

**HUE UNIVERSITY  
HUE UNIVERSITY OF AGRICULTURE AND FORESTRY**

**VU DUC BINH**

**STUDY ON SCIENTIFIC BASIS FOR SOLUTIONS TO  
PRESERVATION, RESTORATION AND DEVELOPMENT  
OF SEN TRUNG (*Homalium ceylanicum* (Gardner) Benth) IN  
THUA THIEN HUE PROVINCE**

**SPECIFIC FIELD OF STUDY: SILVICULTURE  
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**SUMMARY OF DOCTORAL THESIS IN FORESTRY**

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Scientific supervisor: Assoc. Prof. Dr. Nguyen Van Loi

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# INTRODUCTION

## 1. Introduction

Thua Thien Hue is a coastal province in the North Central of Vietnam with a total natural area as of December 31, 2017 is 502,629 ha, of which the forested area is 312,243 ha, and the coverage is 56.3% (MARD, 2018). At present, the use of indigenous trees for reforestation, forest restoration and enrichment is a major concern of the forestry sector. Sen trung (*Homalium ceylanicum* (Gardner) Benth) is identified as major plantation species in the provinces of the North Central Region of Vietnam (MARD, 2014). Sen trung wood has twisted wood veins, smooth texture, hard wood, heavy, easy to process, less termite and often used to build boats, sleepers, construction. This is a species that has the ability to recover forest on poor soil. Thus, Sen trung is currently one of the tree species prioritized for forest restoration and development. However, the results of research in Vietnam on Sen trung has remained limited, the cultivation of this species has not yet developed, the models of forest planting have been less successful. There is a lack of information on silvicultural characteristics, cultivation techniques and demonstration models of Sen trung for replication. Therefore, the subject: "***Study on scientific basis for solutions to preservation, restoration and development of Sen trung (Homalium ceylanicum (Gardner) Benth) in Thua Thien Hue province***" is necessary and has scientific and practical significance.

## 2. The aim of the study

**General objectives:** To identify the scientific basis of biological, silvicultural characteristics, and practical basis on management situation, summarizing plantation models, breeding techniques to conserve, restore and develop Sen trung species in Thua Thien Hue province.

### **Specific objectives:**

- To identify some biological and silviculture characteristics, population status and activities of management and conservation of Sen trung species in Thua Thien Hue province;
- To identify the scientific basis for planning and propagation techniques for conservation and development of Sen trung species in Thua Thien Hue province;
- To propose solutions to management, preservation and development of Sen trung species in Thua Thien Hue province.

### **3. Scientific and practical significance:**

**Scientific significance:** The thesis has provided the scientific basis for biological and silvicultural characteristics, cultivation techniques to propose solutions to contribute to the restoration, conservation and development of Sen truong species in Thua Thien Hue province.

**Practical significance:**

- The thesis has selected 50 plus trees, contributing to supplementing and completing cultivation techniques to provide large timber of Sen truong species, sustainability in the economic and ecological environment;
- The thesis has built a natural distribution map, a proper regional map for restoration, conservation and development of Sen truong species in Thua Thien Hue province.

### **4. The new contribution of the thesis:**

4.1. The thesis has added new and basic information about biological and silvicultural characteristics in communities of natural and planted forests of *Homalium ceylanicum* (Gardner) Benth as a basis for proposing solutions to the management of conservation, restoration, and development this species in Thua Thien Hue province.

4.2. The thesis has selected 50 plus trees, evaluated plantation forest models, and proposed technical cultivation guidelines for *Homalium ceylanicum* (Gardner) Benth species in Thua Thien Hue province.

### **5. The layout of the thesis**

In addition to the Introduction and Conclusion parts, the main content of the thesis consists of 130 pages and is divided into 3 chapters: Chapter 1: The Literature review; Chapter 2: Subjects, scope, content and research methods; Chapter 3: Results and discussions

## **CHAPTER 1: THE LITERATURE REVIEW**

Based on the study of documents related to Sen truong in the world and in Vietnam, the research results has remained limited. The thesis has statistics of research projects related to the following areas: (1) *Research on classification, name, morphology, use value, and phenology*: The studies have described briefly morphology, the use value, phenology and unified with scientific name *Homalium*

