IV. PLANTATION ESTABLISHMENT

4.1 Plantation plan

Planning is an important activity in the planting programme. The planning document is needed as a reference in the planting programme from nursery to maintenance of plantation. Planning is a common process that is done in planting activities including preparation of technical design based on data from detail inventory and identification of the planting sites. Therefore, the components of planting plan are preparation, inventory and identification of planting sites, and technical design.

4.1.1 Preparation

4.1.1.1 Site selection

A team of multidiscipline expert on forest planning, silviculture, site suitability, soil and water conservation, social science etc., conducts site selection. Important information that should be investigated is the land status and its ownership. The information then should be confirmed by forestry institution to check the legal aspect of the land. Considering establishing plantation is a long-term investment, land status with potential conflict should be avoided.

4.1.1.2 Arrangement of work plan

Work plan consist of steps of activities and procedure with timetable. The timetable should consider the planting time in the field, which is related to season.

4.1.1.3 Preparation of materials and equipments

Materials and equipments needed are bamboo and durable timber for poles, maps of topography, soil classification, land use, etc. as basic information to investigate the planting sites. For field measurement some equipments are needed, especially compass, abney level, and measuring band.

4.2 Planting site selection

Selection of planting site is an important activity in the establishment of plantation forest in Perum Perhutani. According to operational standard, boundaries of

planting area are determined by staking boundary marks, pegs for marking prohibited zone (zones, where cultivation is prohibited) and pegs for marking special area. The objectives of this staking is to create temporary boundaries for planting site. Those boundaries indicate the definite forest land which will be managed in one period of planting.

Pegs for marking prohibited zone establish minimal distance of the planting site from places which are not allowed to be planted. Those pegs for marking prohibited zones are installed with minimal distance of (Biro Pembinaan Hutan Perum Perhutani Unit III Jawa Barat, 1996) :

- 5 m from the edge of dam, cliff, monument and river
- 10 m from the edge of steep cliff
- 25 m from the area of water springs

Pegs for marking special area are staked with distance of 3 m from waterlogged and barren soil.

For selecting the species to be planted on a certain tract of land, species site matching is conducted using criteria's of land suitability issued by Center of Soil and Agroclimate Research, Bogor (CSR/FAO Staff, 1983). Suitability of a certain tract of land is evaluated on the basis of several soil and climatic properties, such as :

- Annual average temperature
- Annual rainfall
- Number of dry months and wet months
- Soil drainage
- Soil depth
- Soil pH
- Cation Exchange Capacity
- Salinity

Those soil properties are also called land characteristics. For a certain species, each land characteristic is categorized into S1 (highly suitable), S2 (moderately suitable), S3 (marginally suitable), and N (not suitable). Afterwards, for making

conclusion on the suitability level of a certain tract of lands for a specific species, only one of the land characteristic which determine the suitability, namely that characteristic whose suitability level is the worst for the specific species. This procedure is in accordance with LIEBIG's law of the minimum which states that plant growth is determined by the worst environmental variable.

This scheme of species site matching is very quantitative and has involved economic consideration for producing a certain crop species in a certain tract of land. In the beginning, this scheme has been developed to an advanced stage for agricultural crops, and therefore nearly all important (major) agricultural crops have possessed this quantitative criteria of species site matching. On the other hand, for forest tree crops (forest plantation), this quantitative criteria has been developed only for a few species, such as those presented in Appendices 8 through 17, for species teak (*Tectona grandis*), mahogany (*Swietenia macrophylla*), damar (*Agathis loranthifolia*), rasamala (*Altingia excelsa*), moluccan sau (*Paraserianthes falcataria*), lamtoro (*Leucaena leucocephala*), acacia (*Acacia auriculiformis*), eucalypt (*Eucalyptus grandis*), gelam (*Melaleuca leucadendron*) and pine (*Pinus merkusii).*

For the use of Appendices 8 through 17, some land characteristics are measured on surface soil, whereas others are measured on subsoil. Surface soil usually is identical (but not always) with horizon A, whereas subsoil is usually (but not always) identical with horizon B.

