"Improving Forest Functions in Bengkulu Province through Community Participation in Rehabilitation of Degraded Forest by Using Local Prospective Commodities"

TECHNICAL GUIDELINES FOR SEED HANDLING AND PLANTING OF KAYU BAWANG (*Azadirachta excelsa* (Jack) M. Jacobs)

Yansen, Kamboya, Rustama Saepudin, Herry Gusmara, Gunggung Senoaji, Nyoman Mudiarte, Ahmad Mawardi, Merli Dwi Santri and Irsa Awalia

December 2018

ITTO PD 477/07 Rev. 4 (F)

"Improving Forest Functions in Bengkulu Province through Community Participation in Rehabilitation of Degraded Forest by Using Local Prospective Commodities"

TECHNICAL GUIDELINES FOR SEED HANDLING AND PLANTING OF KAYU BAWANG (*Azadirachta excelsa* (Jack) M. Jacobs)

By:
Yansen, Kamboya, Rustama Saepudin, Herry Gusmara, Gunggung Senoaji, Nyoman Mudiarte, Ahmad Mawardi, Merli Dwi Santri and Irsa Awalia

DIREKTORAT PERBENIHAN TANAMAN HUTAN

Jakarta, December 2018

ITTO PD 477/07 Rev. 4 (F)
Improving Forest Functions in Bengkulu Province through Community Participation in Rehabilitation of Degraded Forest by Using Local Prospective Commodities

TECHNICAL GUIDELINES FOR SEED HANDLING AND PLANTING OF KAYU BAWANG (*Azadirachta excelsa* (Jack) M. Jacobs)

By:
Yansen, Kamboya, Rustama Saepudin, Herry Gusmara, Gunggung Senoaji, Nyoman Mudiarte, Ahmad Mawardi, Merli Dwi Santri, and Irsa Awalia

Translated by: Yansen

Collaboration between:

The Directorate of Forest Tree Seed, Ministry of Environment and Forestry, Government of Indonesia. Manggala Wanabakti Building, Jl. Gatot Subroto, Block I Floor 13rd, Central Jakarta.
Telp. : 021-5730332
Facs. : 021-5730175
e-mail : ittopd477bengkulu@gmail.com

The Environment and Forestry Service of Bengkulu Province
Jl. Pembangunan, Padang Harapan, Kota Bengkulu
Telp : (0736) 20091, 22856
Facs : (0736) 22856

Second Edition, December 2018

Published by:
The Directorate of Forest Tree Seed
ITTO Project of PD 477/07 Rev. 4 (F)
Manggala Wanabakti Building, Jl. Gatot Subroto, Block I Floor 13rd, Central Jakarta.
Telp. : 021-5730332
Facs. : 021-5730175
e-mail : ittopd477bengkulu@gmail.come-mail :

.

PREFACE

Rehabilitation and conservation of forest resources as well as socio-economic empowerment of communities surrounding forests is one of the keys to the success of sustainable forest management in Bengkulu Province. Through the Program of "Improving Forest Functions in Bengkulu Province through Community Participation in Rehabilitation of Degraded Forest by Using Local Prospective Commodities", ITTO in collaboration with the Ministry of Environtment and Forestry intends to contribute to sustainable forest management through rehabilitation activities using prospective local species. One of these local species is Kayu Bawang which has the scientific name *Azadirachta excelsa* (Jack) M. Jacobs.

To support the program, a technical guideline on seed handling and seedling planting was developed. The first edition of the book has been published under the title "Technical Guidelines for Seed Handling and Planting of Kayu Bawang (Dysoxylum mollissimum Blume)". However, in its development and after going through a more in-depth study through tracing the key to botanical determination, the book has been revise with a Latin name that is more accountable, *Azadirachta excelsa* (Jack) M. Jacobs

In this revised edition, the title used is "Technical Guidelines for Seed Handling and Planting of Kayu Bawang (*Azadirachta excelsa* (Jack) M. Jacobs)." From this revised edition of the book it is expected that the application of techniques and methods that have gone through a series of studies can improve the cultivation techniques of Kayu Bawang which has been used so far. Hopefully this book can be a good use for all parties.

Jakarta, December 2018

Ir. Mintarjo, M.MA
Director of Forest Tree Seed

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

1.1. Background

Bengkulu Province consists of 2,007,223.9 ha land area. According to Ministerial Decree of Forestry No. 784/Menhut-II/2012, the area of forest in Bengkulu is 924,631 ha, or about 46.1% of land area. The area of forests in Bengkulu Province is categorized as protection forests (about 250,750 ha), production forests (about 210,916 ha) and conservation forests (about 438,095 ha) (Forestry Service of Bengkulu Province, 2013).

Production forests are divided into production forests and limited production forests. In the area of production forests, there are only about 13% of primary forests and 52% of secondary forets remaining. Furthermore, limited production forest area has lost about 50% of its forest cover, with only about 10% of primary forests and 40% of secondary forets remaining.

In general, from the total forest area in Bengkulu Province, national parks still have relatively good forest cover; in which primary forest cover are still around 76% and secondary forest are about 16% of the existing area. However, other conservation areas such as nature reserves and natural tourism parks have been degraded significantly. Of the 4,300 ha of total nature reserve, only around 31% are still forested, and they are only in the form of secondary forest. The remaining coverage is non-forested area. Forested areas of natural tourism parks are only around 33%.

Protected forest area coverage is still in the form of primary forest for about 42% and in the form of secondary forest for about 33%. This means that the non-forested area of protected forests reaches almost 25% out of 250,750 ha. The forms of changes of forest land to be non-forested area are non-vegetational area, shrubs, plantations or other agricultural land. Due a to reduced forest vegetational cover, the amount of forest biodiversity is predicted to experience a significant decline. The functions of forest environmental services in water management regulation (hydrology), maintaining of local climate and providing wildlife habitat are also degraded (Forest Service Province Bengkulu, 2013)

The remaining forest areas in Bengkulu are also increasingly threatened due to an increased of encroachment and illegal logging activities and the establishment of several large non-forestry companies. This forest area was not only damaged by illegal settlements, but also damaged by the impact of activities of large companies which engage in mining and plantation sectors. For example in mining activities, the clearing of forests for road construction has opened access for encroachers to enter the forest. Even in some places, post-mining reclamation activities have not been carried out properly. The establishment of large oil palm plantations in Bengkulu also stimulated the community to expand their plantation land by encroaching forest areas.

