ECOLOGICAL DISTRIBUTION OF SANDALWOOD AT DIFFERENT ALTITUDE IN TIMOR TENGAH SELATAN DISTRICT, EAST NUSA TENGGARA

By

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Improving the Enabling Conditions for Sustainable Management of Sandalwood Forest Resources in East Nusa Tenggara Province

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Introduction

A study was conducted to detect the ecological distribution of sandalwood (*Santalum album*) in TTS (South Central Timor) District in July-September 2011. Assumption in this study is if sandalwood can grow well in a broad range of ecological elements there should be no worry about the development of sandalwood biophysically. This assumption was formulated as such because in year 2010 the ITTO team has successfully mapped the key issues in growth inhibition of sandalwood population in TTS which is a matter of policy. Supposing that all natural sandalwood ecological factors do not show anomalous symptoms, findings of the ITTO team in 2010 have strong justification.

After research was conducted it was found that symptoms of ecological anomalies in the growth of sandalwood in the TTS are not found. Observations on climatic, biotic and edaphic aspects of sandalwood at five different locations showed that there were no drastic changes in the ecological distribution of sandalwood. If in previous studies such as those conducted by Hamzah (1976) and Surata (2006) that discovered the ecological distribution of sandalwood was proven to be able to grow well in dry tropical climate region, in rather rough soil formation, rather porous soil, soil with neutral-alkaline pH and rather fertile, results obtained from this study gave similar results and can be easily found in communities of dry and lightly vegetated tropical forest. The exception is in the fact that sandalwood can grow in soil with low nitrogen content. Thus on the whole it can be said that sandalwood can grow relatively equally well on a variety of ecological conditions in the TTS. This study therefore can recommend that in the future development potential of sandalwood in the TTS is still very promising with the prerequisite of improving aspect of policy requirements.

This research can be conducted thanks to the good cooperation that exists between the various parties, especially the ITTO-Indonesia-Ministry of Forestry, the NTT ITTO Project Management Team, NTT Provincial Forestry Service, Forest Service and the TTS research team consisting of consultants and TTS District Forestry staff. In particular, it must be said that this research could also implemented because of the major contribution of Ir. Yani Septiani, M.Sc as ITTO Project-Indonesia leader in the Ministry of Forestry who has opened the opportunity to conduct this
study, Dr. Titik Setyawati of the R&D of the Ministry of Forestry, Government of Indonesia who has served as a supervisor during the execution of the study and Mrs. Elizabeth Lukas and Mrs. Esther Martha as implementer of the ITTO at NTT in facilitating the administration during the implementation of this study. The research was also well conducted because of the no small role that was played by our colleague Christian L Koenunu, Forester, and fellow researchers from the TTS Forest Service for their hard work in collecting the field data. For this good cooperation, I wish to say my utmost thanks. Hopefully this good work can be a useful input for the sandalwood development in the future.

Kupang, 24 September 2011

Researcher

Dr. Ir. L. Michael Riwu Kaho, M.Si.
Bab I. Foreword

Background

Sandalwood (Santalum album), is an endemic plant species in some ecoregions in East Nusa Tenggara (NTT) that are very important and have a high economic value. In historical records cited by Ormelling (1955), sandalwood was mentioned as the most important natural commodity that has been traded with several parties from abroad. Jan H van Linschoten (1596 cited by Ormelling, 1955) reported that the island of Timor is an island when seen from a distance is a white island because it is covered by sandalwood plants that grow freely on the island of Timor and is the only reliable commodity in the interinsular trade. The natural distribution of sandal-wood in the NTT Province is on the island of Flores (West and East Flores), Adonara, Solor, Lomblen, Alor, Pantar, Rote, West Timor, Sumba, and also in the Maluku Province (Wetar, Roma, and Leti). Sandalwood on Timor Island is known as hau meni or ai nitu and sendana in the Malay language and in the world trade is known as sandalwood.

The superiotity of NTT sandalwood as a commodity is because it is the best in the world due to the advantage of high content of essential oil and its high production of core wood. Oil content (Santalo) in sandalwood excude a distinctive scent. High economic value of the sandalwood oil produced from the distillation of wood is not only used as a fragrant raw material to make perfume but it is also used as medicine. In addition, sandalwood is also used as industrial materials such as wood handicraft, sculpture, hand fan, beads, incense ingredients, aromatherapy and others. High quality sandalwood can keep excuding its aroma for centuries. Because of these advantages the sandalwood has become an important trade commodity in East Nusa Tenggara province and an important contribution to the local revenue (PAD). Until the early 1900s, the sandalwood is an important source of local revenue for the NTT province. In the period of between years 1986/1987-1990/1991, it has contributed around 28.2 to 47.6% to the local income. Unfortunately, the economic value of sandalwood exploitation that relied on the utilization of tree potential of natural stands was very little followed by re-planting and restoration of this potential and has put aside efforts in conservation. Additionally sandalwood management policy was still rudimental and is not effective, so it can not provide optimal benefits to the region and its people. The existing sandalwood population has been greatly reduced to an alarming state. There are no more
significant contributions to sandalwood to the NTT PAD, sandalwood population continues to decline reaching the risk of being vulnerable to extinction. Communities in the province, especially in the island of Timor and Sumba are traumatized to go back to planting sandalwood due to ineffective policies in the past.