*ceylanicum* (Gardner) Benth); (2) *Research on distribution, ecology, growth and regeneration*: studies have confirmed that Sen trung is distributed in China, Bangladesh, India, Laos, Myanmar, Nepal, Sri Lanka and Thailand and Vietnam. Studies have shown ecological characteristics, forest stand structure where there is a natural distribution of the Sen trung species. However, the information is qualitative, judgmental and not specific; (3) *Research on selection and propagation*: Studies have provided limited information on selection, sexual and asexual propagation; (4) *Research on planting, caring and nurturing plantation forests*: The studies have given us the ability to cultivate, grow, care, and nurture plantation forests. However, the information has remained limited, empirical and qualitative; (5) *GIS technology has been widely applied in forest resources management* in many countries around the world. Some authors have integrated remote sensing imagery, AHP (*Analytic Hierarchy Process*) and FAHP (*Fuzzy Analytic Hierarchy Process*) into GIS to assess land adaptation and conservation, development of some agricultural and forestry species. However, there has not been any research on application of GIS and FAHP to develop a natural distribution map, conservation, and development planning for Sen trung species.

## **CHAPTER 2: SUBJECTS, SCOPE, CONTENT AND RESEARCH METHODS**

### **2.1. Subject and scope of the study**

- Research object: Sen trung tree species in natural forests and plantation forests.
  - The scope of research: In Thua Thien Hue province.
- Research period: from November 2015 to November 2018.

### **2.2. Research contents**

- (1). Research on biological characteristics and silvicultural characteristics of Sen trung species in Thua Thien Hue province;
- (2). Research and assessment of the status of the plantation, management, conservation and threats, risk of Sen trung species decline in natural forests in Thua Thien Hue province;
- (3). Research on selection of plus trees and completion of propagation techniques of Sen trung trees species;

(4). Developing a map of potential and suitable distribution areas for forest restoration with Sen trung tree species in Thua Thien Hue province;

(5). Proposing solutions to sustainable management, conservation and development of Sen trung tree species in Thua Thien Hue province.

## **2.3. Research methods**

### **2.3.1. Viewpoints and approaches of the thesis**

The viewpoint and methodology of the thesis are to study the biological and silvicultural characteristics of species that do not separate those characteristics in the organic interaction relationship of species in the community. The topic uses systematic approach, on the basis of the combination of individual ecological approach and typical ecological populations.

### **2.3.2. Specific research methods**

a. *Inheritance method*: Selectively inherit published reports, data, and scientific documents about Sen trung species.

b. *Research methods on biological and silvicultural characteristics of Sen trung species in relation to forest plant communities where it distributes.*

Using research methods commonly used in forestry such as: (1) Morphological characteristics according to the morphological method of comparison; (2) Method of the study of the factors affecting the ecological characteristics of Sen trung species distribution: According to the site survey and silvicultural survey; (3) Survey of high tree layer by survey method of 24 plots of 2,500 m<sup>2</sup>; (4) Study of the structure of the composition by Daniel Maramillod's IV% index; (5) Study of tree layers structure of forest stands with the distribution of Sen trung species by Thai Van Trung (1978); (6) Simulation of the distribution rules of  $N/D_{1.3}$  and  $N/H_{vn}$  by Nguyen Hai Tuat and Ngo Kim Khoi (2005); (7) Research on forest tree distribution types by the method of Bao Huy (1993); (8) Study of the relationship between Sen trung species and other species using the 6-sample plot survey method; (9) Survey of regeneration by the forestry inventory process with 25 m<sup>2</sup> plots.

c. *Evaluation methods of plantation forests' status, management, conservation and threats of Sen trung species decline in natural forests*: (1) The thesis used a quick survey tool, oriented interview questions for 30 people to assess the current state of exploitation and use; threats, risk of Sen trung species decline in natural forests; (2) Summary and assessment of Sen trung plantation forest models: The thesis interviewed 50 people to collect evaluation information to summarize the Sen trung planting techniques and

evaluated growth on 6 plantation forest models with 3 plots (plot 500 m<sup>2</sup>)/01 model.

d. *The method of selecting plus trees and completing the propagation process of Sen trung*: (1) Selecting plus trees by national standards No. 8775-2017 and Le Dinh Kha (2003). Profiles of 50 plus trees were built according to the Regulation on forest seed management. The plus tree distribution map was built on ArcGIS software; (2) Testing some indicators of Sen trung seed according to Industry Standard 04TCN 33: 2001; (3) Experimental breeding of Sen trung from seeds.