The efforts to reduce deforestation are even more difficult due to economic pressure, lack of social awareness and weak law enforcement. The rise of conflicts between communities and the private sector in terms of forest utilization is partly due to limited available area for the community. The people often feel to be neglected because they see the private sector can access the forest, but on the other hand they cannot do that. As there are development schemes that can involve the community, the community management space, such as for agriculture, can be expanded. The development of community plantation programs, community forests or village forests can facilitate community's involvement in forest management. However, the community must also be educated that forest utilization has some rules to follow. Therefore, the provision of greater management space to the community must also be followed by efforts to empower the community itself.

Therefore, forest rehabilitation programs need to consider many aspects. Forest rehabilitation should not be only aimed to improve ecological function of forest ecosystems, but also to provide economic benefits to the community. In order to achieve sustainable forest management, these two main things are the key, i.e. the rehabilitation and conservation of forest resources, and socio-economic empowerment of communities around the forest. As forest rehabilitation is one of the priority programs of the Ministry of Environment and Forestry, various activities to support forest rehabilitation continue to be implemented.

A collaborative program between International Tropical Timber Organization (ITTO) and Ministry of Environment and Forestry of Republic of

Indonesia, "Improving Forest Functions in Bengkulu Province through the Community Participation in Rehabilitation of Degraded Forest by Using Local Prospective Commodities", is one of the efforts to rehabilitate degraded forests. Forest rehabilitation in this program is by planting prospective local species of woods. The selected tree to be planted is species Kayu Bawang (*Azadirachta excelsa* (Jack) M. Jacobs). Since it was also aimed to contribute to the socio-economic development of the community, then the community members were involved in the program.

1.2. Purpose

There are many things to do to achieve program objectives, including the use of suitable technology to produce quality planting materials. Forest rehabilitation activities indeed begin with the preparation of planting material or seedlings of forest plants to be planted. Each species has different characteristics of regeneration and development of seedlings. Therefore, information about seed handling and planting is a starting point for the success of the program. The purpose of compiling the "Technical Guidelines for Seed Handling and Planting of Kayu Bawang (*Azadirachta excelsa* (Jack) M. Jacobs)" is to collect information about the characteristics of the Kayu Bawang and handling practices that have been carried out so far. This information was then supplemented with the results of existing studies to develop more systematic technical guilines for seed handling and planting of Kayu Bawang. It is expected that this information can serve as an additional guide for everyone who intends to plant Kayu Bawang.

1.3 Objective

1. The objectives of the compilation of book "Technical Guidelines for Seed Handling and Planting of Kayu Bawang (*Azadirachta excelsa* (Jack) M. Jacobs)" as follows:
2. Collecting and compiling information on seed handling and planting of Kayu Bawang.
3. Providing systematic technical instructions that can be used by various parties.

4. Presenting information about Kayu Bawang for wider audience.
5. Supporting the development of Kayu Bawang on a wider scale.

II. KAYU BAWANG

2.1. Geographical and ecological distribution and taxonomy

Kayu Bawang (*Azadirachta excelsa* (Jack) M. Jacobs) is widely distributed in Sumatra. In other places this wood is known by other names. In West Java, this wood is called "ki bawang", while in Sulawesi it is known as "tumbawa sela". Kayu Bawang belongs to the Meliaceae family. In Bengkulu Province, Kayu Bawang is widely distributed in North Bengkulu and Central Bengkulu. Outside Indonesia, the distribution of Kayu Bawang includes India, Burma Myanmar, Southern China, Melanesia to Australia, East Fiji and Samoa (Sosef et al., 1998).

Kayu Bawang can grow at elevation between 0 - 1,000 m ASL, with the average rainfall ranging between 500-3,500 mm/year. This tree can also grow in almost all types of soil, but the best growth of the plant requires fertile, loose soil conditions and good aeration (Provincial Forestry Service Bengkulu, 2003). In Bengkulu Province, Kayu Bawang is spread in several districts. Based on research conducted by Forestry Research Institute (FRI) Palembang (2010), Kayu Bawang could be found in regencies of North Bengkulu, Central Bengkulu, South Bengkulu and Rejang Lebong (Table 1). Among those 4 rengencies, Bawang Kayu stands are most commonly found in North Bengkulu and Central Bengkulu. These two regencies are at the lowland areas. According to the results of the interview, it was claimed that the two regencies were recognized as the area of origin (natural distribution) of Kayu Bawang.

Table 1. The distribution of Kayu Bawang in Bengkulu Province

No.	Distribution Area	
1	Bengkulu Utara District	Sawang Lebar Village, Curup Village, Pondok Kubang Village and Senabah Village
2	Bengkulu Tengah District	Kembang Ayun Village, Pasar Pedati Village
3	Bengkulu District	Air Sulau, Batu Ampar Village, Lubuk Ladung Village, Merambung Village, Simpang Pino Village, Bakal Dalam Village
4	Rejag Lebong District	Lubuk Saung Village, Bandung Marga Village, Pal 7 Village, Beringin Tigo Village, Pelalo Village, Kampung Delima Village

Sumber: Forestry Research Institute Palembang 2010

Berdasarkan taksonomi, Kayu Bawang diklasifikasikan sebagai berikut (Utami *et al*., 2018):

Kingdom	:	Plantae
Class	:	Dicotyledonae
Order	:	Rutales
Family	:	Meliaceae
Genus	:	Azadirachta
Spesies	:	*Azadirachta excelsa* (Jack) M. Jacobs
Other name	:	*Azadirachta integrifolia* Merr., *Azedarach excelsa* (Jack) Kuntze, *M. excelsa* Jack, *Trichilia excelsa* (Jack) Spreng.
General Name	:	Sentang (nama dagang), Kayu Bawang (Indonesia)

2.2. Morphological characteristics

The height of the Kayu Bawang tree can reach 30-40 m and the stem diameter (dbh) can reach 100 - 120 cm. The bark is gray to light brown with a rather slippery texture. The leaves are a single compound with ellipse shape and the tip is tapered with pinnate leaf veins. The fruit is fleshy and round. The seeds are oval-shaped with a length of about 2 cm and a diameter of 1 cm, with hard outer skin (Forestry Service of the Province of Bengkulu, 2003).

2.3. Cultivation Aspects

Currently, propagation of Kayu Bawang is using generative regeneration from seeds. Although there have been several studies on vegetative propagation, for example through cuttings, Kayu Bawang planters still rely on generative regeneration from seeds. Seeds of Kayu Bawang are are recalcitrant; hence they cannot be stored for long. Siahaan et al. (2008) stated that the decrease in germination ability reached 55.5% after being stored for 4 weeks. Storage in the refrigerator can increase the germination of Kayu Bawang by 5.8% compared to storage in room temperature. Other experiments also showed that Kayu Bawang, in which fruits were collected from trees and then skin was peeled, showed low germination rate. On the other hand, seeds collected from the ground have a much higher germination rate. Therefore, further and

comprehensive research on the characteristics of Kayu Bawang seeds needs to be conducted. In addition to seed collection, Kayu Bawang nursery could also be grown by sapling transplantation method.