Currently, the population of sandalwood in the province of East Nusa Tenggara (NTT) has continued to decline as a result of mismanagement of the system, the high rate of theft, fire and livestock disturbance and lack of preservation and planting activities in both the public and forest lands. Darmokusumo et al., 2001 states that there has been a rapid decline in population, reaching a value of 53.95%. Data obtained from the NTT Forest Service (2010) presented at the ITTO seminar, which informed that if during the period between the years 1969/1970 - 1986/1987 the sandalwood felling reached 102,885 of sandalwood trees, with a production of 9,510,444 kg of sandalwood, then in the period of the succeeding 10 years, between the period 1987/1988 - 1996/1997 the number of trees felled dropped to 143,316 trees, with a production of 7,465,917 kg of sandalwood. Ten years later, between the years 2001 - 2007, sandalwood production amounted to a low 2,178,697 Kg. This decline in productivity is positively correlated with sandalwood population decline. If the data in 1987 showed a tree population of 544,952, the NTT sandalwood tree inventory in 1997 indicated that the population has dropped to 250,940 trees. For 10 years there has been a decline of 46.05% in sandalwood population.

The current sandalwood population decline in NTT province is a worrisome issue for the province which currently has the status of endangered by the International Union for Conservation of Natural Resource (IUCN), it even belongs in the Appendix II of CITES (WWF Indonesia, 2008). Forest Area Consolidation Center (BPKH) in its research between the years 1995-2000 has discovered that sandalwood is almost extinct within the area of the state forest. The average number of trees ranges between 0, 167 to 3, 065 plants / ha. However, a study conducted by ITTO in 2010 found that the sandalwood population on private lands is relatively good. Survey on respondents from several sampling points showed that the population of sandalwood trees as well as mother trees on land owned by the respondents ranged from 5-20 stems / ha with an average of 10 stems / ha. In addition, there is also the fact that the sandalwood trees are found spread fairly evenly in all villages in TTS (South Central Timor) on private land (Figure 1).
Things to consider in a situation like this somewhat paradoxical situation is the synthesis theory of climax vegetation which mandates that certain plant communities adapt to particular climatic, and biotic edafik condition (Smith and Smith, 1990). In that regard, Surata (2006) described that sandalwood habitate well in dry climates where the temperature reaches 35°C, relative humidity during the dry season ranged from 50-60%, and altitude ranging from 0 -1,200 m above sea level (asl). If so then the success of sandalwood growing uniformly across the country indicates that sandalwood plant has a wide adaptability of habitat in its growth. Thus, in the case of its absence in the state land, it is definitely not because of biophysical reason but rather a matter of policy. This is the assumption that is the object of this study.

**Purpose and Usefulness**

The purpose of this study was to test the response of the sandalwood population for different biophysical conditions. The purpose of this research is a contribution of thought for decision-makers in the management of sandalwood in order that sandalwood population can grow back normally.
Chapter II. Material and Method

Time and Location
Research was planned for a period of three months beginning from June 2011 to September 2011 in five villages in TTS District which has been surveyed before to find out about sandalwood spread in the second year of ITTO activities. The five villages chosen from the 23 initially inventorized villages is based on its altitude, as follows:

1. Village Kuanfatu at Sub-District Kuanfatu : 457 mdpl
2. Village Haunobenak at Sub-District Kolbano : 750 mdpl
3. Village Anin at Sub-District South Amanatun: 755 mdpl
4. Village Oelbubuk at Sub-District Central Mollo: 997 mdpl
5. Village Eonbesi at Sub-District North Mollo: 1044 mdpl

Method
Observation on relationship between population size, spread and ecosystem determinant factor will use the technical analysis of terrestrial community. In this research re-calculation will conducted on the population size of the sampled five villages which will then be followed by notations on the community factors covering the climatic, edaphic and biotic aspects. The details of sandalwood community which will be analyzed are as follows:

1. Climatic factor: all elements related to altitude. In this case, all five sample villages were chosen based on altitude and climatic factors determined by altitude. This research observed rainfall, air temperature ans relative humidity.
2. Edaphic factor: thematic map of soil type, thematic map of soil class, estimation of erosion (USLE), chemical fertility and soil physics which are observed through laboratorium analysis covering some variables which are soil texture and structure, organic material, Nitrogen, Phosphorus, Potassium, soil reaction (pH), cation exchange capacity (KTK), and C/N ratio.
3. Biotic factor: important value index (INP), species diversity (index Shannon-Wiener), fauna diversity (IPA method), as well as vegetation analysis and analysis of species association (qualitative and correlationship).
Sampling

1. Vegetation Sampling

Methods of data collection at each sampling plot using transect method (Soerianegara and Indrawan, 1988). For each transect measuring 1 km (1000 meters) with a width of 20 meters. At each sampling area, transects consisted of plots per transect. Transect is made in length cutting topographic contour lines with a distance between transects of 100 meters, then each plot is divided into four equal parts, each part is measured for each plant level.

To make for an easier summary, sample area is again divided into plots, which are:

- **a)** Tree stage, measuring 20 m x 20 m
- **b)** Poles stage, within the 20m x 20 m plots, made to measure 10m x 10m
- **c)** Sapling stage within the 10m x 10m plots, made to measure 5m x 5m.
- **d)** Seedling stage within the 5m x 5m plot, made to measure 2m x 2m.

Transect division into measuring plots as mentioned above can be seen in **Figure 2** below.

![Figure 2. Transect for Vegetation Analysis](image)

In each plot, identification is done on flora for each level of growth from seedling, sapling, poles and trees by using grouping categories as follows (Soerianegara and Indrawan, 1988).

- **a)** Trees, plants with height of > 10 m.
- **b)** Poles, trees with height of between 5 – 10 m.
- **c)** Sapling, trees with height of 1,5 m - 5 m.
- **d)** Herbs and seedlings, germinating seeds to plant height of ≤ 1,5 m

Parameters measured or recorded include: species of plant, stem diameter, number of species, and the number of plots found for a particular species. Stem diameter measurements performed at about chest height or 1.3 meters above ground level (especially for small trees and tree).
The plant inventory data to determine the amount of measured variables used in the analysis of vegetation formula of Importance Value Index (IVI) based on the Mueller (1974) formula as follows:

Species Density (K) is the number of species in a sample unit area, while Relative Density (KR) is the percentage of species density in relation to density of all species.

\[
\text{Kerapatan(K)} = \frac{\text{Jumlah individu}}{\text{Luas contoh}}
\]

\[
\text{Kerapatan relatif (KR)} = \frac{\text{Kerapatan suatu jenis}}{\text{Kerapatan seluruh jenis}} \times 100\%
\]

**Density** = Number of Individual divided by Area of sample  
**Relative Density** = (Density of species divided by Density of all species) x 100%

**Dominance** is expressed in measurement of basal area. Basal area of tree and pole stand could be identified through measurements of circumference of tree trunk at height of 1.3 meter or at breast height (DBH).

\[
\text{Dominasi (D)} = \frac{\text{Luas bidang dasar}}{\text{Luas petak contoh}}
\]

\[
\text{Dominasi relatif (DR)} = \frac{\text{Dominasi suatu jenis}}{\text{Dominasi seluruh jenis}} \times 100\%
\]

**Dominance** = Basal Area divided by Area of Sample  
**Relative Dominance** = (Species Dominance divided by Dominance of all species) x 100%

**Frequenncy** is the comparison of the total quadrant or measurement plot where a species grows with the total quadrant (measurement plot) where observation is being made.

\[
\text{Frekuensi (F)} = \frac{\text{Jumlah petak ditemukan suatu jenis}}{\text{Jumlah seluruh petak}}
\]

\[
\text{Frekuensi relatif (FR)} = \frac{\text{Frekuensi suatu jenis}}{\text{Frekuensi seluruh jenis}} \times 100\%
\]

**Frequency** = Number of plot where species is found divided by Total number of plot  
**Relative Frequency** = (Frequency of a species divided by Frequency of all species) x 100%
Data and information acquired from measurements of Relative Density (KR), Relative Dominance (DR) and Relative Frequency (FR) can be used as Significant Value Index.

Significant Value Index (INP) = Relative Density (KR) + Relative Dominance (DR) + Relative Frequency (FR)

\[
\text{Summed Dominance Ratio (SDR)} = \frac{\text{INP}}{3} \quad \text{untuk tingkat pohon dan tiang}
\]

\[
\text{Summed Dominance Ratio (SDR)} = \frac{\text{INP}}{2} \quad \text{untuk tingkat pancang dan semai}
\]

Summed Dominance Ratio (SDR) for trees and poles = INP divided by 3
Summed Dominance Ratio (SDR) for seedling and sapling = INP divided by 2

2. Soil sample

Variables on soil observation include the soil physical and chemical aspects. Observation on soil physical aspect includes soil texture, effective depth and surface coarseness. While observation on soil chemical aspect include some variables on soil fertility covering total Nitrogen, organic Carbon, Phosphorus, soil pH, and cation exchange capacity (KTK)

Analyzed soil sample is one composite sample for each sample plot location. Soil sampling is done by with the help of a soil borer. The soil is bored until depth limit is reached where it can be no more bored by the drill bit. Soil acquired through boring is composited for sampling.

