ITTO PD 386/05 Rev.1 (F)

TECHNOLOGICAL DEVELOPMENT FOR THE PRODUCTION OF PLANTING MATERIALS TO SUPPORT SUSTAINABLE PLANTATION OF BALI INDIGENOUS SPECIES THROUGH COMMUNITY PARTICIPATION

REPORTING ACTIVITY 1.1 IDENTIFICATION SEED SOURCES AND SEED COLLECTION FOR SIX SELECTED INDIGENOUS SPECIES

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REGIONAL TREE SEED CENTER FOR BALI AND NUSA TENGGARA
INTERNATIONAL TROPICAL TIMBER ORGANIZATION

2009

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Reporting
Activity 1.1. Identification Seed Sources and Seed Collection for Six Selected Indigenous Species

Project Executing Team ITTO PD 386/05 Rev.1(F)

Bali Provincial Forestry Service and
Regional Tree Seed Center for Bali and Nusa Tenggara and
International Tropical Timber Organization
2009

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SUMMARY

Three seed stands and twenty sites of seed trees throughout Bali and Lombok Island have been identified as seed source for six spesies (*Fagara rhetsa, Manilkara kauki, Alstonia scholaris, Wrightia pubescens, Planchonia valida, Dysoxylum densiflorum*). In line with the seed source identification, the project has produced a Guide on Seed Collection and Handling of the Six Indigenous Species of Bali and made available of botanical name for panggal buaya, putat, and majegau.

The training was conducted on 15-17 February 2007. Forty one participants of the training were farmers and extension officers living nearby seed sources of *Fagara rhetsa, Alstonia scholaris, Manilkara kauki, Wrightia pubescens, Planchonia valida, and Dysoxylum densiflorum.*, and technicians of Regional Tree Seed Center for Bali and Nusa Tenggara. By the end of training, ITTO Project PD 386 handed over seed-collection equipment to farmer groups. The farmer expressed that they would like to support seed collection in the near future.

As a part of activity 1.1., seed collection and procurement of six species (*Fagara rhetsa, Manilkara kauki, Alstonia scholaris, Wrightia pubescens, Planconia valida, Dysoxylum densiflorum*) was conducted in line to production of 1, 1 millions seedlings for Pejarakan Nursery managed by ITTO Project PD 386/05 Rev.1(F). Collection of seeds from the seed tress and seed stands[1] was started in December 2006.

In period of December 2006 to September 2007, Regional Tree Seed Center (RTSC) for Bali and Nusa Tenggara in collaboration with Bali Provincial Forestry Service (BPFS) collected 351,9 kilogram of five species, *F. rhetsa, M. kauki, A. scholaris, W. pubescens, P. valida, and D. densiflorum.*

In period of December 2007 to May 2008, RTSC and BPFS collected 410,6 kilogram of three species, *Fagara rhetsa, Alstonia scholaris, and Dysoxylum densiflorum.* In addition, RTSC for Bali and Nusa Tenggara in collaboration with RTSC for Sumatera made collection of 500 gram seeds from Palembang Provenance.

In period of June 2008 to January 2009, RTSC collected 370.5 kilogram of five species namely *D. densiflorum*, W. *pubescens, P. valida, A. scholaris*, and *M. kauki.*

1. INTRODUCTION

The report covers activity 1.1. consisting of the followings:

1. Activity 1.1.1., seed source identification of 6 species,
2. Activity 1.1.2., training on seed collection,
3. Activity 1.1.3., collection of genetic materials throughout the seed sources.

As a part of activity 1.1., identification of seed source was implemented to six indigenous species of Bali in accordance with producing 1.1 millions planting materials in Pejarakan Nursery managed by ITTO Project PD 386/05 Rev.1(F). The seed source consists of seed stand and seed trees. The identification was made throughout Bali and Lombok Island in 2007 and 2008. The guideline of seed source identification was prepared by Dr. Eko Bhakti, while the Regional Tree Seed Center (RTSC) for Bali and Nusa Tenggara and Bali Provincial Forestry Service (BPFS) conducted the seed source identification.

To improve the skill and knowledge on seed collection of the species for farmers, the project held training on seed collection. The training was conducted on 15-17 February 2007 as a part of Activity 1.1. The participants were farmers and extension officers living nearby seed sources of six selected indigenous species (*Fagara rhetsa, Alstonia scholaris, Manilkara kauki, Wrightia pubescens, Planchonia valida, and Dysoxylum densiflorum*). . Facilitators of the training were Dr. Eko Bhakti, an expert on tree breeding, and two technical staffs of Regional Tree Seed Center. By the end of the training, the leader representing a farmer group received a set of seed collection equipment.

As another part of activity 1.1., Regional Tree Seed Center (RTSC) for Bali and Nusa Tenggara in collaboration with Bali Provincial Forestry Service (BPFS) made available seed of six indigenous species (*Fagara rhetsa, Manilkara kauki, Alstonia scholaris, Wrightia pubescens, Planconia valida, Dysoxylum densiflorum*) for producing 1,1 millions seedlings by the end of the project. The seeds were collected from seed source that has been identified during implementation of activity 1.1.1

This technical report covers three periods of seed collection. The first period was in December 2006 to September 2007, the second period was in December 2007 to May 2008, and the third period was June 2008 to January 2009.

2. MAIN TEXT

2.1. Seed source identification of six species

2.1.1 Species Determination

Species determination of three species was conducted by Research Center for Biology, Indonesian Institute of Science, and the results was as the following Table.

Table 1. Species determination of three species

No	Local Name[1]	Species	Family	Remarks
1	Majegau	*Dysoxylum densiflorum Miq.*	Meliaceae	Letter of Botanical Division 330/IPH.1.02/If.8/2006, 3 May 2006
2	Panggal buaya	*Fagara rhetsa Roxb.*	Rutaceae	Letter of Botanical Division 860/IPH.1.02/If.8/2006, 28 November 2006. Former species of *Xanthoxylum rhetsa*
3	Putat	*Planchonia valida Blume.*	Lecythidaceae	Letter of Botanical Division 860/IPH.1.02/If.8/2006, 28 November 2006.

2.1.2. Guideline of seed source identification

Dr. Eko Bhakti prepared the Guideline of Seed Source Identification for the six indigenous species of Bali. The guideline was introduced to participants of seed collection training held in 15-17 February 2007. Summary of the guideline was attached in Annex 1.

2.1.3. Seed tree and seed stand identification of 6 species

Seed stands and seed trees of majegau (*Dysoxylum densiflorum*), putat (*Planchonia valida*), sawokecik (*Manilkara kauki*), panggalbuaya (*Fagara rhetsa*), bentawas (*Wrightia pubescens*), and pulai (*Alstonia scholaris*) have been surveyed and identified in both private and forest lands throughout Bali and Lombok Islands started in October 2006 to September 2007. A group of trees considered as a seed stand if the stand consisted of minimally 30 trees having good accessibility, bearing fruits, performing good phenotypes, and being free from insect and disease attack. A seed tree was a single tree having good accessibility, bearing fruits, performing good phenotypes, and being free from insect and disease attack. The geographical position and altitude of seed sources and seed trees was determined by GPS Garmin 12 XL. Locality, position, altitude, and number of trees within the seed source are shown at Annex 2 while the map of

[1] The botanical name of pulai, sawokecik, bentawas has been well known.

distribution of mother trees for 6 species as shown at Annex 3. The figures below shows seed stand and seed trees of the six species.