- Seed germination was tested with 5 treatments of immersion water temperature for 8 hours (20 °C; 40 °C; 60 °C; 80 °C; 100 °C). Experiments were arranged in 3 iterations, 500 seeds/iteration /recipe. Data collection: germination start time, germination time and seed germination rate.

- The effect of potting mix was tested with 6 treatments (CT1. 99% soil + 1% NPK; CT2. 95% soil + 5% composted manure; CT3 94% soil + 5% composted manure + 1% NPK; CT4 90% soil + 10 % manure, CT5, 89% soil + 10% manure + 1% NPK, CT6 100% soil). Experiment with 3 repetitions. Data collection and evaluation, selection of the formula with the best survival and growth of seedlings to 6-month-old period.

- The effect of the watering regime was arranged with 4 treatments (CT1. Watering twice a day; CT2. Watering once a day; CT3. Watering every 2 days; CT4. Watering every 3 days). Experiment with 3 iterations. The amount of irrigation water applied in the experiment: CT1: 4.7 liters / m<sup>2</sup>; CT2: 6.2 liters / m<sup>2</sup>; CT3: 7.5 liters / m<sup>2</sup>; CT4: 9.6 liters / m<sup>2</sup>. Periodically collect data of survival rate, the growth of seedlings to 3-month-old.

- The effect of lighting mode was arranged in 4 treatments (cover 25%, 50%, 75% and 0 %). Experiments with 3 replicates, sample capacity of each treatment is 100 seedlings with plastic bags. Light shading was designed by Nguyen Huu Thuoc (1964). Collect periodic data of survival rate and the growth of seedlings to the age of 6 months.

(4) Experiment Sen trung propagation from cuttings.

- Experimental materials for cuttings were taken from material gardens grown from November 2016. The experiment was carried out indoors with an automatic sprinkler system, time of each

watering is 10-15 seconds, adjusting number of sprinkling time during the day in accordance to the weather conditions.

- The effect of growth stimulant IBA and NAA on rooting ability of Sen truong tree were arranged with 15 treatments, and 3 replications. The cuttings were treated with IBA, NAA concentrations (0 ppm, 100 ppm, 200 ppm, 300 ppm, 450 ppm, 600 ppm, 750 ppm, and 900 ppm) for 10 minutes to be dry and cultured on scaffolds land floor B.

- Effects of Sen truong tree cuttings were arranged with 3 treatments (top cuttings, middle cuttings, and original cuttings). Homemade cuttings were soaked in IBA with a concentration of 300 ppm for 10 minutes, dried, then inoculated potting soil (100% soil of B floor). Sample capacity of 90 cuttings / 1 treatment \* 3 replications = 270 cuttings / treatment.

- Effects of cuttings on Sen truong trees was arranged to include 03 treatments with 3 replications. (CT1. 100% land of B floor, CT2 50% land of B floor + 50% sand; CT3 100% sand).

- Effects of the time of cuttings of Sen truong trees was arranged with 4 times in four seasons: spring, summer, autumn, and winter. From September 2017 to August 2018. 3 replications per season x 90 cuttings = 270 cuttings.

*e. Method of mapping:* Map of restoration and development of Sen truong species in Thua Thien Hue province was built on the basis of applying GIS integration model, FAHP (*fuzzy hierarchical analysis*) method, and results of field surveys.

*g. Proposing solutions to preserve, restore and develop Sen truong species:* The solutions were proposed on the basis of reference to existing documents and combined with newly research results of the thesis.

*i. Methods of collecting and processing data:* According to mathematical statistical methods commonly used in forestry.

#### **2.4. The general comment on the natural and socio-economic conditions of Thua Thien Hue province that affect the conservation and development of the Sen truong species.**

Thua Thien Hue has many advantages and great potential for agroforestry development, especially the development of indigenous plants with the potential to grow lumber and large timber forests. Currently, the province has been implementing forestry programs and projects on afforestation and forest restoration with native tree species suitable to local site conditions. Sen truong is not only a valuable indigenous tree species in terms of timber, creating



landscapes but also being used to plant forests and restore natural forests. Therefore, it is necessary to study the conservation, planting, and development of this plant to improve the income of ethnic communities in Thua Thien Hue province to contribute to environmental protection.