Sampling is done following the sampling plot transect where from each transect ten original sample is obtained which then is composited to get five samples to be analyzed. Physical and chemical analysis is done at the Central Arboretum Research and Development Laboratory, Undana Research Agency, University of Nusa Cendana, Kupang.

Detail of research plan on the condition of sandalwood ecology is as follows:

<table>
<thead>
<tr>
<th>Component of Ecology</th>
<th>Parameter</th>
<th>Method of Data Collection</th>
<th>Method of Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate</td>
<td>Rainfall, air temperature, relative humidity</td>
<td>• Collection of Secondary Data; • Verification of primary data for air temperature and relative humidity parameters</td>
<td>Five villages with altitude differences, in situ and ex situ • Data tabulation and analysis of trend; • Schmidt-Fergusson classification</td>
</tr>
</tbody>
</table>
### Soil

- **Physics**: Soil type, soil class, texture and structure, slope class, critical land
- **Chemistry**: soil water content (gravimetric), Nitrogen, Phosphorus, Potassium, organic material, pH, Carbon, cation exchange capacity

| Collection of secondary data for physical fertility |
| Collection of primary data, in situ and ex situ soil sample for parameters of soil water content, texture, structure, Nitrogen, Phosphorus, Potassium, Organic material, pH, Carbon and cation exchange capacity |
| Five villages with altitude difference, in situ and ex situ. Soil analysis for four composite sample, two each for in situ and ex situ for each village |
| Soil sample analysis at the Soil Laboratory Faperta Undana, Kupang; Tabulation and analysis of variance. Expert evaluation |

### Biotic

- **Vegetation Component**: diversity, structure and vegetation composition.
  - Transect
  - Vegetation analysis
  - Field observation
  - Secondary data: vegetation map and land cover
  - Five villages with difference in altitude, in situ and ex situ.
  - Analysis of important value index
  - Diversity index
  - Uniformity index
  - Vegetation spectrum

### Faunal component

- IPA (index point of abundance) method
- Interview
- Inventory
- Observation of imprint and dung
- Five villages with difference in altitude, in situ and ex situ.
- List of fauna

### Community culture

- Collection of secondary data and interview
- Five villages with difference in altitude, in situ and ex situ.
- Qualitative analysis describing community culture related to sandalwood

### Data Analysis

The observed data were tabulated and analyzed using several approaches, namely descriptive analysis, analysis of variance to examine the significance of the mean of different variables on treatment (five degrees altitude), and the analysis of the correlation between the variables of soil fertility with a population of sandalwood.
Chapter III. Results and Discussion
General Condition of Sandalwood Situation in Sample Villages

1. Kuanfatu Village (345 m dpl)

This village is located at an altitude between 300-400 m above sea level. The Village has a high appreciation of sandalwood, especially in the economic perspective. The general public believes that the sandalwood is a plant of the future. No wonder if the public views sandalwood as higher in value than mahogany, teak, gamelina and others. The problem is that it needs a legal guarantee of the right of ownership of sandalwood which in reality is almost totally found in privately owned land. Location map, land cover and point transects in the Kuanfatu village observation can be seen in Figure 3.

![Figure 3](image_url)

Figure 3. Map of Kuanfatu village (land cover and transect point) and picture of sandalwood population

2. Haunobenak Village.

The village is situated at an altitude of between 500-600 m above sea level where almost all people in Haunobenak village have sandalwood in privately owned land. The entire sandalwood population grow naturally and not cultivated. However, this village has an area of 8 ha that is planted with sandalwood since 1989. The cultivated sandalwood grows generally in good condition although most people believe that cultivated sandalwood has a lower quality than sandalwood that grows naturally.
The still existing sandalwood in the village is primarily due to the good economic perspective the Haunobenak village population have for sandalwood. The community used to trade sandalwood at a price of Rp.200 - Rp 300 thousand rupiah per kg. Legal certainty of ownership and technical assistance is a prerequisite for the successful cultivation of sandalwood in the village. Location map, land cover and point transects in the Haunobenak observation can be seen in Figure 4.