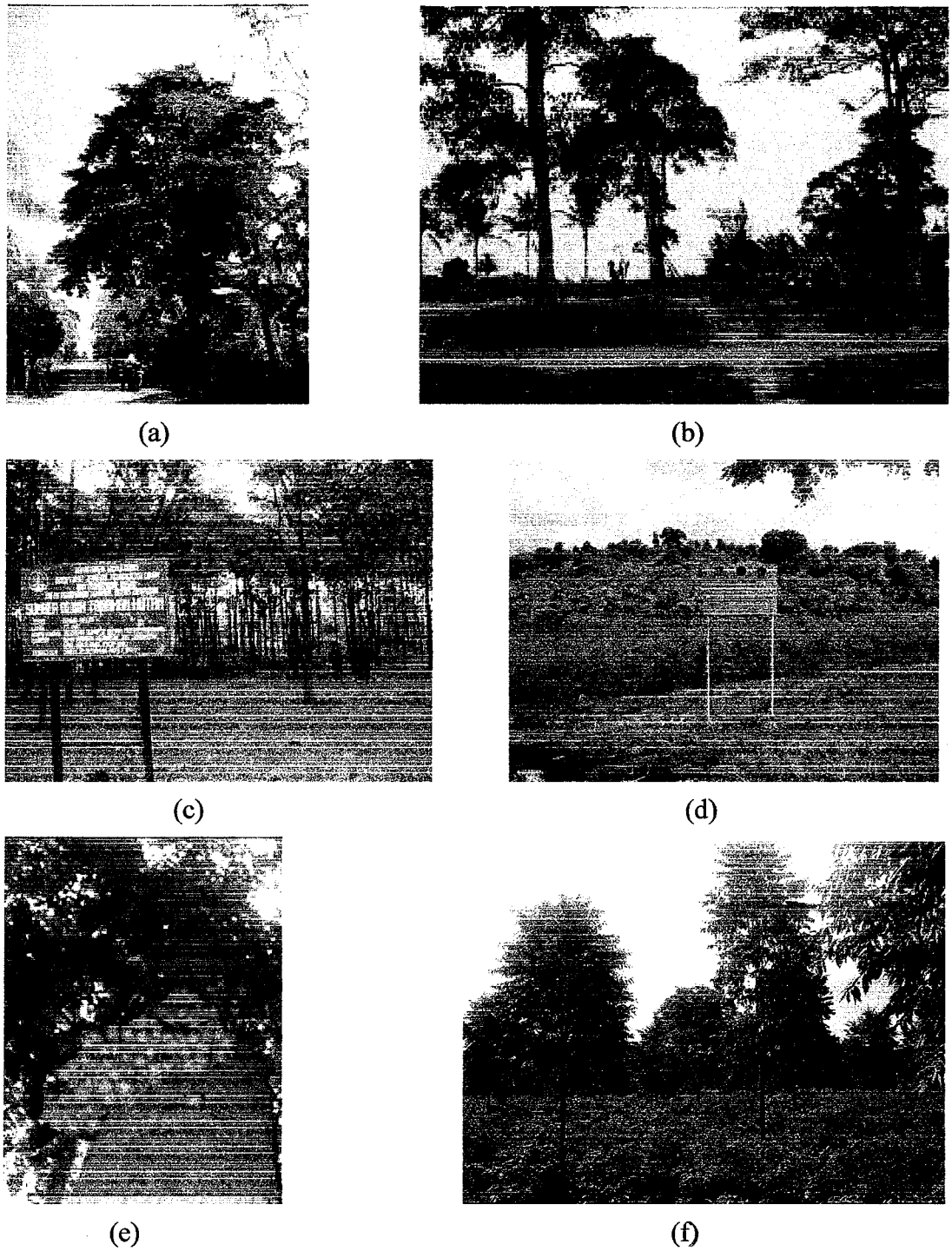


Figure 1. Seed sources of *Planchonia valida* (a); *Alstonia scholaris* (b); *Manilkara kauki* (c); *Fagara rhetsa* (d); *Dysoxylum densiflorum* (e); and *Wrightia pubescens* (f)

2.1.3.1. Majegau (*Dysoxylum densiflorum*)

The seed sources and seed trees of were found in private lands at Tegallingga, Peliatan, Batumadeg in Bali Island; Pemepek, Waja Geseng, and Lebak Sepaga in Lombok. The species grew in lowlands of Bali to mountains of ranging from 74 to 646 meter above sea level. Its population was highly fragmented because of felling, agriculture activity, and household supply. Many seedlings were found under the trees.

2.1.3.2. Pulai (*Alstonia scholaris*)

The trees were usually grown on cemeteries in Bali. Most of the trees were found as individually scattered trees in lowland (3-22 meter above sea level). Trees growing as one stand were found in Kecincang, Karangasem. Its population was highly fragmented. Seedlings were not found under the trees.

2.1.3.3. Putat (*Planchonia valida*)

All seed trees were found as border trees in private trees. The individually scattered trees grew in lowland (10-160 meter above sea level). Its population was highly fragmented. Seedling naturally grow under trees and it was found during early of rainy season.

2.1.3.4. Sawokecik (*Manilkara kauki*)

Regional tree center (RTSC) approved a plantation to be a seed source at Sumberklampok, Buleleng. The trees naturally grow at Bali Barat National Park. The seed trees were found at Mokmer Street, Badung and Nusa Ceningan, Klungkung. For genetic conservation purposes, seed should have been collected in natural forest in the West Bali National Park. Natural regeneration was not found under the trees.

2.1.3.5. Panggal buaya (*Fagara rhetsa*)

There was not information regarding to natural distribution of this species in Bali. RTSC approved a plantation of the species at Sumberklampok as a seed source. Seed trees were found at private lands in the tree villages located at Pecatu (Badung Regency), Kemenuh (Gianyar Regency), Seraya (Karangasem Regency) and Surabrata and Bonian (Tabanan Regency). Most of the trees were grown at border of farmer lands and home gardens. Natural regeneration was found under the trees in the beginning of rainy season.

2.1.3.6. Bentawas (*Wrightia pubescens*)

Seed trees of the species naturally grew in production forest at Pejarakan, Buleleng. The species was reported to be grown in home garden at Kemenuh and Tulikup, Gianyar. The species was also found in Rinca Island, Komodo National Park. Natural regeneration was not found under the trees.

2.1.4. Constraints during identification of seed trees

Constraint during identification of seed trees mainly is reducing number of the trees found in a given location. Number of seed trees tends to be reduced because of felling of the trees by owners. Some seed trees will be cut when the size are commercial.

2.2. **Training on seed collection**

2.2.1. Participants

Training on seed collection was held on 15-17 February 2007. Participants for the training were twenty seven farmers as seed collectors, seven extension officers of four Forestry Districts (Badung, Karangasem, Negara and Gianyar Regency), two Forestry District Officers, and five staffs of Regional Tree Seed Center (RTSC) for Bali and Nusa Tenggara . Training was divided into one-day session in class and two-day visits in nearby seed sources, and forty one participants had been taken part in this training. List of participants was presented in Annex 4.

(a) (b) (c)

(d) (e)

Figure 2. Activities of training on seed collection (a: theoretical aspects presented in class, b: class during the training, c: briefing and discussion prior to seed collection practice, d: practice on seed collection of *Fagara. rhetsa*, d: closing of the training in the field

2.2.2. Facilitators

Instructor of the training was Dr. Eko Bhakti from Gadjah Mada University; Rachmawaty Ariany and Prajitno, technicians from RTSC of Bali and Nusa Tenggara. The training schedule was shown in Annex 5.

2.2.3. Distribution of seed-collection equipment

A set of prunner and storage bag has been given to every farmer group one set each. It is planned that the trained participants will assist the project to monitor flowering, fruiting, and collecting ripen fruits before the seed orchard established by the projects bears the fruits.

2.3. **Collection of genetic materials throughout the seed sources**

2.3.1. Collection of genetic materials throughout the seed sources in December 2006 to September 2007.

Total seed weight of five species (*Fagara rhetsa, Manilkara kauki, Wrightia pubescens, Planchonia valida, Dysoxylum densiflorum*) collected by RTSC and BPFS from 15 seed sources up to September 2007 was 351,9 kilogram as shown in Table 2. During the period, *A. scholaris* growing in Bali has not flowered in September 2007. The seed has been sown in Pejarakan Nursery. Detailed data of the collection was presented data of the collection was presented in Annex 6.

Table 2. Seed collection made by RTSC and BPFS in period of December 2006-September 2007

No	Species	Weight of Seed (kg)	
		Collected by RTSC	Collected by BPFS
1	*A. scholaris*	-	-
2	*D. densiflorum*	174,5	6
3	*F. rhetsa*	73,5	30
4	*M. kauki*	15,7	22
5	*P. valida*	5,2	-
6	*W. pubescens*	8	17
	Total	276,9	75
	Grand Total	351,9	

2.3.2. Collection of genetic materials throughout the seed sources in December 2007 to May 2008.

During this period, seed of three species (*A. scholaris, D. densiflorum, F. rhetsa*) was collected from fifteen seed sources throughout Bali, Lombok, and Sumatera. The collection brought 2.760 kilogram fruits of *D. densiflorum* and 1.31 kilogram fruits of *F. rhetsa*. The weight of seeds extracted from the fruits was 410,6 kilogram as shown in

Tabel 3. Another species (*Planchonia valida, Manilkara kauki, Wrightia pubescens*) will be ready for the next period seed collection in June to January 2009. Most of the seed has been sown in Pejarakan Nursery, and few amounts of the seed have been sown in RTSC Nursery. Detailed data of the collection was presented in Annex 6.