Kayu Bawang has been developed in the form of community-based management since the 1990s, by planting these species on community-owned land known as community forests. Community forests are economically beneficial. It could provide additional income for the community if it is managed properly. In addition, community forests provide ecological benefits by forming tree stands that create an environment resembling of natural forests.

In practice, Kayu Bawang has been cultivated with monoculture and multi-species agroforestry planting system. Monoculture planting is generally carried out by people who have large area of land and adequate fund, so they can only plant Kayu Bawang on their land. Communities in Bengkulu Tengah District and North Bengkulu have accustomed to plant timber trees on the land they own mixed with their crops on agroforestry system. Kayu Bawang has been planted on people's lands for generations (Depari, 2011). Initially, the planting of Kayu Bawang was prepared for building wood materials when their children would have a family. However, this tradition has begun to diminish.

The growth of Kayu Bawang in North Bengkulu in general can be categorized as a productive stands. Apriyanto (2003) found that stand of monoculture planting of Kayu Bawang in North Bengkulu Regency until at the age of 9 years has 1.93 cm/ year diameter increment, 2.11 m/year heought increment and 24.42 m3 /ha/year volume increment. Based on the size of incremental growth, Kayu Bawang monoculture stand in North Bengkulu can be categorized as a productive stand. The stand of Kayu Bawang on private land at the Karang Tinggi Village, Centra Bengkulu (Figure 1.)

Figure 1. Stand of Kayu Bawang on private land at the Karang Tinggi Village, Centra Bengkulu

The planting patterns developed in the community owned lands are adapted to the conditions and the area of available lands, market conditions and community needs. Planting of Kayu Bawang with an agroforestry system in Bengkulu is commonly combined with coffee or rubber. The growth of Kayu Bawang is different with different densities of trees in agroforestry systems (Siahaan et al. 2011). Kayu Bawang planted planted with lower density, i.e less number of trees per area, has a higher average diameter, for both planted with coffee agroforestry, as well as multi species (Figure 2).

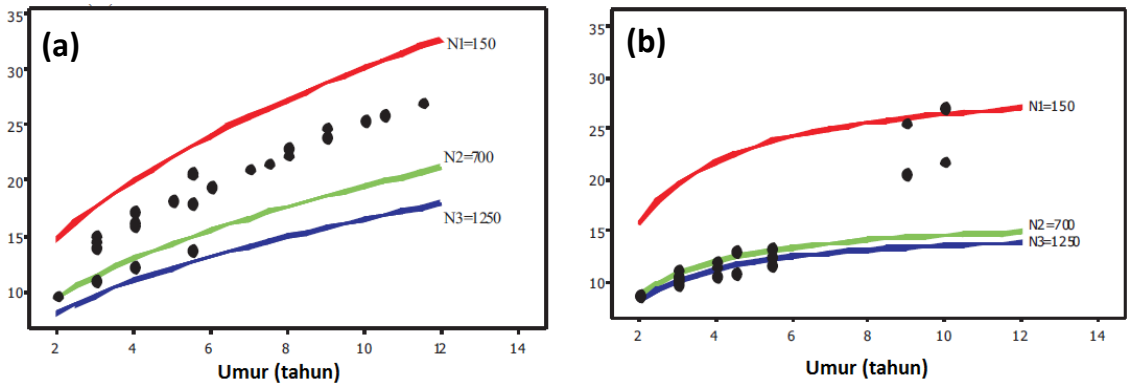

Figure 2. The increase in diameter of Kayu Bawang planted in agroforestry system with coffee (a) and multi species (b). N is the number of individuals of Kayu Bawang per hectare (Siahaan et al. 2011)

The main objective of planting by combining forest tree with plantation crops is to optimize land use. Depari et al. (2013) conducted a study of the potential of volume of Kayu Bawang stands planted in several types of cropping patterns with simple agroforestry systems. These cropping patterns include a combination of Kayu Bawang with coffee and a combination of Kayu Bawang and coffee and rubber.

In this study, observed stands of Kayu Bawang had different ages, i.e. 3, 7 and 9 years. Planting combination had different number of trees per ha of Kayu Bawang. As seen in Table 2, the volume and increment of the Kayu Bawang stands with a density of 500 trees/ha and planted in combination with 3-year-old coffee had a basal area of 6.89 m2/ha and a volume of 43.88 m3/ha. The increment of basal area was 2.3 m2/ha/year. The volume increment was 14.65 m3/ha/year. The potential of this stand is higher than Kayu Bawang planted in a combination with coffee and rubber aged 3 years and a density of 288.89 trees/ha, in which the basal area was 2.83 m2/ha resulting a volume of 15.15 m3/ ha. The increment of basal area was 0.9 m2/ha/year. The volume increment was 5.05m3/ha/year. Furthermore, the volume and increment of the Kayu Bawang stand at the age of 7 years and 9 years combined with coffee also had a volume and increment of stands that are larger than the volume and increment of stands of Kayu Bawang combined with coffee and rubber. This research shows that the combination of Kayu Bawang stand can be done in several forms. However, the volume of wood produced will depend on how many individuals the Kayu Bawang can be planted in each combination of planting.

Table 2. The measurement of several parameters, i.e. number of trees, density, basal area and volume, in combination of Kayu Bawang and coffee, and combination of Kayu Bawang with coffee and rubber.

Keterangan	Planting Pattern							
	Kayu Bawang + Coffee				Kayu Bawang + Coffee + Rubber			
	Age (year)				Age (year)			
	3	7	9	Mean	3	7	9	Mean
Number of Tree	45	30,8	27,67	34,49	26	46,2	28	33,4
Density (tree/ha)	500	342,22	307,41	383,21	288,89	513,33	311,11	371,11
Basal area (m^2/ha)	6,89	8,54	10,68	8,70	2,83	9,37	8,59	6,93
Volume (m^3/ha)	43,88	82,99	116,13	81	15,15	82,8	79,44	59,13
Basal area increment (m^2/ha/thn)	2,3	1,22	1,19	1,57	0,94	1,34	0,95	1,08
Volume increment (m^3/ha/thn)	14,63	11,86	12,9	13,13	5,05	11,83	8,83	8,57

Source : Depari *et al*,(2013)

Kayu Bawang has straight stem and is classified as a fast growing species (Apriyanto 2003). The wood of Kayu Bawang is included in the class B in terms of resistance, which is quite resistant to termite attacks (Nuriyatin et al. 2003). Therefore, this wood can be used for carpentry, handicrafts and furniture. In the Fiji region, Kayu Bawang is used for wound medication (Sosef et al. 1998).