![Figure 4](image)

**Figure 4.** Haunobenak Village map (land cover and transect point) and picture of sandalwood population.

3. Anin Village

Anin village is located at an altitude between 700-800 m above sea level where sandalwood population in the village had declined so drastically because it was felled by the community as a result of the wrong policies about ownership of sandalwood in the past. Almost all of the sandalwood that grows in the village is the result of natural regeneration and community strongly believes that this is the only way that very high quality sandalwood will be produced. Location map, land cover and point transects in the Anin village observation can be seen in Figure 5.
4. Oelbubuk Village

Village Oelbubuk lies in altitude between 1000 - 1100 m asl. In this village most sandalwood are grown on privately owned land, however some are also found growing on land owned by the state. In a valley, an owner of sandalwood has sandalwood trees of more than 100 trees that grow naturally. About 20 species of trees are trees planted since the 1990's but have not reached the ideal size. The main problem affecting sandalwood in this village is large scale theft of sandal-wood and there is also no sufficient knowledge about sandalwood cultivation techniques. Figure 6 shows sandalwood population in Oelbubuk with location maps, land cover and point transect observations in the village. Similar information for Eonbesi village can also be seen in Figure 7.
5. Eonbesi Village

Eonbesi village as an observation village which is located at the highest altitude, ranging between 1100 - 1200 m asl. Sandalwood in this village are almost all found on private land maintained as high appreciation of the cultural and economic value of sandalwood plants. Most people believe that the only naturally growing sandalwood will develop into best quality trees. However community is also trying to develop a way of sandalwood cultivation but has very minimal technical knowledge and is still traumatized by the loss of the right to grow sandalwood in their own land in the past.

Figure 7. Eonbesi Village Map: (land cover and transect point) and picture of sandalwood population

Climatic Aspect

Climatic conditions shown are available variable quantitative data. Rainfall data obtained from a weather station at Fatumnasi village. While the temperature and relative humidity obtained through direct observation in the field (primary data). Observation of these two variables is done three times in a day, ie at 06.00, 12.00 and 18.00 hours. Observed climatic data component are shown in Table 1.
Table 1. Rainfall (mm), temperature (°C) and relative humidity (%)

<table>
<thead>
<tr>
<th>Village</th>
<th>Rainfall (mm)</th>
<th>Temperature (°C)</th>
<th>Relative Humidity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kuanfatu</td>
<td>1125</td>
<td>28,1 b</td>
<td>60,2 a</td>
</tr>
<tr>
<td>Anin</td>
<td>1178</td>
<td>28,09 b</td>
<td>63,6 a</td>
</tr>
<tr>
<td>Haunobenak</td>
<td>1202</td>
<td>25,8 ab</td>
<td>78,1 b</td>
</tr>
<tr>
<td>Oelbubuk</td>
<td>1278</td>
<td>23,5 a</td>
<td>85,8 c</td>
</tr>
<tr>
<td>Eonbesi</td>
<td>1286</td>
<td>23,6 a</td>
<td>87,5 c</td>
</tr>
</tbody>
</table>

Note:
1. Rainfall data are estimates of Fatumnasi station and therefore no statistical test is made
2. Figure followed by same letter means no difference in a 5% test level (post analysis of variance)
3. Figure followed by same letter means no difference in a 5% test level (post analysis of variance)

The data in Table 1 shows that rainfall in the five observation villages are relatively different from the general range of rainfall in West Timor, which is between 1000 to 1500 m / year. Similarly, it is true for data of temperature and relative humidity. Surata (2006) explained that sandalwood grows in areas with average rainfall of 625-1625 mm / year, climate type D and E according to Schmidt and Ferguson (1951). Average temperatures range between 10 °C - 35 °C during the day. The relative humidity in the dry season is 50% - 60%. Evidently sandalwood has not yet lost its properties and the need for climatic tolerance limits of their natural habitat. However, there is a real tendency that the temperature in both becomes lower with the increase in altitude. Conversely increasing altitude also coincided with increasing relative humidity. Thus we can say that the available factors of temperature and relative humidity will allow for differences in population performance and variable productivity of sandalwood.

Edaphic Aspects

Broadly speaking, the soil at the five villages of research can be divided into three orders according to the soil classification of Soil Survey Staff (1992), namely Entisol, Inceptisols, and Mollisols (Soil and Agro-climate Research Center, 1995). Distribution of soil types can be seen in Figure 8.

Order Entisol with alluvial soils are soils without natural generatic horizon or a horizon that began to be formed. Land like this are found in the Kuanfatu and Haunobenak villages. The land is very productive when sitting on recent alluvium. If sitting on a barren sand near the beach or tidal area, the land is less fertile. But if fertilized and the water controlled, the soil is quite productive.
Order Alfisol with sub orders ustals Haplustalfs soils (USDA, 1975) is a well weathered soil, acidic to neutral, but less reddish brown with the lower layer fine to moderate textured soil, base saturation of high-stress-institutional seasonal toward montmorillonite clay. High calcium levels with high cation exchange capacities. The land is located on terraces sloping reef flat tilted younger, lower terraces and more stable, plain fan of older alluvium or pyroclastic rocks, basalt and young andesite. The land is a dominant trait in the Anin village.