Tabel 3. Seed collection made by RTSC and BPFS in period of December 2007-May 2008

No	Species	Weight of Seed (kg)	
		Collected by RTSC	Collected by BPFS
1	*A. scholaris*	0.6	0.0
2	*D. densiflorum*	83.8	221
3	*F. rhetsa*	80.2	25
4	*M. kauki*	#	#
5	*P. valida*	#	#
6	*W. pubescens*	#	#
	Total	164.6	246
	Grand Total	410.6	

2.3.3. Collection of genetic materials throughout the seed sources in June 2008 to January 2009

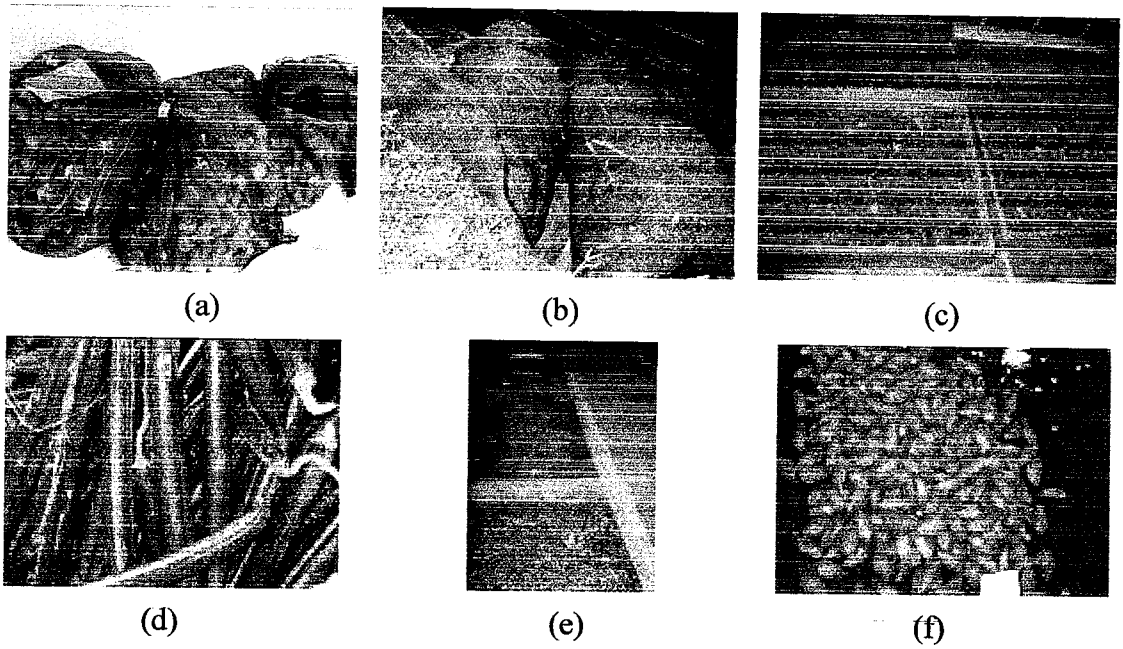
The RTSC was collected seeds with total amount of 370.5 kilogram in this period. The seeds that collected comprising *D. densiflorum* 7 kg, *P. valida* 50 kg, *W. pubescens* 54 kg, *A. scholaris* 1.5 kg, and *M. kauki* 258 kg as shown in Table 4.

Tabel 4. Seed collection made by RTSC and BPFS in period of June 2008-January 2009

No	Species	Weight of Seed (kg)	
		Collected by RTSC	Collected by BPFS
1	*A. scholaris*	1.5	#
2	*D. densiflorum*	7.0	#
3	*F. rhetsa*	#	#
4	*M. kauki*	200.0	58.0
5	*P. valida*	50.0	#
6	*W. pubescens*	54.0	#
	Total	312.5	58.0
	Grand Total	370.5	

(a) (b)

Figure 3. Collect fruits of *Fagara rhetsa* (a) and *Alstonia scholaris* (b)



(a) (b) (c)

(d) (e) (f)

Figure 3. Fruits collection of (a) *Dysoxylum densiflorum*; (b) *Fagara rhetsa*; (c) *Manilkara kauki*; (d) *Wrightia pubescens*; (e) *Alstonia scholaris*; and (f) *Planchonia valida*.

3. CLOSING

By identifying the seed source as shown in Annex 2, it is expected that seeds needed for producing 1,1 millions planting materials will be fulfilled by the end of 2008.

The participants of the training were enthusiasm active during the training period. The training was more focused on practices of seed collection in the field. They expressed that they would like to contribute in seed collection activities organized by the project in near future.

The amount of seed collected in period of December 2007-May 2008 has been increased than the amount of seed collected in previous period. RTSC and BPFS have been collected 351.9 kilogram seeds in period of December 2006-September 2007, 410.6 kg of seed in period of December 2007-May 2008, and 370.5 kg of seeds in period of June 2008 to January 2009. The total weight of seed collected up to January 2009 was 1,133 kilograms.

ANNEXES

Annex 1. Summary of report on seed collection and handling consultancy

I. INTRODUCTION

1.1.The importance of good seed quality

The benefits of using good quality seeds, collected from selected parents trees, are twofold: improved survival and greater product yield. Seed from healthy, well formed trees provide assurance that resulting planting stock will have good form, survival and better resist stressed conditions. Good quality seed will give higher yield in terms of stem volume and wood quality. The investment in seed selection will be more than compensated for by higher product yields.

Seed quality consists of three components as follows:

- **Genetic quality.-** It refers to the inherent characteristics of the tree from which seeds are collected.
- **Physical quality.-** It refers to physical conditions of seed, especially to the mechanical conditions (whole/broken) size, color, age, and the health (pest and diseases attack). The physical condition of seed is relatively easy to assess and can, to some extent, be directly observed. It is very much influenced by the different activities related to collection, handling, processing and storage.
- **Physiological quality.-** It mainly refers to the internal biological conditions of seed and is concerned with condition of the morphological structures and biochemical processes in seed related to maturity at the time of collection and deterioration after collection. Physiological quality is influenced by the handling, processing and storing of seed. It is dependent on the internal progress of the biological process of the seed and is not always easy to detect from visual inspection of the seed, but physiological quality can be revealed by germination test.

Genetic quality of seed can be improved by genetic means, namely through tree improvement program, while physical and physiological qualities can be maintained by proper seed collection, handling, processing and storing. The guidelines will mainly focus on the improvement of seed genetic quality through tree improvement programs.

1.2. Source of good quality seed

Individual trees or stands from which seeds are collected called seed sources. Seed sources can be classified based upon the genetic quality of seeds produced and the

intensity of management of the seed sources. Seeds for panggal buaya, sawo kecik, pulai ,bentawas, majegau and putat may be collected from the following seed sources:

- Seed tree
- Seed production area.

With regard to genetic quality, seed tree is the lowest while the seed orchard is the highest reflecting the intensity level of genetic improvement effort that has been done.

1.2.1. Seed tree. - Seed tree is an individual tree from which seed is collected. It should have superior characteristics such as straight stem fast growth and free form pest and disease.

1.2.2. Seed production area.- Seed production area (also called seed stand) is a stand of trees that is improved for seed production. Genetic improvement comprises selective thinning to remove poor quality and unhealthy trees and to achieve optimal spacing for seed production.

1.2.3. Seed orchard. Seed orchard is a stand established for the specific purpose of seed production. It usually consists of families of superior genetic quality and are planted at a regular spacing and specific design.

1.3. Current occurrence and stand conditions

1.3.1. Panggal buaya (*Fagara rhetsa*)

Panggal buaya generally grows at altitudes from 150 to 700 m. In Bali panggal buaya grows at altitudes from near sea level (i.e. Sumber Klampok) up to 500 m asl. (i.e.Seraya-Karangasem). The optimum mean annual rainfall is between 1850 and 2500 mm. The species grows better in areas with relatively short dry season (2-3 months). Panggal buaya is found to grow on various soils: regosol (Inceptisol), mediteranian and latosol (Alfisol). It prefers light to medium texture and well-drained soil.