III. SEED SOURCES OF KAYU BAWANG

The availability of seeds depends on the source of the seed. According to Mulawarman et al. (2002), the source of seeds is trees or stands that are used as seed collection area. Based on the Seed Source Standard Guideline by Ministry of Forestry (2010), seed sources can be obtained in two ways: (1) designing existing stands (natural forest or plantation) as sources of seeds or (2) building new sources of seeds by planting. For the first way, the stands were not initially grown for seed production but for other uses, such as timber production, protected forests, and so on. For the second method, the devlopment of stand was initially intended decided to produce seeds.

The advantage of the designation of existing stands as sources of seeds is that seeds can be produced earlier. If we build a new seed source, we have to wait for 5 - 20 years (depending on the species) before the seeds can be harvested. However, building seed sources will ensure higher genetic quality seeds that can be obtained, provided that the genetic material for development is carefully selected.

Another advantage is that it is cheaper to identify existing stands than developing and managing them as seed sources. However, assigning existing stands as seed sources may result in lower genetic quality of the seeds. Existing natural forests and plantations can be assigned as seed sources, depending on species and availability of stands.

The decision to assign an existing stand into a source of seed or to build a new seed source needs to consider the following:

1. If high-quality stands do not exist, new seed sources must be developed.
2. If there are only few seeds of a species that are needed, it may be too expensive to build a source of seed, so it is recommended to convert the existing stand into a seed source.
3. Under certain conditions, identified seed stands might be used as a seed source if assigned seed source has not been producing seeds yet.

3.1. Designation of seed sources

a. Identification of seed sources

The purpose of identifying the area for seed sources is to fulfill the need of adequate quantity of seeds with high genetic quality. There are 8 criteria to be considered when identifying seed sources. The first six criteria can be used for field orientation or quick assesment for receiving or rejecting an area as a source of seeds (complete information can be seen in the Guidelines for Identification and Description of Seed Sources). Those 8 criteria as follows:

1) Accessibility

The stand is easy to be acessed in every season. Even it is better if the area is next to the road. If the stands is not easily to be accessed, it is difficult to manage the seed source, which is difficult to implement management, supervision and inspection. In addition, collecting seeds will be more difficult.

2) Number of trees and size of area for seed source

a) If a source of the seed is identified in natural forest, the number of parent trees must be considered when determining the size of the seed source. The minimum number is 25 parent trees for target species in a seed source. This amount is needed so that the genetic variation is quite wide. If less than 10 trees are in the seed source, then the genetic variation is narrow. Consequently, the quality of stands grown with seeds from such seed sources may not be good. The minimum number of 25 trees is a general guideline ("rule of thumb") and preferably more.

b) The parent trees should not be related. This means that the trees are not close relatives, which is the siblings of the same mother. In natural forests, family structures could be identified, in which adjacent trees come from the same parent because the seeds fall close to the parent tree.

c) It should be noted that we need to avoid collecting seeds from one or a few trees, because the genetic variation is not wide enough. Therefore, it should be better get 25 family groups in the

seed source. Appointing family groups is sometimes easy to do in natural forests, but the structure is sometimes unclear. Therefore, the parent tree should be at least 50-100 m apart.

d) Trees in plantations are assumed to originate from many mother trees, and the seeds are well mixed. As in natural forests, there should be a minimum of 25 trees in plantations. The number of trees in planttaions is not a problem because there are generally hundreds of trees in plantations. Based on the assumption that seedlings in plantation originated from many well mixed mother trees, family structures as in natural forests were not found. Therefore, seeds could be collected from all trees (not requiring minimum distance requirements).

e) The size of the seed source depends on the number of seed requests. Seed source managers should estimate future seed demand and compare it with seed availability for that species. It is recommended to plant additional trees. This additional area will be usefull if the demand for seeds exceeds estimation or it turns out that production per hectare is lower than expected.

3) The quality of stands

a) The quality of stands is a very important criterion. Selected stands should be of good quality (above average) to keep the seeds collected also of above-average quality.

b) The stand is chosen based on the appearance of the phenotype (tree appearance). Tree phenotypes are the result of a combination of genetic and environmental factors. However, only the genetic properties are passed on to the next generation. Selection based on phenotypes can be effective if there is a large genetic influence on the phenotypic traits. If the superiority of the phenotype is a reflection of environmental influences, then the selection made is not effective. The seeds produced from that source might not of high quality. Generally there are large genetic influence in traits such as trunk, while stem height and diameter is ver much influenced by environmental factors. Therefore, the

selection of phenotypes will generally be more effective for trunk-like properties than the growth in height and diameter.

c) Stands should also be selected based on quality criteria. For example, if planting for furniture materials, the selection criteria should be branch-free and height of stem below the branch. If the plantation is intended for pulp production, the criteria are wood volume and stem shape. If the purpose is for fruit production, the selection criteria are fruit quantity, fruit size or taste.

d) Seed sources can only be identified if selection criteria have been determined. Seed sources for furniture production, for example, cannot be identified before the stem shape is observed. If the observation is conducted too early, the selection may not be effective.

e) Seed sources could not be assignated in natural stands or plantation in which high-quality trees have been cut down and the remaining trees are of low quality.

4) Flowering and fertilization

a) It should be considered that stands that will be designated as sources of seeds have flowered and produced seeds. Flowering and fertilization in trees should be examined or observed. Fruit observations can be conducted by searching for fallen fruit and seeds or looking for seedlings growing on the forest floor. Community around the stands can also be asked about flowering and fertilization of the trees.

b) We should avoid to identify stands as sources of seeds if we could not ensure that the stands have produced seeds. In addition, the seed source should not be designated when the stand is still to young, and it has not yet begun to flower and bear fruit.

5) Security

Stands designated as sources of seeds should be safe, protected from illegal logging, land grabbing for agriculture and other uses, fire disturbances, disturbance of livestock and wild animals that can damage stands and disrupt seed production.

6) **Health**

Stands should be healthy. Stands are accepted as a source of seeds if they are free or less attacked by pests and diseases.

7) **Origin**

a) For the designated seed sources in natural forests, the origin of the tree has to be clearly known.

b) For the designated seed source in the plantation, it is better to know the origin of the tree. This provides information on tree geographical provenance, and how many parent trees are available.

c) In certain conditions, in which the information is not available or partially available, we sometimes have to ignore the criteria and be forced to designate the source of the seed even though the origin is unknown.

8) **Isolation**

a) Isolation is not required for identified and selected seed stands.

b) In the seed production area, the isolation pathway is better to be bulit to prevent pollen contamination from outside area. However, this criteria often could not be met when assigning the seed source.