## **CHAPTER 3: RESULTS AND DISCUSSIONS**

### **3.1. Biological and silvicultural characteristics of Sen trung**

#### **3.1.1. Morphological characteristics and phenology of Sen trung**

##### **3.1.1.1. Morphological characteristics of Sen trung**

###### *a. Trunk morphology:*

Sen trung is a large evergreen tree, straight, round, 40 m in height, 80 cm in diameter. The bark is gray or gray-brown, the flesh is pale yellow, 5-8 cm thick. Young branch is cylindrical, thin, golden brown without feathers, clearly fallen leaves traces, branches grow horizontally.

###### *b. Leaf morphology:*

The leaves are single-spaced, long, oval or oval egg-shaped, 11 - 18 cm long, 5-8 cm wide, with short pointed tips, broad wedge-shaped bases or nearly circular, intact or small serrated. The upper surface of the leaf is glossy green, the underside is lighter, hairless, middle veins are prominent on the underside, lateral veins are 8-12 pairs, small veins are shaped in network, petioles are 5-12 mm long. Young pink brown leaf have a red border.

###### *c. Flower morphology:*

The inflorescences are shaped like cotton, in armpit leaves near the tip of the branch, 10 - 20 cm long. The bisexual flowers are small, about 3 mm wide, with a lot of whitish fuzz; flower stalks 1 - 3 mm long. Each cluster has 3 - 20 flowers. Flowers pattern 4 - 6, original stations, sepals are a narrow and elongated strip on the outside. The calyx and the corolla are covered in smooth fluff inside. Petals 4 - 5, with oval size of 2 mm x 1 mm; Flowers 4-6, single flowers, stamen 2 - 2.2 mm long, smooth. Anther with coronary shape about 0.4 mm. The gourd is nearly lowered, a box carries 4 - 6 ovules and 5-6 hose filamentous stigmas.

*d. Fruit morphology:* Fruit follicle globular, the remaining sepals have the big size with the fruit, 2.5 mm diameter, 2.5 - 5 mm long, in light brown color when it is ripe.

##### **3.1.1.2. The phenological characteristics of Sen trung**

Table 3.1 result shows that Sen trung sprouts from February to April and is in young red leaves from March to the end of May. The deciduous period is usually from January to February. Flowering

period is from May to July. Period of young fruit formation is from June to August. Period of fruit ripening and fruit drop is from August to October. Therefore, it is necessary to pay attention to the different phenomenon of ripe fruit to harvest suitably.

### ***3.1.2. Effect of ecological factors on the distribution of Sen truong species in Thua Thien Hue***

The thesis evaluated the role and importance of major ecological factors such as climate, soil, topography and forest status characteristics where Sen truong species are distributed. The appropriate area of distribution for Sen truong species was calculated by weightings according to the fuzzy hierarchical analysis method (FAHP) and the appropriate point of each ecological factor indicator integrated into GIS.

#### ***3.1.2.1. Effect of climatic factors on distribution of Sen truong species in Thua Thien Hue province***

Sen truong has a natural distribution in Thua Thien Hue province with an annual average temperature of 24.4 °C. The average annual rainfall is 3,367 mm. The average air humidity is 87.4%. The table assessing the impact of climatic factors on the distribution of Sen truong species in natural forests shows that 37.73% of the total natural area of Thua Thien Hue province is considered suitable for Sen truong distribution, in which most of the area has been assessed appropriately at an average level of 33.76%.

#### ***3.1.2.2. Effect of soil characteristics on the distribution of Sen truong species in Thua Thien Hue province***

Approximately 30.48% of the total area of existing soils in Thua Thien Hue province has been assessed suitable for Sen truong species distribution, of which most of the area is distributed in the group of yellow red soil, soil thickness is over 70 cm. However, the area assessed with Sen truong distributed in natural forests at high level is only 19,706.7 ha, accounting for 3.92%, mainly concentrated on the type of red-yellow feralit soil developed on parent rocks magma acid (Fa) and dystric gleysols (D).