Mostly panggal buaya grows on farm land, either in clusters (groups) or isolated trees. It grows naturally or is planted by farmers using the available seedlings on site. Its current distribution includes Badung, Tabanan, Karangasem, Jembrana, Buleleng and Gianyar. No seed production area or seed orchard has been established.

1.3.2. Sawo kecik (*Manilkara kauki*)

Sawo kecik grows naturally at altitudes from the sea level to about 500 m with the mean annual rainfall ranging from 1500 to3600 mm and dry season ranging from nil to 6 months. It can be found on a variety of soils, with preference of light texture and free drainage. In Bali natural stand of sawo kecik can be found in West Bali National Park. A seed stand has also been established in West Bali even though has not yet been managed properly. Sawo kecik is also planted in temples and along the road sides in a number of locations as ornamental trees. In temples it is planted as isolated trees or in groups consisting of a couple of trees.

1.3.3. Pulai (*Alstonia scholaris*)

Pulai occurs at altitudes from sea level up to 1000 m. Its optimum mean annual rainfall is in the range 1100- 3800 mm with 2-5 dry months. Pulai grows in various soil types: alluvial, lateritic soil, and volcanic soil with soil reaction of acid to alkaline. In Bali pulai stands are not existent and the species is mainly planted around temples and grave yards as isolated trees or in groups consisting of only few trees.

1.3.4. Bentawas (*Wrightia pubescens*)

Bentawas can grow at sites starting from sea level up to 1000 m altitude with mean annual rainfall ranging from 875 to 4000 mm. The species tolerates drought. Bentawas can also grow on various soils with light to medium texture. In Bali bentawas grows at scattered sites in Bali, such as Badung, Karangasem, Gianyar, Buleleng, Tabanan dan Jembrana Districts. Stands of bentwas are not existence and trees grow in isolated individuals or in groups consisting of a couple of trees.

II. SEED TREES

At present time seed production area and seed orchard are not available for panggal buaya, sawokecik, pulai, bentawas, majegau and putat. A seed stand has been identified for sawo kecik and panggal buaya in West Bali, but its seed production is very limited due to lack of proper maintenance, especially selective thinning. For an immediate need of good quality seed the seed has to be collected from seed trees until the seed of better quality from seed production area or seed orchard is available.

As mentioned in the preceding section that no good stands are available for all species. Trees are mainly found on farm land, temples and grave yard containing a small number of trees, often times only 3-5 trees. On farm land farmers frequently cutting down trees with the best characteristics and leaving behind the inferior ones (this practice is called negative or dysgenic selection) . Limited number of trees and negative selection will result in poor quality of seeds produced. The utilization of the highest quality of selected seed is very crucial to reverse the trends of genetic degradation while improving the productivity and health of grown trees.

2.1. Selection of seed trees and seed collection

The following guidelines can be used:

- Seed trees should be selected in the best stand available. If the stand consists of individual trees of good quality, the chance of producing high quality seed from selected tree in the stand is also high. In contrast, if seed collected from a stand where most trees are of poor quality, the seed collected will likely produce poor quality trees.
- Seed trees should have good phenotypic characteristics in terms of growth, form, wood quality, free from pest and disease.

- Seeds should only be collected from these selected seed trees. Avoid collecting seeds from distressed or stunted trees even though such trees usually produce abundant seed and easier to harvest. Trees with the most desirable characteristics are usually the most difficult to collect seeds from because they are the tallest and most difficult to access.
- Isolated trees should not be selected even though they have good characteristics and seeds from these trees should not be collected.
- While it is important to collect seed from the best parent trees, it is also important to gather seed from several parent trees. Collecting seed from several parent trees assures a diversity among seedlings being planted. At minimum, be sure to collect from 15-25 individual trees.
- To avoid the chance of collecting seeds from closely related individuals, take seeds from trees separated by 70 m or more.
- To ensure genetic variation, collect seeds from throughout the crown (top, sides, and bottom) of each tree to ensure that a range of pollinators are represented in the seeds.
- Harvest only mature seed from ripened fruits.
- Pick similar quantities of seeds from each tree so that no one tree is over represented. This can help prevent inbreeding in future generations.

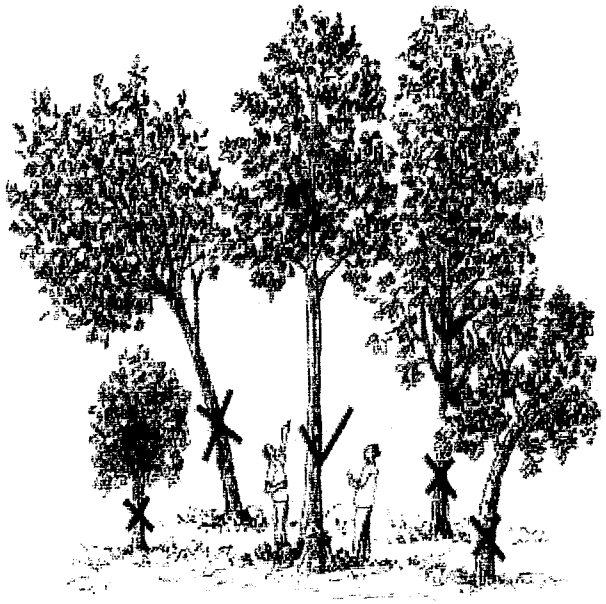


Figure 1. Selecting the best seed tree (adapted from Mulawarwan *et al.* 2003)

The above guidelines for selecting seed trees are very ideal and not all can be followed. As mentioned in the preceding section, the tree population of panggal buaya, pulai,

bentawas and sawokecik in Bali are mostly very small and highly fragmented. Trees of good phenotypic characteristics are difficult to find due to long practice of dysgenic selection. Consequently, the minimum requirement of selecting seed trees can be adjusted as follows:

Panggal buaya.- Seed trees should have good phenotype, not stunted, free from pest and disease. The minimum distance between seed trees is 50 m. Seeds should be collected at lesat from 25 trees.

Sawokecik.- Phenotypically good trees, free from pest and disease. The minimum distance between seed trees is 50 m. Seeds should be collected at least from 25 trees.

Pulai.- Seed trees should have good phenotype, free from pest and disease and have started producing fruits. The minimum distance between seed trees is 50 m. Seeds should be collected at least from 25 trees.

Bentawas.- Seed trees have good phenotype,free from pest and disease. The minimum distance between seed trees is 50 m. Seeds should be collected at least from 25 trees.

III. SEED PRODUCTION AREA

Seed production area may be established by converting the existing best stand into seed production area by progressive thinning of poor trees in the stand. Seed production area can also be a stand specifically planted for the production of good quality seed. Considering that the good stand for all four species being developed in Bali is practically not available, the following guidelines will focus on the second method.

3.1. Site selection

Site for establishing seed production area should meet as much as possible the following criteria:

- Should benefit flowering and fruiting for the species of interest. It must be assured that the species will produce fruit at the site in question. Observing the fruiting of the species being developed at or near the site where the seed production area will be established is the best strategy. Species requirement for climate (altitude, rainfall) and soil as described in the preceding section can be very useful for site selection of the seed production area of the respective species.
- Relatively flat and slightly sloping or undulating.
- Not vulnerable to natural disasters such as flood, land slide, frequent wildfire etc.
- Good accessibility and labor availability.

3.2. Seed source

- The seed source used for establishing seed production area must be known and collected according to the method of proper seed collection described previously.
- Seeds must be from at least 15-25 of good quality parent trees; each tree is represented by the same amount of seed.

3.3. Size

- The size of seed production area is dependent upon the amount of seed needed and the seed production capacity of respective species. From management and pollination point of view the size of seed production area should be reasonably large at least 1 ha.
- Seed production area should be isolated from pollen contamination of the same species by establishing isolation buffer. The width of isolation for insect pollinated species is at least 50 m. Panggal buaya, sawo kecik, pulai and bentawas are all insect pollinated species. The isolation buffer may be empty space or planted with different species.

3.4. Thinning

Trees having poor phenotypic characteristics such as slow growth, crooked stem form, attacked by pest or disease are cut and removed. Thinning must be done progressively several times (2-4 times) to avoid risk of wind throw and finally leaving around 120 – 200 trees per hectare.