In contrast with agricultural crops, the quantitative criteria in Appendices 8 through 17 for forest crops have not included some soil chemical properties namely Cation Exchange Capacity, total N, available P_2O_5 and available K_2O. This is due to lack of experience in forestry crops, and to the traditional assumption (which is now could be considered obsolete) that for forestry,soil chemical properties are less important than soil physical properties

4.3 Kind of plantation

In the reforestation programme, the decision to choose whether pure plantation or mixed plantation is depending on the condition of the planting sites and the aims of the planting. Compared with pure plantation, mixed plantation has more

advantages, such as more resistance to pests and diseases and more efficient in utilising space.

In mixed plantation, the canopy and root system are multistrata, therefore, it can utilized space more efficiently and protecting soil from erosion more effectively. Pure plantations are simpler in structure and harvesting operation could be done easier.

4.3.1 Mixed plantation

Teak (*Tectona grandis*), sengon (*Paraserianthes falcataria*), tusam (*Pinus merkusii*), mahogany (*Swietenia macrophyla*) are main species planted in Java. The planting system is using tumpangsari (taungya) susyem, where farmers around the planting site are allowed to plant agricultural crops in the planting site (Figure 4.1). Beside main species, there are also planted *Scleicera oleosa*, *Leucaena leucocephala*, source of green manure, and thorny woody plant *Caesalpinia sappa* to fence the planting site.

Figure 4.1 Establishment of teak forest using tumpangsari system. Farmers planting cassava, maize, and groundnut in between rows of teak.

There is some requirement to apply tumpangsari system, i.e. the soil should be fertile enough to grow agricultural crops, the slope is not more than 40%, and there are enough number of farmers who are willing to participate the programme. When these requirements are not fulfilled, the planting is done specially hired workers.

4.3.2 Pure plantation

Acacia (*Acacia mangium*), gmelina (*Gmelina arborea*), eucalyptus (*Eucalyptus* spp.), meranti (*Shorea* spp.), sungkai (*Peronema* sp.), mindi (*Melia azedarach*), and damar (*Agathis loranthifolia*) are usually planted as pure plantation. Mangium is the main species planted in the industrial forest plantation (timber estate) for pulp industry in Indonesia. Reasons for this are easy to plant and maintain, good fiber quality for pulp and paper, and fast growing with mean annual increment 30 m^3/ha/year. It has been estimated that in Indonesia the plantation mangium has reach 2 million ha. Other fast growing species, which are commonly planted for pulp and paper industry are gmelina and eucalyptus. Mangium, gmelina and eucalyptus are planted as pure plantation.

Forest plantation in Indonesia is not dominated by only fast growing species, but also slow growing (long rotation) species with economically more valuable, such as teak, mahogany and meranti. Problem with meranti is that seeds of this species loosing viability very rapidly; and secondly, the young seedlings are shade tolerance where high mortality when planted in open area. Nursery trees should be planted prior the planting of meranti seedlings.

Sungkai is high demanding species which need high light intensity to grow optimally. So, this species is suitable to the planted in open area as pure plantation. This species could be used as nursing trees for meranti in a mixed plantation.

Agathis in Indonesia is commonly found as pure plantation. However, in some area, such as in the district of Banjarnegara, agathis are planted together with *Salaca edulis*, palm baring fruits. Meanwhile, in the Gunung Walad Educational Forest, Faculty of Forestry – Bogor Agricultural University located at the district of Sukabumi, people plant medicinal plant, caffe, banana etc. under mature agathis forest.

Mindi is a multipurpose tree species where its timber, seeds and fruits could be utilized. Fruits of mindi can be used as biopesticides. This species has been planted by people as shade trees in tea plantation or in mixed plantation.

4.4 Planting distance (spacing)

There are several things which should be considered in determining spacing, namely tree species to be planted, soil fertility, silvicultural techniques to be adopted and economical consideration. On fertile soil, planting distance tend to be wider because plant growth is expected to be more rapid. Beside that, land cover by vegetation is also rapid (Lamprecht, 1989; Lemmens and Soerianegara, 1994).