It is recommended to compare several prospective seed sources and to determine the best one as the seed source. Sometimes it is not possible to find a source of seeds that meets these 8 criteria. Thus, stands must be chosen that meet the criteria as many as possible and are believed to meet the objectives for high-quality seed production.

b. Classification of seed sources

1) Seed source can be classified into identified seed stands, selected seed stands and seed production areas (see Table 3).

2) Identified seed stands, selected seed stands, and seed production areas can be designated from plantation forests, whereas from natural forests mostly can only be identified and selected seed stands.

3) The classification is mainly based on stand quality. Identified stands have an average quality compared to other stands that are the same species at a location. The quality of selected seed stands is above average. Seed production areas are specially identified or selected seed stands, usually by thinning, to improve the quality and production of seeds.
4) Management of identified and selected seed stands is almost non-existent or very limited (such as weed cleaning, thinning, etc.).

c. Development of Seed Souces

When a seed source is built specifically only as a source of seed, there is more possibility of obtaining higher-quality genetic seed production than the designation of seed sources. However, this depends on a number of considerations that must be taken when building seed sources.

Sources of seed that is developed specifically only as a source of seed as follows:

a. Seed production area
b. Provenance seed stand
c. Seedling nursery
d. Clonal nursery
e. Pruning nursery.

In accordance with the level of breeding, the better class of the seed source, the higher the genetic quality. As this Technical Guideline is intended to guide activities in the field, the procedures for building seed sources are not discussed in this technical guide.

Table 3. Matrix for seed source identification

Actvities for Designation of Seed Source	**Natural Forest**		**Plantation Forest**		
	Identified seed stand	**Selected seed stand**	**Identified seed stand**	**Selected seed stand**	**Seed production area**
1. Accessibility	Easier to access is better				
2. Number of trees	A minimus of 25 parent trees with distance between tress about pohon 50-100 m		Many parent trees, distance between tress is not a problem		
3. Stand quality	Average	Above average	Above average	Above quality of identifies seed stand, or the improvement of identified/selected seed stand through thinning	Above average
4. Flowering/fruiting	Known				
5. Security	Guaranteed				
6. Health condition	Free of pests and diseases				
7. Origin	Clear, as it is natural forest		It is better to know the origin (provenance, seed source)		
8. Isolation pathway	Not needed		It is reccomended to make isolation pathway, however generally the isolation pathway dose not exist		

3.2. Source of seeds of Kayu Bawang

In Bengkulu Province, the source of Kayu Bawang seeds could be found in Talang Boseng Village, Pondok Kelapa District, Bengkulu Tengah Regency, which has been designated as an “Identified Seed Stand” by the Sumatra Forest Plant Seedling Center on December 7, 2015 with the Seed Source Number: 17.09,001, covering an area of 1 ha. Finally, the Region I Forest Plant Seedling Center (a new name), facilitated by the ITTO PD Project 477/07 Rev.4 (F), established a new source of Kayu Bawang belongs to Mr. Sanusi in Penyangkak Village, Kerkap District, North Bengkulu Regency on the 18th May 2016 with Number of Source of Seed: 17.03,007, covering an area of 0.75 Ha. More than 50 individuals of Kayu Bawang grow mixed with coffee plant (Figure 3) with a diameter of more than 80 cm. This stand of Kayu Bawang has a good phenotype, flowering in May 2016 and is expected to be harvested in November - December 2016. Both seed sources of Kayu Bawang above comply with 8 criteria that have been described in Sub-Section 3.1.

In addition to the seed sources mentioned above, there are other stands of Kayu Bawang that can be designated as potential sources of seeds, such as at the Ujung Karang Village, Bengkulu Tengah Regency. Kunarso and Siahaan (2008) also identified and mapped Kayu Bawang tree in Sawang Lebar Village, Air Besi District, North Bengkulu Regency. Whereas in Seluma Regency there are also stands of Kayu Bawang which can be assigne as a source of seeds. However, based on observations in 2015, some of Kayu Bawang stands in Seluma District have not yet been fruitful.

Figure 3. Stand of Kayu Bawang in Penyangkak Village, Kerkap District, North Bengkulu

IV. SEED/FRUIT COLLECTION AND GERMINATION

Kayu Bawang can be propagated using seeds or seedlings growing around the mother tree. Kayu Bawang trees currently grown by cimmunity are all reproduced generatively by seeds. In 2015, without knowing the cause, Kayu Bawang in several areas in Bengkulu was reported to be fruitless. However, those Kayu Bawang were furiting in 2016. The flowering season started around February and seed collections were conducted in May - July 2016. However, the seed source of Kayu Bawang in Penyangkak Village of North Bengkulu (Number of Source of Seed 17.03.007, an area of 0.75 Ha) was reported to be flowering in May 2016, and was expected to harvest the fruit in November - December 2016.

The weight of seed of Kayu Bawang varies. For skinned seed, the number of seeds per kilogram is around 100-150 seeds, while for unskinned seeds, the number of seeds per kilogram reaches 350 seeds. Kayu Bawang seed may have a 80% percent growth rate, with a short dormancy period of approximately 10 days. During this 10-day period the percentage of growth may decrease to 50% (Riyanto, 2001). The recalcitrant seeds of Kayu Bawang can not be stored for long. As the Kayu Bawang seeds are rapidly decreasing in viability, the storage of seeds for Kayu Bawang is still an obstacle in seeding.

4.1 Collection of fruit/seed

There several ways or method for collecting seeds/fruits of Kayu Bawang, which depend on the type and size of the tree. The collection methods that can be applied include:

a. Collecting seeds from the floor of the tree stand

This method is cheap and easy to do. Kayu Bawang fruit is quite large (the dimensions of the seeds could reach 2 cm in length and 1 cm in diameter), making it easy to see on the floor of the stand and to be collected. Falling fruits on the forest floor are also usually rather open skin which may facilitate germination (Figure 4). In addition, Kayu Bawang is also usually planted in agroforestry with other plants, such as coffee. This makes the stand floor relatively clean and easier to collect seeds. However, several things must be considered for the seeds collected from the base of the stand, including:

- Fruit may be attacked by microorganisms
- Falling fruits are often not old enough.
- Fruits coming up first will fall first and the quality may not be good

Therefore, collected fruits from the floor of the stand must be sorted properly. Seeds collected from the stand floor should not be mixed with seeds collected directly from the tree, but must be included in a separate container. Fruits seeds collected from the forest floor may carry seed pests or diseases.

Once collected, fruits/seeds can be placed in a container. Each container used to store fruit temporarily is labeled so that the seed identity is still known. This becomes even more important when fruits/seeds were collected from different locations.