The following are the guidelines for thinning of seed production area:

- The first thinning is carried out when tree height is 5-6 m or when the crown starts closing, with about 50 % of the poorest trees are felled and the remaining best ones are retained. With the initial spacing of 3 x 3 m (1111 trees/ha) there will be around 550 trees per ha retained after the first thinning. Thinning may be done by setting up contiguous thinning plot in the seed production area with a size of 0.1 ha for each plot. With the initial spacing of 3 x 3 m, there will be about 110 trees per plot. Thinning is done with an intensity of 50 %, retaining about 55 best trees in each plot, but maintaining more than 3 trees at adjacent position is not allowed (see the diagram in Figure 2).
- The second thinning should be done when tree height is 7-8 m or when their crown begins to close, with a thinning intensity of 50 %. This second thinning can be carried out using the same plots as the first thinning. The best 25-30 trees will be retained.
- The third thinning should be conducted when trees reach 9-10 m tall with a thinning intensity of 50 %. This thinning is done similar to that of the second thinning. With the initial stand density of 1110 tree per ha, there will be around 120 -150 trees per ha after the third or final thinning.

Size of SPA: 5 ha
Initial stocking: 1110 tree per ha

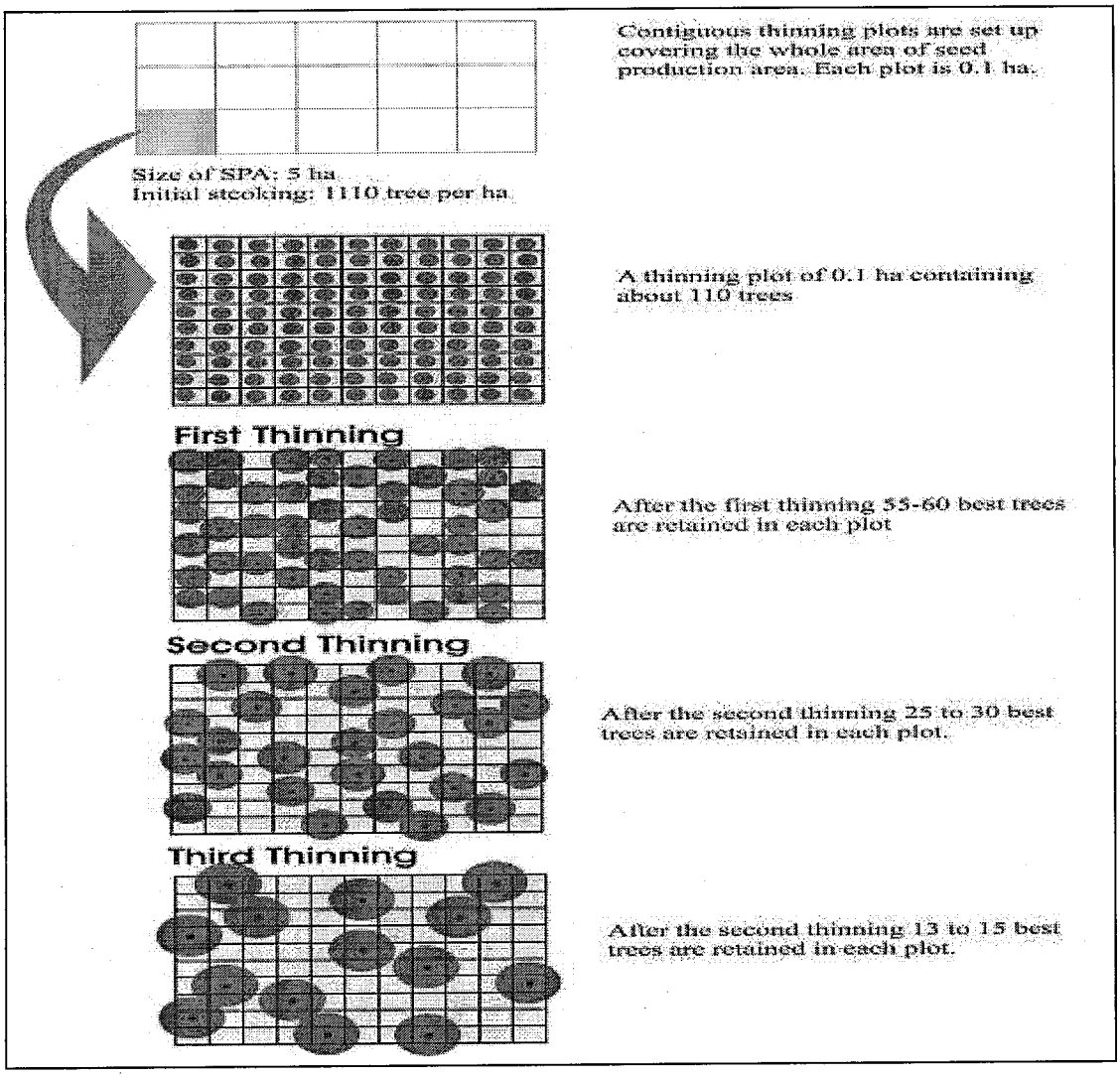


Figure 2. Diagram showing thinning procedures

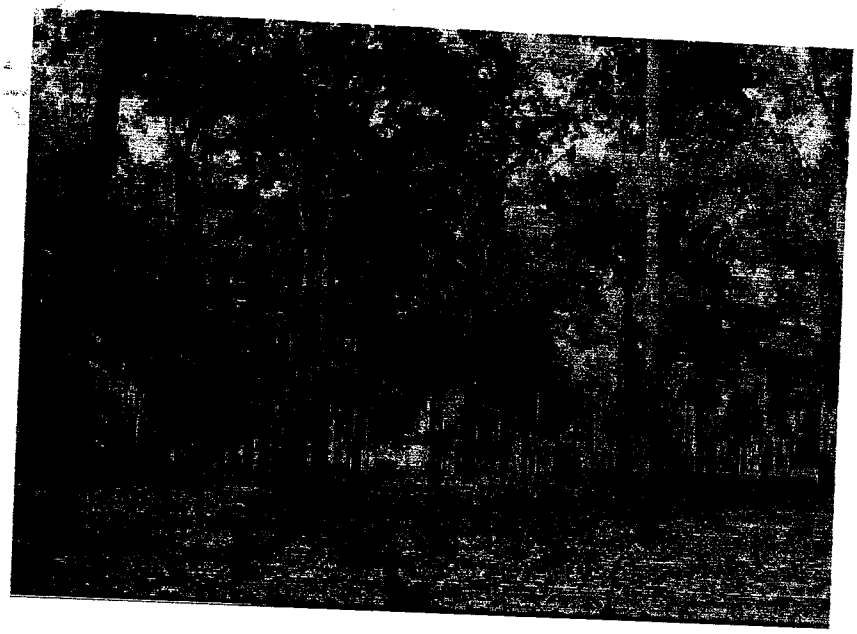


Figure 3. An example of seed production area after final thinning having 130 trees per ha

IV. SEED COLLECTION AND HANDLING

The best time for seed collection and the method of seed handling for each species is described below.

4..1. Panggal buaya (*Fagara rhetsa*)

Panggal buaya generally starts flowering soon after the formation of new leaves, namely at the beginning of rainy season. In Bali flowering is from August to November. Panggal buaya is a cross pollinated species and crossing requires biotic agents to transfer pollen from anthers to stigmas. A number of pollinators have been noted, among others are black ants, bees, flies and weevils.

The good time for seed harvest is from February to March. Ripen pod is red or black After harvest seed should be cleaned from debris such as leaf and twig and then put in bag (plastic, gunny or cloth). Pods should be dried immediately on tarpaulin or bamboo tray; drying should be done in shade and not under the direct sunlight for 2-3 days and then ready for seed extraction. Seed extraction is done by releasing seed from pods by hand. The seeds are then washed with clean water. It is suggested to sow the seed after cleaning. To speed the germination, the cleaned seed are soaked in water for 4-7 days. There are around 16,000 seeds per kg.

4.2. Sawo kecik (*Manilkara kauki*)

In West Bali the fruit of sawo kecik generally can be harvest in the month of September to December. However, the fruit may be mature earlier in June or July. In South Bali

(Tuban, Nusa Dua, and Benoa), the fruit has been mature in May. Fruit color of sawo kecik is green and will turn to red or brownish red when ripen. Fruit collected by climbing and picking the fruit. Sawo kecik has thick and juicy fruit flesh. Seeds can be extracted easily when ripen by pressing the fruit between thumb and forefinger, but the flesh sometime is hard and needs to be softened. The best way to do this is by wetting the fruit with water and afterwards put the seed in closed plastic bag for 3-4 days; the flesh fruit are then ready for seed extraction by hand. Seeds are washed with clean water and put on bamboo tray or wire net and dried under room temperature. Dried seeds should be put in sealed bag or sack and stored in a dry-cool room (refrigerator will be better). To speed the germination, the cleaned seed are soaked in water for 1 days. There are around 1250-1600 seeds per kg.