Generally, the initial spacing is related also with the type of wood product to be planted. Narrow spacing is more suitable for obtaining fire wood and pulp, because for this purpose, more abundant log volume is emphasized, so that thinning intensity is not so severe. On the other hand for obtaining construction wood and veneer raw materials, spacing should be determined so as to support the formation of straight boles(Lamprecht, 1989).

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Spacing which is usually used varies between 2 x 2 m^2 and 4.5 x 4.5 m^2 although there are sometimes cases where wider or narrower spacing than that range is used for specific purpose. Wider spacing (5 x 5 m^2 or more) is usually related with enrichment planting (Lamprecht, 1989; Lemmens and Soerianegara, 1994).

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Initial spacing tends to be narrower if the products from thinning operation (felled trees) have high economic value.

1. Teak (Tectona grandis)

Teak is a tree species which has been utilized by Perum Perhutani for along time. Spacing which are usually used for teak planting are 2 x 2 m^2, 3 x 1 m^2, 3 x 3 m^2, 4 x 2 m^2 and 4 x 4 m^2, depending on site condition. In the working area of Perhutani, the common spacing is 3 x 1 m^2. However, wider spacing of 6 x 1 m^2 is also adopted sometimes (Biro Pembinaan Hutan Perum Perhutani Unit III Jawa Barat, 1996) :

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Initial growth is rapid for teak, make it difficult to plant it together with other tree species. However, model of mixed crops can still be applied for a certain crop together with teak. This system is usually called tumpangsari system.

Tumpangsari is a cropping system adopted from taungya system (existing in Myanmar) (Lamprecht, 1989). The benefits of this system are : 1) reducing the cost of planting, 2) gain of additional harvest from agricultural crop, 3) main crops (forest crop) which are still young are cared for by the farmer, 4) idle land before establishment of the stand can be utilized, 5) cultivated land is available for local community around the forest.

Crops which are allowed to be planted together with the main crop (forest crop) in tumpangsari system are agricultural crops such as rice, corn, tobacco, chili, ground nut, and soybean. On the other hand, certain crops are not allowed in tumpangsari with forest crop, these crops are cassava, potato, banana, and climber (liana) plant, due mainly to their competitive effect with the forest crop. However, such prohibited species are sometimes still planted due to specific consideration. Beside agricultural crop, there are also other forest crop (tree) planted together with the main crop, namely :

- Intercrop tree : such as leucaena, which is intended mainly to reduce erosion
- Edge crop tree : such as johar, which is intended mainly to mark the boundary of planting area
- Filler crop tree : such as kesambi (*Schleichera oleosa*) and fruit tree, which is intended primarily to increase tree diversity in plantation forest and to obtain some products (such as fruit) before wood is harvested.
- Hedge crop : such as *Caesalpinia sappan* which is intended to prevent the entry of animal to plantation forest. In this case *C. sappan* is thorny, and is effective enough to deter the entry animal (especially farm animal).

Beside that, teak can also be combined with leucaena, acacia and meranti (*Shorea* spp.).

2. Meranti (Shorea spp*.)*

The best spacing in the planting of *Shorea* spp. is 4 x 4 m^2, whereas that for enrichment planting with 4 months old seedling (red meranti) is recommended to be 1 x 3 m^2 (Lemmens and Soerianegara, 1994).

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3. Pine (Pinus spp*.)*

Pine is a species commonly planted in Perhutani, especially at medium to high altitude. For resin production, planting spacing is 4 x 4 m^2. For wood product, the spacing is 3 x 3 m^2 or 3 x 2 m^2 (Lemmens and Soerianegara, 1994).

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. This species can also serve as shade tree for coffee. In this case, pine is planted with spacing of 3 x 3 m^2, and after 5 – 7 years (or if the pine has been 4 m tall) coffees are planted. Pine is also intercropped with Ireland potato (Lamprecht, 1989). Forest crops which are also planted together with pine are *Ceiba pentranda* (edge crop) and caliandra (hedge crop).

4. Damar (Agathis spp*.)*

In the taungya/tumpangsari system, food crop is planted between rows of dammar tree for 1 – 2 years. Shade tree such as lamtoro are also planted together with dammar, because dammar like shady and relatively humid site. For resin production (tapping) dammar is planted with wide spacing, namely 10 x 5 m^2. For obtaining straight and long round wood, spacing of 3 x 3 m^2 is used (Lemmens and Soerianegara, 1994)..