Order Mollisols with sub orders Ustolls and Rendolls with soil type calciustolls / Rendzina. The land is characterized by epipedon Molik or over a thick horizon dominated by divalent cations (Supardi, 1979). The land has also experienced weathering, shallow, rocky, dark, the reaction neutral to slightly alkaline soil. The land is generally lack of potassium, with the addition of lime to overcome the lack of additional nutrients. Cation Echange Capacity (CEC) is high. Saturation of calcium causes an imbalance of nutrients, especially magnesium-low incremental. The land is located in a narrow region only, coral terraces, located on the hard limestone and maris, supporting open grasslands and acacia forest. This land dominates Oelbubuk and Eonbesi villages.

Further statistical analysis of the degree of soil fertility in the five observations villages are as follows.

**Figure 8.** Soil type spread in TTS District
Table 2. Analysis of some variables of soil physical and chemical fertility

<table>
<thead>
<tr>
<th>Village</th>
<th>Texture</th>
<th>pH (H₂O)</th>
<th>N-total (%)</th>
<th>P (ppm)</th>
<th>CEC (me/100 g)</th>
<th>Effective depth (cm)</th>
<th>Erosion (ton/ha/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kuanfatu</td>
<td>Sandy Clay Loam</td>
<td>7,4 a</td>
<td>0,19 a</td>
<td>25,5 a</td>
<td>40,2 a</td>
<td>26,7 a</td>
<td>25,6 a</td>
</tr>
<tr>
<td>Anin</td>
<td>Sandy loam</td>
<td>7,8 a</td>
<td>0,17 a</td>
<td>36,6 ab</td>
<td>44,1 a</td>
<td>30,7 a</td>
<td>25,7 a</td>
</tr>
<tr>
<td>Haunobenak</td>
<td>Dusty Clay</td>
<td>7,2 a</td>
<td>0,21 a</td>
<td>66,7 b</td>
<td>56,7 a</td>
<td>40,6 a</td>
<td>29,7 a</td>
</tr>
<tr>
<td>Oelbubuk</td>
<td>Loamy Clay</td>
<td>7,3 a</td>
<td>1,19 a</td>
<td>45,5 ab</td>
<td>47,4 a</td>
<td>25,5 a</td>
<td>24,7 a</td>
</tr>
<tr>
<td>Eonbesi</td>
<td>Loamy Clay</td>
<td>7,3 a</td>
<td>0,18 a</td>
<td>50,1 b</td>
<td>64,1 a</td>
<td>34,7 a</td>
<td>32,9 a</td>
</tr>
</tbody>
</table>

Note: figure at the same column followed by same letter means no significant difference at 5% test level.

Data in Table 2 shows that although there area different types of soil order but the texture of the soil generally only covers two groups, namely soil dominated by loam and by clay. Land on the loam formation is easily wetted but retain less water in a long period. On the other hand, easily moistened clay can simultaneously hold more water in a long time. Properties of being easily moistened and water retention in the longer term will benefit the young sandalwood plants that require wetter soil. This assumption is consistent with the findings of Nuningsih et al. (1994) who did research in North and South Mollo Mollo which have different geological formations similar to this study. It was reported that the formation of clay soil and rocky loam in South Mollo as Oelbubuk and Eonbesi appeared to have the characteristics of sandalwood trees and vegetative shoots better than the sandalwood that grows in limestone formations in North Mollo. For example, the number of clumps produced per mother plant in North Mollo Sub-District (mean 8.32 ± 6.03) was lower than that in the South Mollo Sub-District (mean 9.91 ± 7.71).

If the variable conditions of chemical soil fertility is refered, it will show a tendency that sandalwood can actually grow on soil with lower nitrogen levels. If nitrogen is an essential nutrient for plants then the fact that sandalwood can grow on soil with lack of nitrogen verified that sandalwood is a semi-parasitic plant that rely on host plants as a nutrient supplier. Similarly, the fact that the sandalwood is less sensitive to the effective depth indicates that sandalwood is able to survive in such a restrictive condition as long as the soil has a high level of phosphorus. The fact that land in sandalwood habitat has a high erosion tendency, exceeding the threshold of tolerable erosion of 22 tonnes / ha / year. Another fact indicates that the soil habitat of sandal-wood in all the five sample villages have a high cation exchange capacity indicates that breeding efforts with the fertilization is unlikely to inhibit
the growth of sandalwood as a high CEC is easily an indicator of whether fertilization is needed or not.