4.3. Pulai (*Alstonia scholaris*)

In Bali the fruit of pulai can be harvested from October to November. However, fruit may be mature earlier in June to September. When ripen the fruit color turns from green to brown. The fruits can be collected directly from the tree or from covers on the ground after shaking the branches. Harvest must be done before the pod is open and the seed is dispersed. Collection must be well timed, typically within about two weeks after the seed is mature, the seed is then dispersed. After harvest the fruits should be dried immediately in the sun until they are open and release the seed, typically after one week. If the fruits are harvested before mature, after-ripening process in the shade is necessary. Since the seeds are small and easy to be blown away with the wind, it is better to dry fruits in bags. Seeds should be stored in container in a dry-cool room. Pretreatment is not necessary before sowing. There are around 37.000-90.000 seeds per kg.

4.4. Bentawas (*Wrightia pubescens*)

The best time for fruit harvest is from July to September. In West Bali, the fruit can be harvested earlier in June. It is hard to identify mature bentawas fruits by color. The best method to identify the ripen fruit is by breaking the fruit and releasing the seed with fingers; if the seed looks fully filled and hard, it indicates that the seed is mature. Another method is to look at tree crown; fruit maturity coincides with the time of trees to fall their foliage. Mature fruits should be harvested timely and not be allowed to desiccate. Fruits can be harvested directly from the tree. To make seed extraction easier, latex in the fruit should be removed by cutting the bottom and top of fruit and let the latex comes out. Seeds are extracted by twisting the fruit to separate two tight loci. For each locus seed is released from fruit flesh and the seed wings are removed. Clean seed is not allowed to be exposed to open air as it can reduce their moisture content rapidly. Due to recalcitrant nature, seeds should not be stored, and must be sown immediately after harvesting. Pretreatment is not necessary before sowing. There are around 30.000-65.000 seeds per kg.

4.4. Majegau (*Dysoxylum densiflorum*)

In East Bali the fruit of majegau generally can be harvest in the month of December to February. In West Lombok, the fruit may be mature later in February to March. Fruit color of sawo kecik is light brown and will turn to dark brown when ripen. Mature fruit breaks its fruit coat. Fruit should be collected by climbing and picking the fruit. Majegau has thick fruit flesh. Seeds can be extracted easily when ripen by manually pressing the fruit between thumb and forefinger, but the flesh sometime is hard and needs to be air drying. Seeds are soaked in water for 1 day and washed to remove its aril. Due to recalcitrant nature, seeds should not be stored, and must be sown immediately after cleaning. Pretreatment is not necessary before sowing. There are around 1,500-1,700 seeds per kg.

4.5. Putat (*Planchonia valida*)

Putat is found along creek and lowland in Pupuan, Bonian, Penebel and Mengwi of Tabanan Regency. The fruit of putat can be harvested in the month of August to September. Mature fruits is dark green. Fruit should be collected by climbing and picking the fruit. There are 6-8 seeds in one pod. Seeds can be extracted easily when ripen by manually pressing the fruit between thumb and forefinger. It suggested to sow the seeds immediately after extraction the seed. Pretreatment is not necessary before sowing. There are around 17,000 seeds per kg.

V. SEED REPRODUCTION

Only very limited information has been available regarding the seed reproduction of panggal buaya, sawo kecik, pulai and bentawas. In this regard general recommendation for other species may be applied. Seed collection from seed production area or seed orchard should not be done until the final thinning has been completed to reduce the risk of obtaining inbred seed as a result of inbreeding. Seed collection should also not be carried out when the majority of trees in the seed production area or seed orchard do not flower (less than 50 %). Seed collection on trees in the seed production area or orchard that flower very early or very late should also be avoided.

VI. GLOSSARY

Clone: A population of genetically identical individuals. Such a population is obtained by asexual reproduction.

Family: A group of individuals having one or both parents in common.

Inbreeding: Mating between closely related trees, and in the extreme case is selfing. Inbreeding of normally crossed pollinated trees will result in inbreeding depression such as low survival, reduced growth etc.

Parent tree: A selected tree from which seeds are collected to be used for progeny test, establishment seed production area, or seed orchard.

Phenotype: The tree or characteristic as we see it; the product of interaction of the genes (genotype) with the environment where a tree grows.

Pollination. Deposition of pollen on the receptive part of the female flower.

Roguing: Systematic removal of individual not desired for the perpetuation of the population.

Seed production area (seed stand): A stand consists of selected trees with desirable characteristics.

Seedlot: A group of related trees given a number and identified a unit throughout the course of experiment.

Seed source: The locality where seeds are collected.

Seed trees: A tree from which seeds are collected.

Vegetative propagation: Propagation of a plant by asexual mean, as in budding, grafting, cutting, air-layering (marcoting). Hereditary characteristics of the resulting clone (ramet) are identical with those of the original plant (ortet).

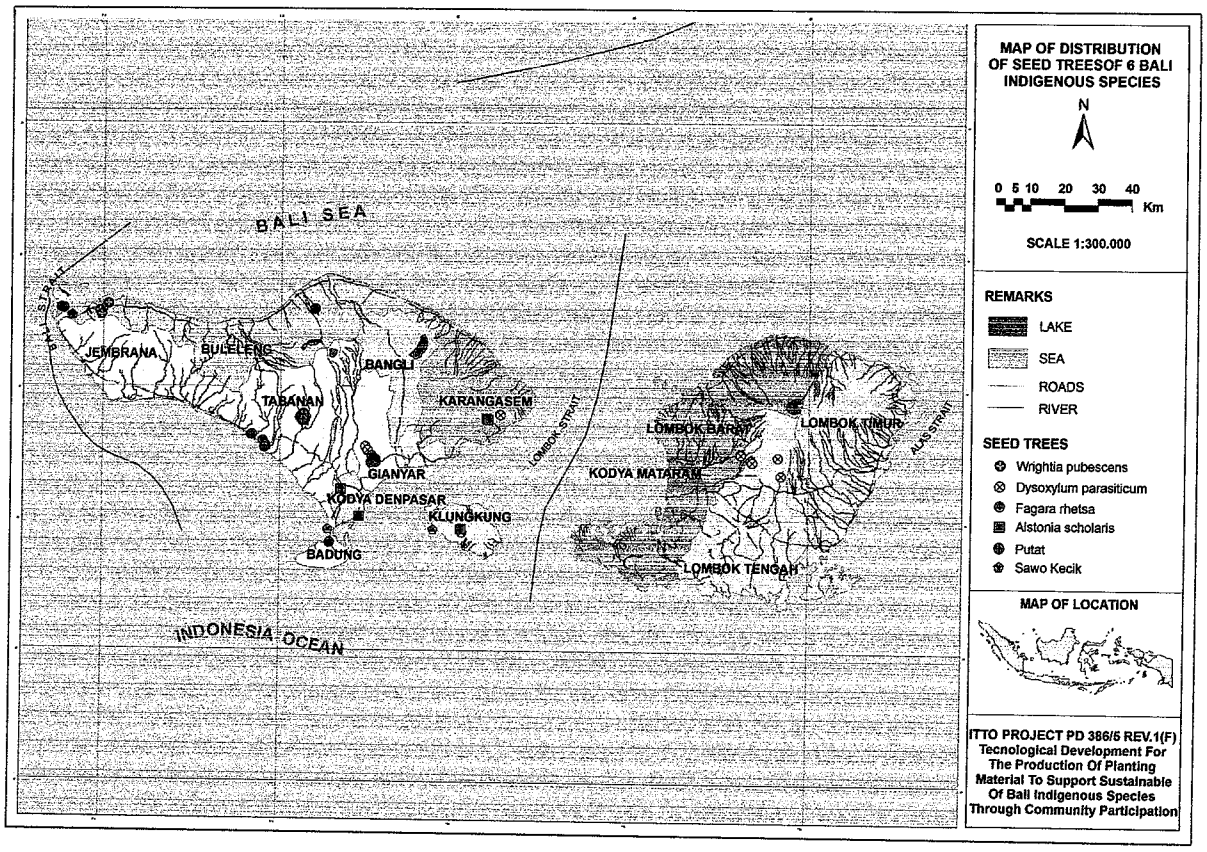
Annex 2. Locality, position, altitude, and number of trees found in the seed source identification