5. Mangium (Acacia mangium)

Planting spacing which is commonly used for mangium planting varies between 2 x 2 m^2 to 4 x 4 m^2. Greater growth of mangium within the first two years of planting in the field, occurred at mangium planted with spacing of 2 x 2 m^2 and 2.5 x 2.5 m^2 as compared with those planted with spacing of 3 x 3 m^2 (Awang and Taylor, 1993; Lemmens, Soerianegara, and Wong, 1995)

*6. Sengon (*Mollucan sau*/Paraserianthes falcataria)*

Sengon planting stocks are usually planted with initial spacing of between 2 x 2 m^2 and 4 x 4 m^2. In agroforestry system, sengon is combined with annual crop in the first year. On the following years, grazing by farm animal can be conducted. In the alley cropping system, sengon trees die and will easily and this increase their mortality. If they grow again (regrowth) the growth is somewhat poor (Lemmens and Soerianegara, 1994).

7. Mahogany (Swietenia macrophylla)

Mahogany is planted in the field with spacing of 2.5 x 2.5 m^2 or 3 x 3 m^2. Monoculture planting system of mahogany could increase susceptibility toward pest and disease attack. Therefore, mahogany is usually planted together with other fast growing species such as leucaena, and sengon, which serve as shade tree when the mahogany is still young. Beside that, mahogany planting can also be combined with corn, upland rice, and cassava at agroforestry system (tumpangsari) (Lamprecht, 1989; Lemmens and Soerianegara, 1994)..

8. Puspa (Schima wallichii)

Puspa is planted with spacing of 1.8 x 1.2 m^2 or 3.6 x 1.8 m^2. This wider spacing can increase the increment twice as much.

9. Kayu afrika (Maesopsis eminii)

Kayu afrika can be used as alternative for sengon. Optimal growth of kayu afrika could be reached with tree density of 125 trees per ha. This species can be planted with various other crops in agroforestry system, namely as shade tree for coffee, tea, and cacao. Kayu afrika can also be used in enrichment planting, as edge crop, and boundary crop. Although planted with other species, the growth is not disturbed, but the final product is decreasing very much (Hanum and van der Maesen, 1997).

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10. Gmelina (Gmelina arborea)

Planting spacing which is usually used for gmelina renges between 2.5 x 2.5 m^2 and 3.5 x 3.5 m^2 (Lemmens and Soerianegara, 1994).

11. Kayu putih (Melaleuca leucadendron)

Kayu putih is usually planted in degraded land using seedlings with initial density of 5,000 plants per ha. Plant species which are usually intercropped with kayu putih are cassava, corn, and ground nut. Tumpangsari occurs in the first two years after planting of kayu putih in the field (Oyen and Dung, 1999).

12. Eucalypt (Eucalyptus deglupta and Eucalyptus urophylla)

This species is usually planted with spacing of 3 x 2 m^2 for pulp raw material. For production of fire wood and poles, initial spacing could be closer (Lemmens and Soerianegara, 1994).

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13. Mindi (Melia azedarach)

Planting of mindi is conducted using spacing of 4 x 3 m^2. This species is feasible to be planted with other agricultural crops (Hanum and van der Maesen, 1997).

14. Sungkai (Peronema canescens)

Sungkai is not suitable to be planted with other species, but sungkai can be used as shade tree for planting of dipterocarps. Planting spacing commonly used is 3 m x 1 m, although other spacings such as 3 x 2 m^2 and 4 x 2 m^2 can also be used (Lemmens and Soerianegara, 1994).

15. Kesambi (Schleichera oleosa)

Kesambi is a tree species which is also planted as filler crop in teak plantation (tumpangsari system). In this system, kesambi is planted within rows of teak plant with distance of 3 m from the main crop. For every four main crops, there is one kesambi tree interplanted in the row. Therefore spacing between one kesambi tree and another kesambi tree is 15 m (Biro Pembinaan Hutan Perum Perhutani Unit III Jawa Barat, 1996).