Meanwhile, ground reaction data (pH) showed that between sampling sites, soil reaction ranges from neutral to slightly alkaline. Soil reaction of this kind is common typology of soil reaction in Timor Island (Monk et al, 1997 and Riwu Kaho, 2005). If Sandalwood can be grown on such soil type reactions it can be presumed that there are no detrimental aspects of soil reaction to the spread of sandalwood. Overall it can be said that from the point of view of the indicators of soil fertility, sandalwood can actually be cultivated, contrary to the common assumption of some people who do not believe that sandalwood could be cultivated.

**Living communion with other vegetation**

Based on the observation of the coexistence of sandalwood with other vegetation in the field, it can be reported that sandalwood can actually live in co-existence with other plants without interruption its growth. Observations at five locations (Table 3) show that in all strata of sandalwood growth it can grow with a variety of other plants that are also living on the same growth strata.

In the list of IUCN (2007) sandalwood ecology is described as plants that can live in a variety of situations that support its growth as a hemi-parasitic plant. Because of this nature, the description of the IUCN explained that sandalwood grows easily be spread in an area covered by dry deciduous forest vegetation (dry deciduous forests) as in small Sunda, Indonesia, the Philippines, China and India.

**Table 3.** Vegetation species growing together with sandalwood in five observed villages

<table>
<thead>
<tr>
<th>Type</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td><em>Eucalyptus urophylla</em></td>
</tr>
<tr>
<td>2.</td>
<td><em>Podocarpus sp.</em></td>
</tr>
<tr>
<td>3.</td>
<td><em>Sesbania grandiflora</em></td>
</tr>
<tr>
<td>4.</td>
<td><em>Rapanea haseltii</em></td>
</tr>
<tr>
<td>5.</td>
<td><em>Casuarinas junghuniana Mig</em></td>
</tr>
<tr>
<td>6.</td>
<td><em>Matani/Kayu Merah (Pterocarpus indicus</em></td>
</tr>
<tr>
<td>7.</td>
<td><em>Toddalia asiatica</em></td>
</tr>
</tbody>
</table>
Surata (2006) explained that the sandalwood require short and long term host plants in order to support its life as a hemi-parasitic plant. He further explained that for the time being it was found that three species of long-term secondary host are the best are: *Casuarina junghunniana*, *Cassia siamea* and *Azederachta indica* and for medium term secondary host area *Acacia villosa*, *Leucaena leucocephala* and *Sesbania grandiflora*. If Surata’s statement is acceptable then the list of community plant life in the villages of sandalwood observations

8. *Cassia siamea*
9. *Sterculia foetida*
10. *Acacia leucocephala*
11. *Artocarpus heterophyllus*

### Pole
1. *Eucalyptus urophylla*
2. *Podocarpus sp.*
3. *Sesbania grandiflora*
4. *Croton caudatus geisel*
5. *Toddalia asiatica*
7. *Sterculia foetida*
8. *Acacia leucocephala*
9. *Azederachta indica*

### Sapling
1. *Eucalyptus urophylla*
2. *Thecoma stan (semak bunga kuning)*
3. *Daphniphyllum glaucescens BI*
4. *Santalum album*
5. *Podocarpus sp.*
6. *Scutellaris discolor*
7. *Croton caudatus geisel*
8. *Matani/Kayu Merah (Pterocarpus indicus Lantana camara L.*
9. *Omalantus populneus (geisel) Pax*
10. *Celtis wightii planch*
11. *Rapanea haseltii*
12. *Putranjiva roxburghii*
13. *Veccinium cf. varingifolla (Bl.) miq*
14. *Leucaena leucocephala*

### Seedling
1. *Tecgoma stan (semak bunga kuning)*
2. *Eucalyptus urophylla*
3. *Daphniphyllum glaucescens BI*
4. *Santalum album*
5. *Scutellaris discolor*
6. *Veccinium cf. varingifolla (Bl.) miq*
7. *Podocarpus sp.*
8. *Omalantus populneus (geisel) Pax*
9. *Lantana camara L.*
10. *Rapanea haseltii*
11. *Asophila glaucus J.Sm*
12. *Jambolifera trifoliata*

### Grass
1. *Themeda arguens*
2. *Andropogon spp*
3. *Heteropogon contortus*
4. *Ischaemum timorense*
5. *Eulalia amaura*
6. *Digitaria spp*

Source: primary data from vegetation analysis
supported this statement because all listed species are found in completion. If other species are found that are not in the list submitted by Surata but is proven not to interfere with sandalwood plants, they should be considered as plants living in co-existence and in the future sandalwood development these species are worth to be considered for development as host plants for the cultivation of sandalwood.

Meanwhile other results of analysis which data is found in Table 4 shows some sandalwood nature in communal living with other vegetations.