No	Species	Locality (village/district/ island)	Position		Altitude (m asl)[1]	Number of trees	Remark
			South	East			
1	*Dysoxylum densiflorum*	Tegallinggah, Karangasem, Bali	08°26′02,5″-08°26′07,6″	115°37′20,0″-15°37′25,1″	74	61	Seed source, private land
2		Peliatan, Gianyar, Bali	08°31′17,9″-08°31′52,4″	115°15′46,9″-115°16′10,7″	140-180	10	Seed trees, private land
3		Batumadeg, Nusa Penida, Bali	08°44′51,9″-08°45′00,9″	115°31′17,7″-115°31′22,6″	110-300	10	Seed trees, private land
4		Pemepek, Lombok Tengah, Lombok	08°33′14,6″-08°33′32,8″	116°17′31,6″-115°17′42,6″	396-466	9	Seed trees, private land
5		Wajageseng, Lombok Tengah, Lombok	08°32′43,1″-08°35′39,7″	116°21′48,9″-115°22′21,6″	431-646	5	Seed trees, private land
6		Lebak Sepaga, Lombok Barat, Lombok	08°32′11,2″-08°32′20,5″	116°15′53,4″-115°15′56,1″	372-394	4	Seed trees, private land
7	*Alstonia scholaris*	Kecincang, Karangasem, Bali	08°26′43,3″-08°26′54,5″	115°35′13,6″-115°35′28,4″	74-100	22	Seed source, private land
8		Pedungan, Denpasar, Bali	08°38′08,7″-08°42′29,6″	115°11′54,8″-115°14′50,9″	20-57	5	Seed source, private land
9		Batumadeg, Nusa Penida, Bali	08°44′26,6″-08°44′28,2″	115°31′13,1″-115°31′15,2″	110-300	3	Seed trees, private land
10	*Planchonia valida*[2]	Tegallinggah, Karangasem, Bali	08°26′02,2″-08°26′05,6″	115°37′23,8″-115°37′24,4″	70-100	5	Seed trees, private land
11		Semaja, Tabanan, Bali	08°29′53,4″-08°30′52,0″	114°59′04,6″-114°59′46,0″	10-160	9	Seed trees, private land
12		Ekasari, Jembrana, Bali	08°14′30,8″-08°15′02,2″	114°31′26,8″-114°31′45,6″	34-70	11	Seed trees, private land

No	Species	Locality (village/district/ island)	Position		Altitude (m asl)[1]	Number of trees	Remark
			South	East			
13		Pupuan, Tabanan, Bali	It is found along creek nearby roadside in Busung Biu, Pupuan, and Bonian			15	Seed trees, private land
14		Mengwi, Tabanan, Bali	It is found on lowland nearby roadside in Mengwi up to Baturiti				
15	*Manilkara kauki*	Sumberklampok, Buleleng, Bali	08°14′30,8″-08°15′02,2″	114°27′14.3″-114°27′37.9″	25	702	Seed source number: 51.08.001, forest land
16		Nusa Ceningan, Kelungkung, Bali	8°41′58,1″ - 115°26′46,2″		25	-	Seed trees, grown along road side, private land
17		Mokmer, Badung, Bali	(8°44′33,4″/115°09′50,5″)-(8°44′33,4″ /115°26′46,2″)		15	10	Seed trees, grown along road side, private land
18	*Fagara rhetsa*	Sumberklampok, Buleleng, Bali	08°09′08,5″-08°09′12,2″	114°27′14.3″-114°27′37.9″	35	633	Seed source number: 51.08.002 forest land
19		Pecatu, Badung, Bali	08°46′42,0″-08°49′52,0″	115°10′08,5″-115°07′33,8″	52-73	45	Seed trees, private land
20		Bonian, Tabanan, Bali	(8°29′23,9″/114°57′34,7″-8°30′22,3″ /114°59′19,0″) - (8°31′07,2″/114°59′44,6″-8°31′30,4″ /114°59′36,7″)		15-37	45	Seed trees, private land
21		Kemenuh , Gianyar, Bali	(8°32′44,0″/115°16′50,1″-8°33′51,3″ /115°16′43,4″) - (8°33′49,1″/115°17′27,5″-8°33′20,2″ /115°17′26,9″)		24-48	40	Seed trees, private land
22	*Wrightia pubescens*	Tegal Bunder, Buleleng, Bali	(8°08′30,5″/114°34′42,4″)-(8°08′30,5″ /114°34′42,4″)		23-91	15	Seed trees, private land
23		Pejarakan, Buleleng, Bali	(8°09′37,2″/114°33′24,1″)-(8°10′11,7″ /114°33′38,4″)		57-78	14	Seed trees, forest land

Note: 1. asl: Above sea level,

Annex 3. Map of distribution of mother trees for 6 species



Annex 4. List of Participants of training on seed collection on 15-17 February 2007

No	Name	Address	Occupation
1	I Wayan Kawit	Sumberklampok, Buleleng	Forestry Officer of Sumberklampok
2	I Ketut Tama	Sumberklampok, Buleleng	Forestry Officer of Sumberklampok
3	Saini	Sumberklampok, Buleleng	Farmer
4	Suama	Sumberklampok, Buleleng	Farmer
5	Putu Suardana	Pejarakan, Buleleng	Farmer
6	Kadek Surata	Pejarakan, Buleleng	Farmer
7	Wayan Sudiamada	Pejarakan, Buleleng	Farmer
8	Komang Suladra	Pejarakan, Buleleng	Farmer
9	I Ketut Darsana	Adnyasari, Negara	Farmer
10	I Ketut Ranta	Adnyasari, Negara	Farmer
11	I wayan Sukra	Adnyasari, Negara	Farmer
12	I Nyoman Citra	Nusa Penida, Kelungkung	Farmer
13	I Nyoman Suriawan	Nusa Penida, Kelungkung	Farmer
14	Wayan Rarat	Nusa Penida, Kelungkung	Farmer
15	Nyoman Suyasa	Pecatu, Badung	Forestry Extension Officer
16	I wayan Darma	Pecatu, Badung	Farmer
17	I Wayan Koji	Pecatu, Badung	Farmer
18	I Wayan Peneng	Pecatu, Badung	Farmer
19	I Wayan Sadia	Rejasa, Tabanan	Forestry Extension Officer
20	I Made Wirya	Blimbing, Tabanan	Forestry Extension Officer
21	I Nyoman Sukarda	Selemadeg Barat, Tabanan	Forestry Extension Officer
22	I Nengah Sudarta	Pesagi, Tabanan	Farmer
23	I Wayan Sugiada	Kerambitan, Tabanan	Farmer
24	I Made Sutarna	Selemadeg, Tabanan	Farmer
25	I Nyoman Sumarta	Pesagi, Tabanan	Farmer
26	Ketut Sandiasa	Kemenuh, Gianyar	Farmer
27	I Wayan Linggah	Kemenuh, Gianyar	Farmer
28	I Made Sumarta	Kemenuh, Gianyar	Farmer
29	Ketut Alit	Kemenuh, Gianyar	Farmer
30	I Wayan warga	Kemenuh, Gianyar	Forestry Extension Officer
31	I Nengah Sudiarta	Tegallinggah, Karangasem	Farmer
32	I Made Wage	Tegallinggah, Karangasem	Farmer
33	I Wayan Suradnya	Tegallinggah, Karangasem	Farmer
34	Slamet Hermanto	Tegallinggah, Karangasem	Forestry Extension Officer
35	Idham	Secang, Karangasem	Farmer
36	Sutrisno AR	Karangasem	Forestry Extension Officer
37	I Ketut Wiradana	Denpasar	RTSC
38	Komang Pasek S	Denpasar	RTSC
39	Tawardi	Denpasar	RTSC
40	I Made Suantra	Denpasar	RTSC
41	Udin Syamsudin	Denpasar	RTSC