16. Suren (Toona sureni)

Planting spacing used for suren is 1.5 x 1.5 m^2. Suren is not recommended to be planted as monoculture, because pest attack will increase. In West Java, suren is planted together with sengon to control the attack by stem borer pest (Lemmens, Soerianegara, and Wong, 1995)

17. Khaya (Khaya anthoteca)

Species within genus of Khaya is usually planted with narrow spacing or 2 x 2 m^2. Mixed planting is also conducted by planting them together with gmelina. This planting system is intended also to overcone to attack by pest and diseases (Lamprecht ,1989).

4.5 Site preparation

Preparation of planting area is initiated with land clearing. Land clearing is absolutely necessary in land preparation for tumpangsari, because soil tillage can only be done after the land has been cleared. This activity is conducted on May – June (Biro Pembinaan Hutan Perum Perhutani Unit III Jawa Barat, 1996).

Activities included within land clearing are as follows :

1. Slashing shrub, bush, herbs, and residual trees.
2. Gathering materials for planting stakes, bund, working hut and hut for the land cultivators.
3. Maintaining trees and stumps of kesambi to protect the soil and water.
4. Burning garbages after the weather is suitable to do the burning.
5. Maintaining stumps at sloping land and rows of intercrop tree which function to enhance soil structure and control erosion.

Soil tillage is the next work to be conducted, namely on June – July. This activity is also known as soil tillage I. The objective of soil tillage I is to provide proper growing medium for seeds or planting stocks which will be planted to allow optimal growth. Soil tillage I is intended to refine (reduce the soil clump size) (Biro Pembinaan Hutan Perum Perhutani Unit III Jawa Barat, 1996).

. Activities included in soil tillage I are follows :

1. Hoeing or digging the soil up to a depth of 20 – 25 cm to facilitate gas exchange and water absorption.
2. Soil infested with alang-alang is hoed/dug up to a depth of 30 – 35 cm to uplift the roots and burn then.
3. Discarding stumps or root segments to be burnt afterwards.

Alang-alang (*Imperata cylindrical*) field is a potential land which can be utilized to develop plantation forest. Agroforestry is able to accelerate the conversion of alang-alang field into more productive land through the following mechanism (Friday, Drilling. and Garrity, 2000).

- Protecting the whole area from the danger of fire.
- Planting trees
- Suppress alang-alang so that it is not able to compete with other crops for light and water; and

- Accelerate the growth of trees by addition of fertilizer, lime or organic materials

Theoretically, alang-alang field can be rehabilitated and utilized for long term use through several things, namely (Friday, Drilling. and Garrity, 2000).

- year 1 (herb stage) : rice, vegetable
- year 2 (herb stage) : vegetable, banana
- year 3 (herb/shrub stage) : vegetable, banana, coffee, lada (*Piper* sp.)
- year 4 – 6 (shrub stage) : coffee, lada, banana, fire wood
- year 7 – 8 (shrub/pioneer tree stage) : coffee, lada, fruit, fire wood
- year 9 – 20 (tree/pioneer tree stage) : tree, fruit, fire wood
- year 20 and afterwards (adult tree stage) : resin, fruit, tree, fire wood

Beside those long term potential, alang-alang field can be directly cultivated to obtain land for plantation forest establishment. Techniques which are commonly applied to eradicate alang-alang are chemical and mechanical method. Chemical eradication of weed is conducted by using herbicide, such as glyphosate. Mechanical method is conducted by cultivating the land infested with alang-alang, by turning the soil upside down with hoe or plough so that alang-alang root could be lifted and exposed to sunlight to be burnt/discarded afterwards. Plowing of the soil is conducted up to a depth of 30 – 40 cm and is repeated two weeks later. Pressing technique such as lodging and rolling, can also be conducted, namely by lodging the alang-alang to accelerate the natural regeneration of trees (Friday, Drilling. and Garrity, 2000)..

Land preparation in the form of second gebrus (gebrus II) is conducted on August – September with the aim of loosening the soil to make it ready to be planted. Fine structure of the soil will allow easy penetration by root development. Gebrus II is conducted by refining the soil structure at the row of main crop, row of intercrop tree, row of other supporting tree, and at the cultivated area for agricultural crops (Biro Pembinaan Hutan Perum Perhutani Unit III Jawa Barat, 1996)..