**Table 4.** Sandalwood growth nature related to communal living with other vegetation.

<table>
<thead>
<tr>
<th>Village</th>
<th>Sandalwood percentage (SDR) compared with other species</th>
<th>Average population (number/transect)</th>
<th>Correlation between rainfall and population</th>
<th>Nitrogen correlation with population</th>
<th>t test sandalwood population among soil formation (calculated t : table t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kuanfatu</td>
<td>20,4 a</td>
<td>22,3 a</td>
<td>0,58</td>
<td>0,47</td>
<td>43,1 &gt; 2,12</td>
</tr>
<tr>
<td>Haunobenak</td>
<td>17,1 a</td>
<td>24,7 a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anin</td>
<td>11,5 a</td>
<td>19,3 a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oelbubuk</td>
<td>30,4 a</td>
<td>33,3 a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eonbesi</td>
<td>30,3 a</td>
<td>30,7 a</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
- Source: processed primary data
- Sandalwood SDR only on transect line, not included outside transect
- SDR value is the average from all sampling strata
- Population value is average individual per transect from pole and tree strata with the consideration that these two strata are the source of tree for harvest

Data in Table 4 shows that sandalwood proved able to grow in good coexistence with other plants in all villages of observations that differs in altitude. Even in the villages of Oelbubuk and Eonbesi, sandalwood component is dominant in comparison with other components. However, probably due to data variability the difference in the proportion of sandalwood compared to other vegetation in the five observed villages are not real. This means that sandalwood can grow uniformly along with all other vegetation in the same degree of co-existence at all levels of altitude. This is verified by looking at the data of average sandalwood populations found in all transect lines which shows no real difference.

Further search is directed at the influence of rainfall that may occur between the villages of observation on the population. It is assumed that amount of rainfall is linear with height following the formula \( r = a + bh \), where \( r \) is the rainfall (mm/year), \( a \) and \( b \) are constants, while \( h \) is the altitude (m asl) (Spurs & Barnes, 1989). The results of the calculation of the correlation coefficient indicate the correlation coefficient (\( r \)) is weak (0.58) between
populations of sandalwood and rainfall. That is, sandalwood can grow on any rainfall throughout the range of tolerance generally as proposed Surata (2006), between 625-1625 mm / year at an altitude up to 1200 m asl. Altitude and rainfall in all observation villages is still within the range in question.

Correlative calculation is also directed at the relationship between soil fertility, in this case represented by total nitrogen, with the population. The test results also showed weak correlation ($r = 0.47$) between the two variables in question. That is, sandalwood can actually grow in infertile soil. In other words, sandalwood has wide enough tolerance for soil in arid climates, slightly alkaline soil and oxidized, but has a high cation exchange capacity. The characteristics of this soil is in accordance with the characteristics of land common on the island of Timor. Surata (2006, citing Hamzah, 1976) explains that in order to produce good growth, sandalwood require fertile soil, porous and well drained, alkaline soil reaction with thin solum soil - deep. In NTT sandalwood grows in chalky-volcanic host rock, shallow rocky soil, clay soil texture, soil pH neutral-alkaline, moderate levels of N, P2O5 medium-high, black ground color, red-brown, soils generally litosol, mediteran and complex land. All the above characteristics correspond except that actually sandalwood can still grow despite a soil with low nitrogen content. On the above conditions, further verification come from the test results to the population of sandalwood that grows in loamy clay formations and somewhat rough / rocky in the villages of Eonbesi and Oelbubuk (mean plant population of 22.1 individuals / transect) with a finer geological formations in Kuanfatu, Haunobenak and Anin (mean population of 32.0 individuals / transect). With 43.1 t count> t table 2:12 at the level of 5%, the test proved that sandalwood can grow better in a bit rocky ground. Therefore argument of Surata (2006) that in NTT sandalwood grows in the chalky-volcanic host rock, shallow rocky soil, and the soil a little porous is proven. Because the actual land with such characteristics is spread fairly evenly throughout the TTS, with a note that on somewhat finer ground sandalwood can grow properly, it can be said that the ecological distribution of sandalwood in TTS is fairly evenly distributed throughout the district.
Chapter IV. Conclusion and Suggestion

1. The study results on climatic aspect showed that sandalwood can be found at all levels of altitude and climatic factors that influenced the entire TTS district;

2. The observation of aspects of soil suggests that sandalwood can grow on land that is rather rough with a high tolerance to soil with low nitrogen levels and shallow solum as long as the land has characteristics of land areas of the arid regions of Timor such as neutral soil reaction to slightly alkaline, high phosphorus and high cation exchange capacity.

3. Sandalwood has a high range of living communion with other vegetation in all strata. Some of these species are short and long term secondary host species that were suggested by experts – including other species – that is worth studying as possible host plant

Suggestion

By considering the results of studies that sandalwood in the TTS has the potential ecological spread evenly then sandalwood development efforts need to be encouraged to consider through the most important enabling factors, namely policy.
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