Figure 4. Fruits of Kayu Bawang were collected by picking up from the floor stand (a) and from the tree (b).

b. Collecting/picking fruit from the tree

This method is applied if the tree is tall enough and impossible to reach from the ground. Collecting fruit from the tree can be done by climbing or with the help of hooked pole. Climbing allows the climber to collect fruit on trees more freely and can choose ripen fruits. However, not all parts of the tree can be reached by climbing. In addition, safety aspects must also be considered. On the other hand if you use a pole, then there is the possibility of picking up fruit that has not been ripen yet because it is hard to observe from the ground. Consequently, we might collect fruits with various levels of maturity.

During collection, fruits can be dropped on a tarpaulin or plastic mat, so the fruits are spread on the ground. Then the collected fruits are put into a container to be brought to the processing site. In addition, climbers can carry a container that is strong and light, as a place for fruit to be picked. The container is lowered with a rope when it is full and than the fruits can be put into a larger sack to be taken to the processing or temporary storage. Each container used to store temporary fruit must be labeled so that the seed identity is still known. This becomes even more important, especially for picking fruit from trees of different locations.

4.2 Selection of fruits/seeds

Before the germination process, a seed selection process is carried out. Some things related to seed selection include:

- Seed selection aims to choose seeds that are healthy, fresh and do not appear to be attacked by pests or diseases.
- Seeds collected by picking up on the floor of the stand must be selected and decayed seeds must be discarded (Figure 5).
- Seeds collected by picking up often have begun to germinate. Germinated seeds are separated and can be directly transferred to the sowing bed.
- Fruits picked from the tree are selected to assort old/ripen seeds.

Figure 5. Kayu Bawang fruits that have been collected by picking up from the stand floor which must be selected to get appropriate seeds.

4.3 Seed extraction, seed cleaning and sorting

Seed extraction is the process of removing seeds from the fruit. There are various ways that can be done to extract Kayu Bawang seeds, for example manually by removing the skin or by soaking the Kayu Bawang fruits in water, at least for 24 hours (Figure 6). For Kayu Bawang fruits collected from the stand floor can not be extracted. Because the skins of the falling fruits are sometimes broken and almost detached.

After extraction, the fruits are cleaned and sorted again. This is done because, among others:

- Seeds that have been extracted still contain remaing husks, pods, twigs, fruit flesh and damaged soil, and
- Dirts must be disposed to improve its quality
- After cleaning, seeds can b sorted based on the size of the seeds.

Figure 6. Kayu Bawang fruits were soaked with water (top) and then extracted (bottom).

4.4. Seed storage

Seeds of Kayu Bawang must be germinated immediately because they are recalcitrant, so they cannot be stored for a long time in open space. Siahaan et al. (2008) stated that the decrease in viability of Kayu Bawang seeds was relatively fast, which was indicated by a decrease in germination of 55.5% after being stored for 4 weeks, but in contrats the germination rate increased 9 days earlier. Storage in the refrigerator can increase the germination of Kayu Bawang by 5.8% compared to storage in room temperature. Because of this, long period of storage is not recommended for Kayu Bawang.

Table 4. Effect of storage period on germination, speed of germination and simultaneously of growth of Kayu Bawang seeds (Siahaan et al., 2008)

Storage priod (week)	Germination rate (%)	Germination speed (day)	Simultaneously of growth (%)
0	91,00	30,66	63,15
1	84,00	26,55	53,24
2	83,25	22,46	68,28
3	70,25	23,62	72,50
4	35,50	21,61	87,11

4.5. Germination

For germination, seeds are sown evenly on the surface of the media. A mixture of sand and soil can be used for bed media. To speed up and increase the percentage of germination, seeds can be immersed in a solution of growing stimulating hormones, such as gibberellin (GA). The germination speed of Bawang Kayu seeds can reach 20-30 days. Seeds obtained by collecting from the stand floor can germinate faster.

Germination is defined as when the root (radicle) emerges from the seeds (Copeland and McDonald, 2001). Seeds then absorp the water and then the root is coming out. The type of germination is epigeal germination, where cotyledons (seed embryos) are lifted up (Figure 7).

The fruit has to be mature so that the seed could germinate. Therefore, seed selection process is important to assort seeds that are ready to germinate. Water, oxygen and temperature are important environmental factors that greatly affect germination. Water significantly determines the germination process. When seeds absorb water, the germination process begins (Bradford 1995). But, excessive water is also not good because it will inhibit oxygen from entering the seeds. Oxygen is needed so that germination could be successful. In addition, the temperature also affects the capacity and germination rate.

Considering factors previously mentioned, watering intensity and temperature regulation for germination are very important. Watering of germination sowing beds should be applied every day, which can be done in the morning or evening. In addition, the sowing bed must be shaded. Seeds can be placed in sowing beds with sufficient shades or the intensity of the incoming light of about 50%. This keeps the temperature not too high and also the water does not evaporate too quickly from the soil.

Figure 7. Kayu Bawang seeds begun to germinate

4.6. Transplantation and the development of seedlings

Germinating seeds which have opened two pairs of leaves are ready to be transplanted into the planting media. Transplanting is done by gouging media around the germinating seed until it can be removed along with the roots. The seedlings can then be transplanted into polybags of size 10 cm x 20 cm, each of which contains planting media. The media used can be a mixture of soil + rice husk + manure. Other media in the form of a mixture of soil + rice husk charcoal and added fertilizer. The seeds are placed in seedling beds with sufficient shade or the intensity of the incoming light of about 50%. Shade material can be made plastic (paranet), palm fiber, coconut leaves or straw Watering is done once a day at 6.00 – 8.00 in the morning or at 16.00 -17.00 in the afternoon. Based on the research by Siahaan et al (2006), the provision of compost charcoal as a topsoil mixture for Kayu Bawang seedling media can increase the growth of seedlings. The provision of compost charcoal can improve the structure and texture of the media, increase the nutrient content and increase the pH of the media in polybags. While giving paranet with a shade density of 55% can also increase the growth of Kayu Bawang seedlings (Figure 8).

Figure 8. Seedlings of Kayu Bawang that have been transplanted and grown in polybags

With an appropriate care, Kayu Bawang seeds will grow quickly. Seedlings of 2.5 month-old Kayu Bawang can reach an average height of 33.8 cm (Figure 9). On average, 4 month-old seedlings can be planted in the field.