Other activity which is no less important in the land preparation for planting is the construction of inspection road with the aim of allowing easy supervision and

inspection, easy transportation of seed and seedlings, and providing route (path) for worker's travel in the field. Inspection road is made on June – July.

Beside that, ditches are also constructed to control surface run off in the field so that soil damage due to erosion and land slide could be avoided or reduced to minimum. Ditches are made to comprise main ditch, branch ditch, and sub-branch ditch as the smallest ditch for water drainage from the row of main crop and inspection road. Construction of ditch is conducted on July – August (Biro Pembinaan Hutan Perum Perhutani Unit III Jawa Barat, 1996)..

On July – August, primary (main) row is established to mark the accurate planting spacing and make distance measurement within the main row and between rows. In the main rows, main planting stakes are erected, and painted with red.

Planting pattern which will be adopted should be planned in more detail. The planting pattern could be tumpangsari or banjarharian (using workers which are paid daily). In these two planting pattern, the area to be planted are marked with stakes in different color.

Efforts which should be given attention in the land preparation for planting is erosion control. Construction of bund or terraces can serve as alternatives to control erosion in the planting area. Bunds and terraces will restrain or withhold soil which is scraped by surface run off, to maintain soil fertility. Usually, bunds are put above the row of intercrop tree. Bunds can be made of woods or stones.

4.6 Dispatching of planting stocks

Faulty technique in the dispatching and packaging of planting stocks can kill or damage the planting stocks. Therefore, care is needed to reduce the mortality level, during transportation or loading and unloading of planting stocks. Before being transported, planting stocks are packaged in boxes measuring each 40 x 30 x 40 cm^3. The boxes are stacked with maximum of 3 – 5 boxes. During transportation, planting stocks are covered to avoid excessive evaporation, and damage due to wind blow. After arriving at the planting site, planting stocks are moved to each planting hole by lifting them through human shoulders. This manual moving is adopted because some planting sites (planting holes) are far

from high way or in difficult to access terrain. Plantings are attempted to be done at the same day with the planting stock's arrival (Awang and Taylor, 1993).

Care should be considered in planting stock's transportation, as well as efficiency of cost. Usually, planting stocks in the form of stump are preferred more due to easier and cheaper transportation. Species which are commonly planted as stumps are teak, sengon, mahogany, and rubber. Gmelina, which are botanically feasible to planted with stumps, are not common at present to be planted with stumps.

4.7 Out planting

Planting holes are made with equipments such as hoe, soil forks, etc. To allow easy digging of planting hole, the soil are sometimes plowed. The size of planting hole is usually 30 x 30 x 30 cm3 (Biro Pembinaan Hutan Perum Perhutani Unit III Jawa Barat, 1996).

. During planting it is attempted that root position is made as natural as possible, root collar is positioned at the same level or slightly below the soil surface. Plastic polybags are torn off carefully usually by using small sharp knife. Tearing of the polybag with bare hands (without knife) will add significantly the working duration needed for the planting. In some cases, like planting in mangrove area where the potted nursery medium is easy to crumble, plastic polybag are not torn off and left intact in the field together with the root. In this case, the polybag are slightly torn in the bottom to allow root protrusion.

1. Teak (Tectona grandis)

Teak is usually planted by seeds which are directly planted in the field, or by using stumps. Planting with direct seedling is conducted usually on October (at the beginning of dry season) or being conducted before the first rain come, when soil temperature is still hot. Teak seeds are planted at 2 cm depth (below the soil surface) and are afterwards covered with fine soil. On each planting point, 4 teak seeds are planted to get the opportunity to obtain best seedling. Planting using stump is conducted by taking stumps from 1 year old teak plants. These stumps are made by uprooting this teak plant and prune the root laterals, cut the main stem at a certain height, etc (Biro Pembinaan Hutan Perum Perhutani Unit III Jawa Barat, 1996; Lemmens and Soerianegara, 1994).

2. Meranti (Shorea spp*.)*

This species should be planted in area which has shade in the form of forest stand (such as sengon stand), where the meranti is planted as undergrowth.