#### ***3.1.2.3. Impact of topography on distribution of Sen truong species in Thua Thien Hue province***

##### ***a. Effect of altitude on Sen truong distribution***

In the forest states of Phu Loc and Nam Dong districts, Sen truong scattered at the altitude of 10 - 1,110 m. The average density of

Sen trung trees is concentrated mainly at altitude from 300 m to 600 m with an average density of 11 trees/ha. The density is reduced to 7 trees/ha at altitude above 600 m to 900 m and 5 trees/ha at altitude > 900 m to 1,110 m. Sen trung is not distributed at altitude of 1,110 m.

*b. Impact of topographic position on Sen trung distribution*

*Table 3.7. The density of Sen trung in natural forest is distributed by topographic position in Phu Loc and Nam Dong districts*

Topographic position	Phu Loc district			Nam Dong district		
	Forest density (tree / ha)	A Density of Sen trung (tree / ha)	Percentage of Sen trung (%)	Forest density (tree / ha)	Density of Sen trung (tree / ha)	Percentage of Sen trung (%)
Foothills, along the streams	654	7	1.07	566	6	0.99
Mountain slopes, along the streams	711	10	1.34	578	9	1.58
Mountain tops (over 600 meters high and 200 meters surrounding peaks)	880	0	0	848	0	0

Sen trung is distributed mainly along the streams at the foot of the mountain to the ridge, usually from 10 - 100 m from the stream, the gradient is from  $15^{\circ}$  -  $30^{\circ}$ . Sen trung individuals are scattered on the route, and the quantity range from 6 to 10 trees / ha. The area of Sen trung species distributed accounts for about 99.4% of the total area of the study area, which is mainly distributed on topographic forms with an absolute height of 300-600 m, a gradient of  $10^{\circ}$ - $20^{\circ}$  and at the foothills, ridge, and along with the stream. Unsuitable areas for Sen trung species account for only 0.6% of the total area of the province.

*3.1.2.4. Effect of forest vegetation on Sen trung distribution*

*Table 3.11. Effect of vegetation factor on Sen trung distribution*

Ordinal	Suitable decentralization distribution	Area (ha)	Percentage (%)
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1	High appropriate area	101,782.2	20.22
2	Medium appropriate	29,794.0	5.92
3	Low appropriate area	13,183.7	2.62
4	No distribution	358,560.6	71.24
	Total:	503,320.5	100.00

Approximately 28.76% of the total area of the study area is estimated to have distribution of Sen truong species, in which most of the area with Sen truong distribution is defined as a high-level distribution area, belonging to forest vegetation with canopy cover < 0.5, accounting for 20.22%, while the assessed area may have Sen truong distribution at medium and low level, only 5.92% and 2.62% respectively.

### **3.1.3. Some structural features of natural forests with Sen truong distribution**

#### ***3.1.3.1. Characteristics of the structure of tall tree layer of natural forest with Sen truong distribution.***

##### *a. A number of factors of forest stand survey*

The density of forest stands where Sen truong species are distributed ranges from 467 trees/ha to 1,015 trees/ha.  $D_{1.3}$  from 13.1 cm to 20.8 cm;  $H_{vn}$  from 10.5 m to 13.7 m. On the sample plots, Sen truong has diameter and especially average height which are larger than the diameter and average height of the stand. The reserve of Sen truong species only varies from 1.4 m<sup>3</sup>/ha to 4.9 m<sup>3</sup>/a, accounting for 0.8% to 6.9% of the stand volume. This proves that although the number of individuals is only from 4 to 11 trees / ha, Sen truong also occupies a certain amount of biomass in the stand.

##### *b. Structure of natural forest layer where Sen truong is distributed*

The results show that in the study area in the natural forest states in Phu Loc district and Nam Dong district in Thua Thien Hue, the number of trees concentrates mainly on the A2 floor: 10-20 m (accounting for 64.9% to 70.3%), followed by A3 <10 m (accounting for 22.4% to 31.1%) and lowest is A1 level (only from 4.0% to 7.3%). Sen truong also concentrates mainly on A2 floor (7 trees in Phu Loc and 6 trees in Nam Dong). Therefore, there is a need to restore natural forests where Sen truong is distributed. Appropriate measures should be taken such as canopy opening or additional planting.