Annex 5. Schedule of training on seed collection on 15-17 February 2007

No	Date	Time	Activity	Remarks
1	Day 1 (15 February)	08.00-10.00	Registration	Meeting Room Of RTSC
		10.00-10.30	Opening	Head of RTSC, Forestry Head of Bali
		10.30-10.45	Expectation of participants	Project manager
		10.45-11.15	Coffee break	
		11.15-12.00	Selection of mother trees (for seed orchard and plantation)	Dr Eko Bhakti
		12.00-13.00	Lunch	
		13.00-14.00	Discussion for selection of mother trees in the field	Head of RTSC, Dr Eko Bhakti
		14.00-15.00	Seed handling and seed documentation during collection and transportation	Technicians of RTSC (Prajitno and Rachmawati)
		15.00-15.30	Coffee break	
		15.30-16.30	Discussion for seed handling during collection and transportation	Technicians of RTSC (Prajitno and Rachmawati)
		16.30-17.00	Preparation for field visit to Karangasem, Gianyar and Badung (including grouping, documentation of mother trees, equipments, etc.)	Technicians of RTSC (Prajitno and Rachmawati)
		17.00-	Back to Bima Cottage	
2	Day 2 (16 February)	7.30-10.00	Travel to Tegallingga, Karangasem to visit seed source of *Dysoxylum densiflorum*	
		10.00-10.45	Quick tour to the seed trees	Dr Eko Bhakti
		10.45-11.00	Wrap-up discussion of mother trees at Tegallingga	Dr Eko Bhakti
		11.00-13.00	Travel to Gianyar to visit seed trees of *Zanthoxylum rhetsa*	Stop by for lunch
		13.00-13.45	Quick tour to the seed trees	Dr Eko Bhakti
		13.45-14.00	Wrap-up discussion of mother trees at Gianyar	Dr Eko Bhakti
		14.00-15.30	Travel to Ungasan, Badung to visit seed trees of *Zanthoxylum rhetsa*	
		15.30-16.30	Quick tour to the seed trees	Dr Eko Bhakti
		16.30-17.00	Wrap-up discussion of mother trees at Ungasan, Badung	Dr Eko Bhakti
		17.00-	Back to Bima Cottage	
3	Day 3 (17 February)	7.30-10.00	Travel to Penebel, Tabanan to visit seed trees of *Planchonia valida*	
		10.00-10.45	Quick tour to the seed trees	Dr Eko Bhakti
		10.45-11.00	Wrap-up discussion of mother trees at Penebel, Tabanan	Dr Eko Bhakti
		11.00-13.00	Travel to Bonian and Surabrata, Tabanan to visit seed trees of *Zanthoxylum rhetsa*	Stop by for lunch
		13.00-13.45	Quick tour to the seed trees	Dr Eko Bhakti
		13.45-14.00	Wrap-up discussion of mother trees at Bonian and Surabrata, Tabanan	Dr Eko Bhakti
		14.00-15.00	Summary and follow up of the training course, hand over the seed collection equipments	RTSC
		15.00-15.30	Closing	Project Manager
		15.30-	Travel to home town	

Annex 6. Location, weight, date of seed collection for six species on December 2006 to May 2008

A. Period: December2006 to September 2007

No	Species	Weight of Seed (kg)		Seed Source			Month of fruit collection and processing
		Collected by RTSC	Collected by BPFS	Village (District), Bali	Village (District), Lombok	Other	
1	*A. scholaris**	-	-	-	-	-	-
2	*D .densiflorum*	174.5	6	Tegallingga (Karangasem), Pengajaran (Jembrana), Pangkung Gayung (Jembrana), Batumadeg (Nusa Penida), Peliatan (Gianyar), Pengosekan (Gianyar)	Pemepek (Lombok Tengah), Rarung (Lombok Tengah), Sesaot (Lombok Barat)	-	December 2006-January 2007
3	*F. rhetsa*	73.5	30	Suraberata(Tabanan), Bonian (Tabanan), Pecatu (Badung), Sumberklampok (Buleleng)	-	-	January-February 2007
4	*M. kauki*	15.7	22	Mokmer (Badung), Nusa Ceningan (Klungkung), Sumberklampok (Buleleng)	-	Kraton (Yogyakarta)	July-September 2007
5	*P. valida***	5.2	-	Penebel (Tabanan)	-	-	August-September 2007
6	*W. pubescens*	8	17	Pejarakan (Buleleng)	-	-	September 2007
Total		276.9	75	15 seed sources	3 seed sources	1 seed source	
Grand Total		351.9		19 seed source			

Notes: *: No flowering during this period.

B. Period: December 2007 to April 2008

No	Species	Weight of Seed (kg)			Seed Source			Date of fruit collection and processing
		Collected by RTSC for Bali and Nusatenggara	Collected by BPFS	Collected by RTSC for Sumatera	Village(District), Bali	Village(District), Lombok	Other	
1	*A. scholaris**	0.1	-	0.5	Kecincang (Karangasem)	-	Palembang	December 2008
	Total	0.1	-	0.5	1 seed source	-	1 seed source	-
2	*D .densiflorum*	-	39	-	Karangasem	-	-	16-20 January 2008
		-	78	-	Karangasem	-	-	20-27 January 2008
		-	75	-	Karangasem	-	-	21-26 January 2008
		-	29	-	Karangasem	-	-	30-31 January 2008
		1.5	-	-	Sempidi (Badung)	-	-	9-10 February 2008
		5	-	-	Tegallinggah (Karangasem)	-	-	14-16 February 2008
		3	-	-	Mengwi (Badung)	-	-	16-21 February 2008
		72.5**	-	-		Rarung (Lombok Tengah)	-	17-20 February 2008
		1.8	-	-	Nusa Penida (Klungkung)	-	-	4 March 2008
	Total	83.8	221	-	5 seed sources	1 seed source	-	-
3	*F. rhetsa*	22.3	-	-	Surabrata (Tabanan)	-	-	11-13 March 2008
		14.1	-	-	Kemenuh (Gianyar)	-	-	16-18 March 2008
		18	-	-	Suraberata (Tabanan)	-	-	16-18 March 2008
		3.2	-	-	Seraya (Karangasem)	-	-	26-27 March 2008
		10.5	-	-	Kemenuh (Gianyar), Ungasan (Badung), Bonian (Tabanan)	-	-	26-28 March 2008
		-	25	-	Tegalbunder (Buleleng)	-	-	March 2008
		8	-	-	Bonian (Tabanan)	-	-	14 April 2008

No	Species	Weight of Seed (kg)			Seed Source			Date of fruit collection and processing
		Collected by RTSC for Bali and Nusatenggara	Collected by BPFS	Collected by RTSC for Sumatera	Village(District), Bali	Village(District), Lombok	Other	
		4.1	-	-	Ungasan (Badung)	-	-	28 March 2008
	Total	80.2	25	-	6 seed sources	1 seed source	-	-
4	*M. kauki*	#	#	#	#	#	#	#
5	*P. valida***	#	#	#	#	#	#	#
6	*W. pubescens*	#	#	#	#	#	#	#
Collected seeds by institutions		164.1	246	0.5	-	-	-	-
Grand Total		410.6			15seed sources			

Notes: *: BPTH Sumatera made collection of 500 grams seed, **: 2,5 kg was sown at RTSC Nursery, #: collection period June-December 2008

C. Period: June 2008 to January 2009

No	Species	Weight of Seed (kg)		Seed Source			Month of fruit collection and processing
		Collected by RTSC	Collected by BPFS	Village (District), Bali	Village (District), Lombok	Other	
1	*A. scholaris*	1.5	-	Denpasar	-	-	21-25 October 2008
2	*D .densiflorum*	7	-	Pesagi (Tabanan)	-	-	11-14 January 2009
3	*F. rhetsa*	-	-	-	-	-	-
4	*M. kauki*		50	Tegal Bunder, Buleleng	-	-	20-25 May 2009
		-	8	Benoa, Denpasar	-	-	22-24 May 2009
		200	-	Nusa Dua, Mokmer, and Jimbaran, Badung	-	-	2-30 June 2009
5	*P. valida*	3				Sumba Barat-	1-3 December 2008
		20		Pesagi, Serampingan, Baturiti (Tabanan)			8-11 January 2009
		6		Susut (Bangli)			12-13 January 2009
		19.5		(Gianyar)			13-17 January 2009
		1.5		Penarungan (Badung)			12-13 January 2009
6	*W. pubescens*	54	-	Pejarakan (Buleleng)		-	20-24 October 2009
Total		312.5	58				
Grand Total		370.5					