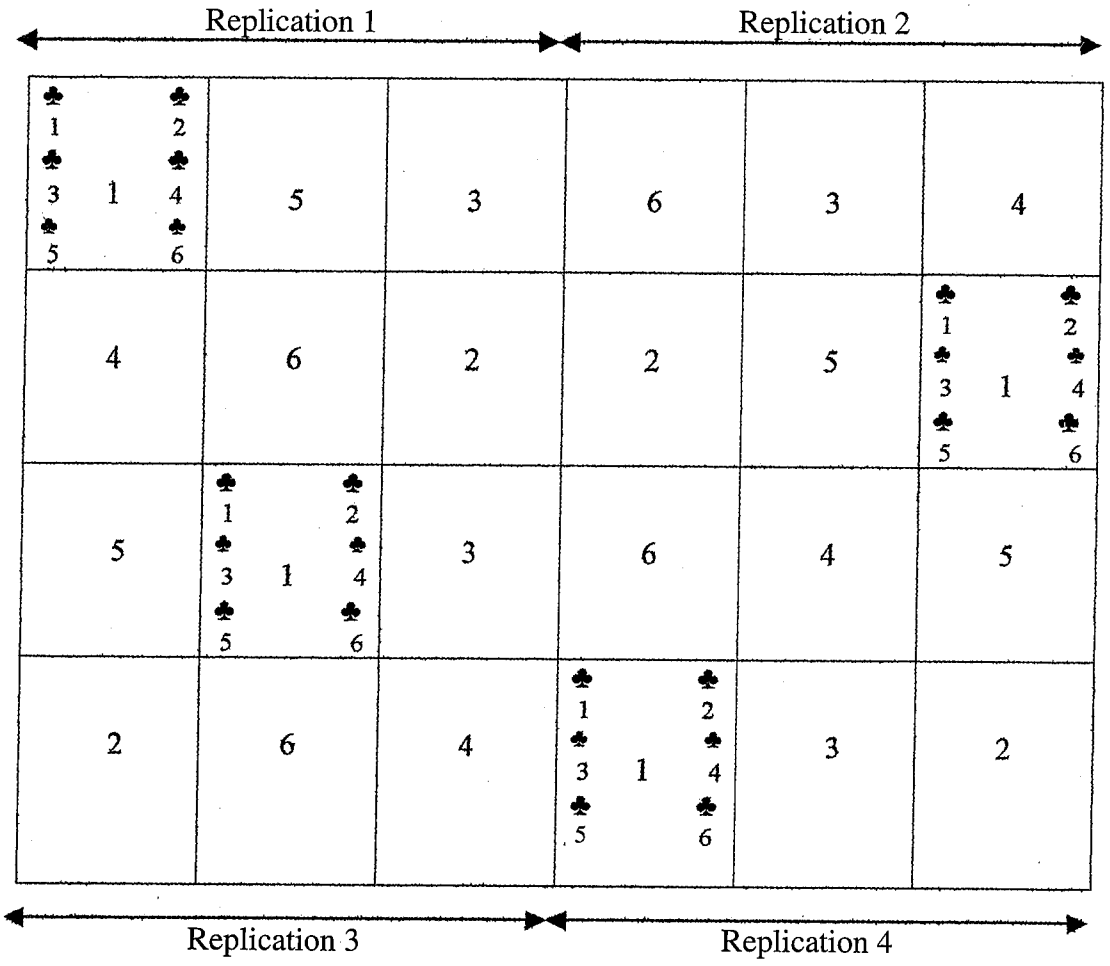
ARRANGEMENT OF A PLOT SHOWING ROW PLANTING OF TREES ACCORDING TO THEIR FAMILY NUMBERING



♣: Represent trees. The numbers (1 to 5) at the top represent family numbers Trees of each family are planted in a row

Appendix 6

ARRANGEMENT OF PLOTS IN A FOUR-REPLICATION RANDOMIZED COMPLETE BLOCK DESIGN WITH 6-TREE-BLOCK PLOTS



♣: Represents trees – Each plot carries six trees of a particular selected mother tree (or family #1 to family #6 in the above example)

Trees from family #1, for example, will be planted at different positions in each of four replications.

Appendix 7

GROWTH DATA RECORDING SHEET

Forest Reserve: _____ Compartment No: _____

District: _____ State: _____

Species: _____ Family Planted: _____

Planting Date: _____ Layout: _____

Planting Spacing: _____ Number of replications: _____

Replication No.	Family	Tree No.	Height (m)	Diameter (cm)	Stem Form*	Remarks

*Codes are used:

1 - Good forms with straight stem;
2 – Good form with minor crooks in stem;
3 – Stem form quite acceptable
4 – Stems are crooked to bent in more or less horizontal positions

Recorder: _____ Date: _____

Comments: _____

_____

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