##### *c. The structural composition of a natural forest where Sen truong is distributed*

Natural forest with Sen truong distribution is a mixed forest of evergreen broadleaf species with a diverse number of species ranged from

29-56 species. However, there are only 25 main species involved in the composition formula. High tree layer composition consists of the dominant tree species such as De gai sapa, Tram moc, Tram trang, Mit nai, Ngat, Cho den, Tram tan, Mau cho and Truong vai. In the sample plots, Sen trung has low coefficient composition ranging from 0.6% -3.3% and does not participate in the composition formulation.

**Table 3.13.** *The composition follows the IV% index on the natural forest states where Sen trung is distributed*

Survey location	Forest states	No. of species	Formula composition	IV% of Sen trung
Phu Loc district	TXG	56	11,2 Cho den+8,8 Tram moc+8,6 Boi loi+8,0 De gai sapa+5,6 Com tang+5,6 Buoi bung+52,2 Other species (including 50 other species)	0,6
	TXB	55	10,5 Mit nai + 8,2 Tram moc + 5,4 Go dong + 5,4 Truong do + 70,5 Other species (including 51 other species)	1,5
	TXN	49	9,6 De gai sapa + 9,1 Tram trang + 6,4 Tram moc + 6,3 Soba + 5,1 Ngat + 63,5 Other species (including 44 other species)	3,3
	TXP	51	7,3 De gai sapa+6,7 Boi loi+6,5 Tram xanh+6,1 Mit nai+5,7 Tim lang+67,7 Other species (including 46 other species)	2,7
Nam Dong district	TXG	29	14,0 De gai sapa+11,2 Kien kien +7,2 Cho den+6,3 De gai an do+5,8 Cho nau+5,6 Truong vai+5,6 Truong khe+5,2 Tram trang+39,1 Other species (including 21 other species)	0,6
	TXB	43	9,9 Mit nai + 9,8 Tram trang + 8,0 Ngat + 7,1 Kien kien + 65,2 Other species (including 39 other species)	2,1

	TXN	47	9,7 <i>Mit nai</i> +6,8 <i>De gai sapa</i> +6,1 <i>Ngat</i> + 5,2 <i>Tram moc</i> +72,2 <i>Other species (including 43 other species)</i>	2,1
	TXP	43	8,1 <i>Mit nai</i> +7,9 <i>De gai sapa</i> +5,9 <i>Tram tan</i> +5,7 <i>Tram sang</i> +5,7 <i>Tram moc</i> +5,7 <i>Cho den</i> +5,1 <i>Mau cho</i> +55,9 <i>Other species (including 36 other species)</i>	2,8

*d. Distribution of tree height and diameter of the stand where Sen trung is distributed:* Distribution of number of trees according to diameter in natural forest stands with Sen trung distribution in Nam Dong and Phu Loc districts is according to the most suitable distance distribution.

*e. Rules of correlation between diameter and height of Sen trung:*

The letter S function best represents the relationship between  $D_{1.3}$  and  $H_{vn}$  according to the regression equation:  $H_{vn} = e^{(3,189 \cdot 7,311/D_{1.3})}$ .

#### **3.1.4. The relationship between Sen trung and other species**

The thesis has identified 420 individuals and 25 species of plants grown in 60 standard plots of 6 trees in Thua Thien Hue province. The number of plots with Sen trung species only is very low at 5 plots / 60 plots, accounting for 8.3% of the total number of plots. Thus, it can be confirmed that Sen trung species has low concentration. Group of species which is very popular with Sen trung is Tram trang, De gai sapa and Cho den.

### **3.1.5. Regeneration characteristics where Sen trung is distributed in Phu Loc and Nam Dong districts, Thua Thien Hue province**

#### **3.1.5.1. Structure of regeneration**

The composition of regenerated tree species ranges from 17 to 47 species, mainly *Mit nai*, *Uoi*, *Cho den*, *De gai sapa*, *Boi loi do*, *Mau cho*, *Ngat* ... The average density of regenerated trees varies from 4,133 - 13,013 trees/ha. The number of regenerated trees of Sen trung in the study area is very low, only 2 trees per 120 survey plots.

#### **3.1.5.2. Density, quality, and origin of regenerating plants**

The average density of forest regeneration where Sen trung species is distributed is 5,960 trees/ha in Nam Dong and in Phu Loc is 8,007 trees/ha. Regarding the origin of regenerated trees, mainly regenerated trees are from seeds accounted for 92.7% - 94.3%.