3. Pinus (Pinus spp*.)*

Pine planting stocks which are ready to be planted are those which have produced the fox tail. *Pinus merkusii* are ready to be planted after minimally 8 months in the nursery, with seedling height of between 20 – 25 cm. On the other hand, *P. caribaea* and *P. kesiya* are ready to be planted after 4 – 6 months in the nursery. For banjarharian system, height of seedlings should be between 40 – 70- cm and the roots have not protruded out of the polybag. Size of planting hole is 30 x 30 x 30 cm^3 (Biro Pembinaan Hutan Perum Perhutani Unit III Jawa Barat, 1996).

Pine seedlings require ectomycorrhiza for optimal growth. Although mycorrhizal association could occur naturally, artificial inoculation could be conducted by planting seeds nearby “mother trees” of 30 – 80 cm tall which have contained mycorrhiza. Other method is by mixing nursery medium with topsoil form old pine forest with ratio of 1 : 4 – 10, or by inoculating with mycelia, spores or mycorrhizal tablet/capsules (Lemmens and Soerianegara, 1994).

4. Damar (Agathis spp*.)*

Potted dammar planting stocks are usually planted in the field after reaching minimal height of 15 cm. The best planting stocks are those of 1 – 1.5 years old with height of 25 – 60 cm. Dammar also require mycorrhizal association which can occur easily in the field, especially if there has been dammar trees in the past in the planting area (Lemmens and Soerianegara, 1994).

5. Mangium (Acacia mangium)

Mangium planting stocks are ready to be planted after 9 – 16 weeks old or after reaching height of 25 – 40 cm (Lemmens, Soerianegara, and Wong, 1995) . Planting stocks are planted in hole with diameter of around 13 cm and depth of 20 cm (Awang and Taylor, 1993).

6. Sengon (Paraserianthes falcataria)

Sengon need full sunlight in the planting area. Seedlings can be planted in the field after reaching height of 20 – 25 cm, the stem has been woody, and rooting system has been large enough. This condition can be achieved in 2 – 2.5 months (Lemmens and Soerianegara, 1994).

7. Mahogany (Swietenia macrophylla)

For out planting in the field, ordinary potted seedling, bare rooted seedlings and stumps (stem length of 20 cm, root length of 20 – 40 cm, and root collar diameter of 0.5 – 2.5 cm) could be used. Mahogany seedlings like shade, so that seedlings are placed under shade for 3 – 6 months before out planting. Mahogany seems to be tolerant toward shade, after out planting in the field. This can be seen from the relatively rapid growth and healthy condition after out planting under the shade in the field. This phenomenon can be used for enrichment planting in natural forest, which lacks lower stratum trees.

Leaves of mahogany planting stocks which will be planted do not need to be pruned, but we only need to leave 2 – 3 pairs of apical leaves intact in the stem. Beside that, roots which protrude out from the pot before planting, are recommended to be pruned. Planting hole is usually of the size 30 x 30 x 30 cm^3.

8. Puspa (Schima wallichii)

Puspa regeneration usually utilize seed, because propagation with stem cutting is not successful. Wildling (seedlings taken from natural forest) are sometime used for outplanting. Planting stocks which are ready to be planted are 6 – 8 months old, and around 20 cm tall. Stump material can be obtained from older plants.

9. Kayu afrika (Maesopsis eminii)

Propagation of kayu afrika can be conducted by using seeds. Direct seedling in the field can also be conducted. Beside seeds, potted seedlings and stump can also be used. Rapid root growth makes the seed of this species better to be sown directly in the pot, rather than in germination box. After 2 – 24 months the planting stocks are ready for out planting.

10. Gmelina (Gmelina arborea)

Gmelina can be planted in the field after reaching height of 23 – 30 cm which is achieved after 3 – 4 months old. Sometimes stump are used for artificial regeneration. However, due to high mortality during stump application, the technique is rarely used anymore. Sometimes, direct seeding in the field is also conducted.