Figure 9. Illustration of the growth rate of Kayu Bawang seedlings

V. PLANTING AND STAND TENDING

5.1. Planting

After transplanting and growing in polybags, Kayu Bawang seedlings will be planted in the field. A 4 month old Kayu Bawang seedlings, is ready to be planted in the field. However, in terms of planting, several things must be considered, such as plant size, planting time, preparation of site preparation, and maintenance of seedlings in the field.

a. Plant size

It must be ensured that the roots of the plant have been long enough and have grown well so that they can maintain the supply of water from the soil when it has been moved in the field. The success of planting depends on the ability of the plant roots to get in contact with the soil so that water and nutrient absorption can be done.

b. The time of planting

The time of planting can also determine the success of growing Kayu Bawang seedlings in the field. Planting is better to be conducted during the rainy season, so that it can be ensured that the water supply is sufficient for the acclimatization and further growth of seedlings. The appropriate time of planting could also avoid the possibility of the highest level of plant stress. If the planting conducted during the sun's heat conditions are very high (for example midday), it will affect the survival rate of the seedlings.

c. Site preparation and stand density

The preparation of the planting location also determines the ability of the Kayu Bawang seedlings to grow in the field. Land preparation for Kayu Bawang planting is carried out by total cleaning of shrubs and weeds at the planting site. This cleaning can be done manually or chemically. After that planting holes are prepared. The initial spacing depends on the planting pattern to be applied. If planted in monoculture, Kayu Bawang can be planted at a spacing of 4 x 5 m, 4 x 3 m, or 3 x 3 m. In monoculture planting patterns, planting can be done rather tightly at the beginning. Then, stands

will be thinned in order to provide enpugh space for the tree to grow well. If Kayu Bawang is planted polyculture with other plants, the spacing can adjust to the type planted on the land, as well as the desired polyculture model. The choice of cropping pattern will determine the individual density per hectare.

5.2. Stand tending

a. Enrichment planting

Seedling might not survive after planting. The mortality of seedling might be due to several factors, such as pest attacks, competition with weeds, damage/eaten by animals, because of the weather, or due to improper way of planting. Unsurvived seedlings need to be replaced with new plants, which are called enrichment planting. The enrichment planting aims to allow the number of plants per hectare match up to the standard or desired amount. Enriched seedlings need to be given intensive fertilizer to be able to catch up with the growth of other plants. The first enrichment planting can be done about 2 - 4 weeks after planting, if there are already dead plants. The second enrichment planting can be done during the first year.

b. Weeding

At the beginning of growth is an important period for seedlings. Therefore, after Kayu Bawang seedlings are planted in the field, the next step that needs to be done is stand tending. Stand tending activities include weed cleaning and fertilization. Cleaning weeds is very important to do. Weeds can inhibit the growth of seedlings/saplings because they will compete to get water and nutrients with the weeds. Competition with weeds will reduce the end volume of wood that should be produced from a field.

Weed control during the first three years of growth will increase seedling growth (West 2006). A good initial development for three years will affect the speed of growth in the following years. Therefore, cleaning weeds is very important. Cleaning weeds can be done mechanically/manually or chemically. Manually, weeds can be done by cleaning up around the seedlings/saplings (circular), cleaning in path or cleaning the total area. For Kayu Bawang planted in agroforestry with other types of plants, it is usually

cleaning the Kayu Bawang plants from weeds along with cleaning weeds that also disturb other plants. For cleaning weeds chemically, it is necessary to avoid herbicides to affect the existing Kayu Bawang seedlings (Figure 10).

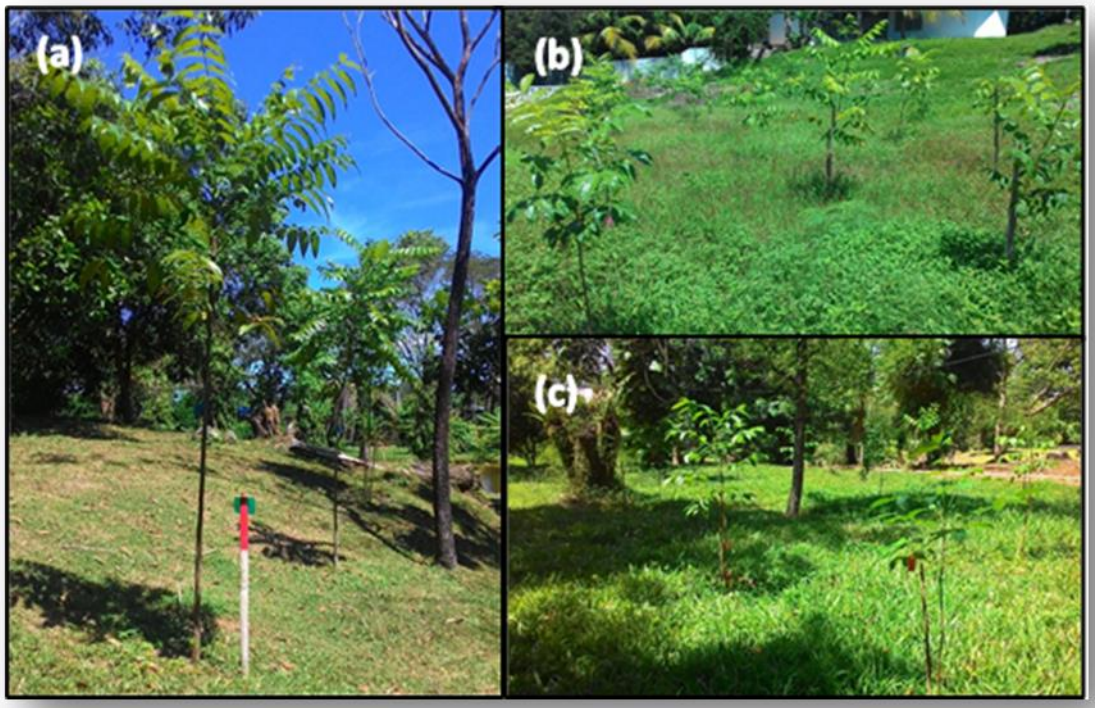

Figure 10. Development of Kayu Bawang saplings. Figure (a) is saplings that have been planted 1.5 years and weeds have been cleared. Whereas images (b) and (c) are seedlings of Kayu Bawang which have been planted for 4 months and the site has not been cleared from weeds.

c. Fertilization

The application of fertilizer could also influence the growth of Kayu Bawang seedlings. The basic application of Green Farm and SP36 fertilizers is able to stimulate plant growth, together with the plant caring on a regular basis. The dose of Green Farm 200 grams/planting hole is an effective and efficient dose in stimulating the growth of Kayu Bawang. While for SP36, the dose of 25 grams/planting hole provides the best response to the growth of Kayu Bawang (Forestry Research Institute (BPK) Palembang, 2010).

d. Eradication of Pests and Diseases

Trees have several types of pests and diseases that often attack. Pests that are often encountered to attack Kayu Bawang include stem borer (Xystrocera globosa), bagworm (Pteroma plagiophelps), grasshopper (Valanga nigricornis), termites (Cryptotermes sp) and ants (Polyrhachys dives). According to Utami (2012), stem borer (Xystrocera globosa) is the most potential pests (compared to other pests) that attack Kayu Bawang with the percentage and intensity of attacks by 11% and 21% in 1.5 year old plants.