### ***3.1.5.3. Distribution of the number of regenerated trees by height***

The proportion of promising regeneration trees in the forest states where Sen trung is distributed in Nam Dong (1,873 trees/ha), Phu Loc (3,980 trees/ha). The number of regenerated trees has sufficient quantity for forest restoration in the study area.

## **3.2. ASSESSMENT OF THE STATUS OF THE PLANTATION, MANAGEMENT, CONSERVATION AND THREATS, RISK OF SEN TRUNG SPECIES DECLINE IN NATURAL FORESTS IN THUA THIEN HUE PROVINCE**

### **3.2.1. Management and conservation status and the threats, risk of Sen trung species decline in Thua Thien Hue.**

#### ***3.2.1.1 Status of management and conservation of Sen trung species in Thua Thien Hue province.***

In recent years, forest protection and management have been well implemented by individuals and organizations. Species conservation and development activities have been effectively implemented by Bach Ma National Park in the period from 2010 up to now with projects such as "Conservation of traditional medicinal plants" (1998 - 2013); "Research on conservation of two rare and precious endangered species Gu lau (*Sindora tonkinensis*) and Kien Kien (*Hopea pierrei*) in Bach Ma National Park" (2009 - 2013); "Study to build models for natural forest restoration at the subdivisions of ecological restoration in Bach Ma National Park" (2005-2012); "Research on techniques for planting Sen trung species in Thua Thien Hue province" (2010-2012) ... The development activities of Sen trung species in Bach Ma National Park have been conducted to grow Sen trung to enrich forests in many different locations for the purpose of species research and development. In 2010, Bach Ma National Park propagated the trial of Sen trung with seeds and produced 3,500 seedlings. In 2011, the park planted 5 hectares of Sen trung trial model.

#### ***3.2.1.2. Threats and risks of Sen trung species decline.***

The thesis has identified five threats and risks of Sen trung species decline (1) Illegal logging activities; (2) Activities of encroachment on forest land for cultivation; (3) Forest fire; (4) Limited awareness of the community; (5) Construction and development of infrastructure. In addition, grazing, mining timber forest products and biological characteristics of the species Sen trung distribution are very scattered, the possibility of natural regeneration

is poor, limiting the preservation and development of this species in nature.

### **3.2.2. Assessment of the status of plantation and growth of Sen truong species on plantation forest models**

#### *3.2.2.1. The status of models and technical measures to plant Sen truong*

##### *a. The status of planting Sen truong trees in Thua Thien Hue*

- Planting scale: The number of households participating in Sen truong planting on medium scale accounts for the highest rate of 50%, followed by the number of small-scale farmers (42%) and the lowest rate is the number of households growing on a large scale over 1.0 ha (8%). Sen truong is grown mainly in home gardens, and the area of the concentrated plantation of households is limited.

- Management method: There are 3 main management methods: household, household group, agency (company). Of which, household management is the most common method, accounting for 86% because most households grow in home gardens in small quantities.

- The main method of planting includes concentrated planting into forests, planting in gardens, campus, and planting on streets and in parks in which small-scale plantations are in home gardens and agencies is applied by many people, accounting for 86% of the samples surveyed.

##### *b. Current status of seed sources for planting Sen truong trees*

Sen truong seed sources are all collected from street trees or in campus, schools, pagodas, scattered trees in the garden. The varieties do not have the origin, and the quality of the seed is not tested, selected or assayed so it greatly affects the quality of Sen truong plantation currently.

##### *c. Current status of techniques and planting site of Sen truong forest*

There are two popular methods of afforestation: mixed and pure plantations. Mainly a mixture of Sen truong trees with native plants such as Muong den, Boi loi, Lim xanh, Vang trung, Dau rai, Sao den .. and a mixture of Sen truong and Acacia. The mixed planting of Sen truong and indigenous trees with a tight band of 2 m to 8 m has an initial density of 625 trees/ha. Mixed planting method of Sen truong and Acacia plantations with the density of 1,110 trees to 1660 trees/ha, of which the rate of Sen truong trees ranges from 30-45% (about 500 trees/ha). The planting period of Sen truong forest is in the autumn-winter season (September to December) and the milking in



spring. The time to take care of planted forests is usually 3 years from the spring of the following year.