11. Kayu putih (Melaleuca leucadendron)

Usually propagation of kayu putih uses seed. Planting stocks are raised in nursery for 3 – 6 months. Sometimes, stumps and stem/branch cutting are used for propagation (Oyen and Dung. 1999).

12. Eucalypt (Eucalyptus deglupta and E. urophylla)

After 3 – 4 months in the nursery and height of 25 – 30 cm, planting stocks are ready to be planted in the field. If the planting area is in dry climate, two weeks before out planting, planting stocks in the nursery should received less water, and full sunlight (Lemmens and Soerianegara, 1994)..

13. Mindi (Melia azedarach)

Propagation of mindi can use stem cutting, root sucker and marcotting. Planting usually is conducted using seeds with planting spacing of 1.5 x 2.5 cm^2 in the sowing bed, under full sunlight. Seedlings are thinned out until the spacing is 15 x 15 cm^2 (at 2 months old). Seedlings are transplanted when the height is 7 – 10 cm (Hanum and van der Maesen, 1997).

14. Sungkai (Peronema canescens)

Sungkai will grow best under full sunlight. Planting stocks are raised in the nursery for 4 – 6 months.

15. Kesambi (Schleichera oleosa)

Regeneration of kesambi can be conducted with seeds and root sucker. Out planting in the field can use seeds or stump. Spacing of seed planting is 7.5 cm. Stump can also be used by using 1 year old plant with diameter of around 1 cm.

Stem of kesambi is cut to 4 cm length of stem and 25 cm length of roots. Planting holes are of the size 30 x 30 x 30 cm^3 (Hanum and van der Maesen, 1997).

6. Suren (Toona sureni)

Planting stocks with minimal height of 1 m, short stump (stem height of 7 cm and root length of 25 cm), bare rooted plants or potted seedlings can be used for planting. For enrichment planting, stump of 1.5 – 2 years old can be used (Lemmens , Soerianegara, and Wong, 1995).

17 Khaya (Khaya anthotheca)

Propagation of khaya can use seeds or stem cutting (Sosef, Hong, and Prawirohatmodjo, 1998). However, sometimes direct seeding in the field fails. Khaya can grow under light shade, but the best growth is under full sunlight. Khaya planting stock are raised in the nursery up to three years old, with height between 0.6 – 1.8 m. If the age and size of planting stocks are older/greater than these dimension, then it is better to use stump for outplanting. Best growth after outplanting in the field is from the use of potted seedlings (Lamprecht, 1989).

4.8 Direct Seeding

In direct seeding, seeds are directly planted in the planting site. This technique has long been done in Indonesia. However, direct seeding is only suitable for tree species with abundance seeds, seeds have high viability and rate of germination, and the site of seeds are relatively big. Tree species which have been commonly planted by direct seeding are teak, sengon, kesambi, lamtoro and johar (*Casia seamea*).

4.8.1 Methods of direct seeding

Seeds of teak are planted upside down (scar facing down) about 2 cm deep. Five seeds are planted for each hole and 2 seeds between two holes. The planting is conducted on the early rainy season around October. If more than one seedling emerge from the five seeds, only one seedling will be choosen and the rest are used to fill the hole where none of the seeds germinate.

Lamtoro and johar are planted densely in arrow between the row of main species, e.g. teak or mahogany. The seeds are then covered with soil to about 1 – 2 cm. Seeds of kesambi are planted in the row of teak, where every 10 teak seedling is planted kesambi seeds (3 seeds per hole). The planting is conducted in the rainy season (2- 3 month after planting teak seed).

4.8.2 Advantages of direct seeding

There are many advantages of direct seeding, in that: no need for nursery establishment, do not depending on the availability of seedling in particular time, the seedling do not experience out planting shock.

4.8.3 Disadvantages of direct seeding

Cost of sedling maintenance may be more expensive than planting seedling with bigger size in the field. Weeding need to be done more intensively. Seeds may be attacked by insect, pathogens, or birds. Many forest tree species have very fine seeds, such as eucalyptus, *Melaleuca leucadendron*, *Ochroma* sp.; that is impossible to be planted using direct seeding technique.

Seeds from genetically improved trees are expensive which demand intensive care to reduce financial loss, and more importantly some species need special treatment after germination, e.g. shading.