Diseases that often attack Kayu Bawang plants include root rot disease (Rigidiporus sp.), leaf spots and shoot and root rot. These disease attacks can occur in Kayu Bawang stands with various age levels. According to Utami (2012), mechanical physical control is able to suppress root rot attacks, while control with pesticides is able to suppress stem borer.

e. Pruning

Based on observations in the field, Kayu Bawang stands which are sparsely planted, there is a tendency that the size of the branches is large and the branch diameter can reach 1/3 of the stem diameter. This is not profitable for Kayu Bawang which is intended for furnitures. Ideally, tree branches are small in diameter, so that they can be naturally decayed, leaving the main stem with large and straight diameters. Therefore, the distance of the initial spacing of Kayu Bawang seedlings was made relatively densed, and then the stand is gradually thinned. For example, first initial spacing is 5 x 2.5 m or 5 x 3 m. It then can be thinned to 5 x 5 m and 5 x 6 m. With the pruning carried out from the beginning, it is expected that the Kayu Bawang stand will grow as expected.

Tree selection technique of Kayu Bawang which could to produce small branch needs to be sought by tree breeders from the Ministry of Environment and Forestry or from Universities. If a parent tree that has the intended character has been found, it can be used as material to build a seed garden. So that planting with seeds obtained from this seed garden will reduce the cost of pruning.

VI. CONCLUSION

Kayu Bawang (*Azadirachta excelsa* (Jack) M. Jacobs) is one of the main timber product from Bengkulu Province. Community plantation of Kayu Bawang shows that planting of timber commodities is quite promising and the potential for utilization is quite extensive. However, even though this planting of Kayu Bawang has expanded, silvicultural principles in the management of stands have not been adequately applied. By choosing Kayu Bawang as one of timber product developed in the ITTO Project PD 477/07 Rev.4 (F), the collection and distribution of information on Kayu Bawang cultivation is important. Kayu Bawang is also quite potential to be developed not only in its original location, but also in other development locations, both in Bengkulu and outside Bengkulu Province. Therefore, data and information need to be disseminated on kayu bawan, including growth requirements, development and management status, potential seed sources with high genetic quality, and nursery techniques. This technical guide is part of this effort.

BIBLIOGRAPHY

Apriyanto E. 2003. Pertumbuhan Kayu Bawang pada Tegakan Monokultur Kayu Bawang di Bengkulu Utara. Jurnal Ilmu-Ilmu Pertanian Indonesia 5(2): 64-70.

Forestry Research Institute (FRI) Palembang. 2010. Penelitian Budidaya Jenis Kayu Bawang. FRI Palembang, Palembang.

Bradford K. J. 1995. Water relations in seed germination. In J. Kigel & G. Galili (Eds), Seed development and germination (pp. 351-398). Marcel Dekker, New York.

Copeland L. O and McDonald M. B. 2001. Principles of seed science and technology (4th ed). Kluwer Academic, Dordrecht.

Ministry of Forestry. 2010. Petunjuk Pelaksanaan Standar Sumber Benih. Direktorat Perbenihan Tanaman Hutan, Ditjen Rehabilitasi Lahan dan Perhutanan Sosial.

Depari E. K, Susatya A dan Wiryono. 2013. Potensi Standing Stock dan Carbon pada Tegakan Kayu Bawang (Dysoxylum mollissimum blume) di Hutan Rakyat Bengkulu. Laporan Penelitian Universitas Bengkulu, Bengkulu.

Depari E. K. 2011. Pengetahuan Lokal Budidaya Kayu Bawang (Dysoxylum mollissimum Blume) di Kabupaten Bengkulu Utara. Jurnal Agriculture, 21 (2).

Forestry Service of Bengkulu Province. 2013. Rencana Kehutanan Tingkat Propinsi Bengkulu. Forestry Service of Bengkulu Province, Bengkulu.

Forestry Service of Bengkulu Province. 2003. Budidaya Tanaman Kayu Bawang. Bengkulu. Forestry Service of Bengkulu Province, Bengkulu.

Kunarso A dan Siahaan H. 2008. Pemetaan Sebaran Pohon Induk Jenis Prioritas Sumatera Selatan. Info Hutan 5 (1): 35-43.

Mulawarman, Roshetko J, Sasongko SM, dan Iriantono D. 2002. Pengelolaan Benih Pohon, ICRAF & Winrock International, Bogor.

Nuriyatin N, Apriyanto E, Syatria N dan Saprinurdin. 2003. Ketahanan Lima Jenis Kayu Berdasarkan Posisi Kayu di Pohon terhadap Serangan Rayap. Jurnal Ilmu-Ilmu Pertanian Indonesia 5(2): 77-82.

Riyanto, H. D. 2001. Kayu Bawang (sp) Berpotensi untuk Kayu Pertukangan. Prosiding Ekspose Hasil-hasil Penelitian Balai Teknologi Reboisasi Palembang, 12 Nopember 2001. Palembang

Siahaan H, Herdiana N, Rahman T, Sagala N. 2006. Peningkatan pertumbuhan bibit Kayu Bawang (Protium javanicum Burm. F) dengan aplikasi arang kompos dan naungan. Prosiding Ekspose Hasil-hasil Penelitian Balai Teknologi Reboisasi Padang 20 September 2006. Padang: 165-170

Siahaan H, Herdiana N, Rahman T. 2008. Pengaruh Periode dan Ruang Simpan Terhadap Perkecambahan Benih Kayu Bawang. Jurnal Penelitian Hutan Tanaman 5 (2): 83-90.

Siahaan H, Herdiana N, Rahman T. 2008. Pengaruh periode dan ruang simpan terhadap perkecambahan benih Kayu Bawang. Jurnal Penelitian Hutan Tanaman 5 (2): 83-90.

Siahaan H, Suhendang E, Rusolono T dan Sumadi A. 2011. Pertumbuhan Tegakan Kayu Bawang (Disoxylum mollissimum) pada Berbagai Pola Tanam dan Kerapatan Tegakan. Jurnal Penelitian Hutan Tanaman 8 (4): 225 – 237.

Sosef MSM, Hong LT, Prawirohatmodjo S (Editor). 1998. Plant Resources of South-East Asia. Prosea 5(3), Bogor.

Utami, S. 2012. Pengendalian Hama dan Penyakit Kayu Bawang (Disoxylum mollissimum). Badan Penelitian Kehutanan, Palembang.

West P. W. 2006. Growing Plantation Forests. Springer-Verlag, Berlin.

.