*d. The consumption of Sen trung products in the market*

As for Sen trung seeds: Harvesting in urban trees and scattered trees which are sold at about 2 to 3 million VND / 1 kg.

Sen trung seedling: 12-month-old tree (seedling standard:  $D_0$  from 4 - 5 mm, Hvn from 35 to 50 cm) with unit price of 6,000 VND / tree and 24-month-old seedlings (seedling standard:  $D_0$  from 8 - 10 mm, Hvn from 80-100 cm) with the unit price of 8,000 to 10,000 VND / tree.

Sen trung wood products: trees with a diameter of 40 cm or more with length of logs is from 8 - 10 m are bought from 4 - 6 million VND / tree by traders.

### 3.2.2.2. Evaluation of Sen trung's growth in plantation forest models

*a. Results of growth assessment of plantation forest models*

\* Evaluation of pure plantation forest model of Sen trung trees

**Table 3.30.** Results of the evaluation of growth of pure plantation forest model of Sen trung species

Model	Standard plot	Planting density (tree/ha)	Current St density (tree/ha)	$D_{1,3}$ (cm)	$S_D$ (%)	$H_m$ (m)	$S_{Hm}$ (%)	$D_t$ (m)	$S_{Dt}$ (%)	Age (Year)	M/ha (m <sup>3</sup> /ha)	$\Delta m$ (m <sup>3</sup> /ha/year)
Model 4. Huang Binh Commune	1	1.650	1.280	4,0	15,5	4,0	17,7	1,9	13,1	2,5	3,2	1,3
	2	1.650	1.240	3,8	16,7	3,9	18,0	1,9	13,5	2,5	2,7	1,1
	3	1.650	1.160	3,6	13,2	3,6	24,4	1,8	11,5	2,5	2,1	0,8
	TB	1.650	1.227	3,8	15,1	3,8	20,0	1,9	12,7	2,5	2,7	1,1
Model 5. Binh Dien Commune	1	1.110	1.040	13,6	19,5	11,0	13,2	2,5	21,6	7,0	83,1	11,9
	2	1.110	1.000	13,3	17,9	10,5	13,0	2,4	21,5	7,0	72,9	10,4
	3	1.110	960	13,0	19,7	10,2	15,7	2,0	25,6	7,0	65,0	9,3
	TB	1.110	1.000	13,3	19,0	10,6	13,9	2,3	22,9	7,0	73,6	10,5
Model 6. Hong Tien Commune	1	1.110	620	24,2	19,6	20,1	9,3	5,0	13,2	17,0	286,5	16,9
	2	1.110	540	23,8	16,2	19,2	9,4	4,4	16,5	17,0	230,5	13,6
	3	1.110	400	23,6	15,9	18,6	8,8	4,2	10,9	17,0	162,6	9,6
	TB	1.110	520	23,9	17,2	19,3	9,2	4,5	13,5	17,0	226,5	13,3

The average growth of the 2.5-year-old reserve is 1.1 m<sup>3</sup> /ha/year. The period of 7-17 years of age has increased correspondingly from 10.5 m<sup>3</sup>/ha/year - 13.3 m<sup>3</sup>/ha/year. Growth in diameter is 1.52 cm/tree/year and growth is 1.53 m/tree/year in the period of 2.5 years of age. By the period of 7-17 years of age, the growth in diameter reaches from 1.4 -1.9 cm/tree/year and increases the height from 1.1 to 1.6 m/tree/year.

*\* Evaluating the model of planting Sen trung mixed forest:*

Results of the evaluation of the growth of 3 models mixed forest of Sen trung + Acacia and Sen trung + Sao den, Dau rai show that the average annual growth of all three models reaches from 0.66 to 0.92 cm/tree/year for D<sub>1,3</sub> diameters and 0.63 to 0.84 m/tree/year for H<sub>vn</sub> height. Annual average growth in reserves in mixed plantation forest models is from 1.9 to 5.0 m<sup>3</sup>/ha/year.

### **3.3. RESULTS OF PLUS TREE SELECTION AND TECHNICAL PROPAGATION OF SEN TRUNG SPECIES**

#### **3.3.1. Selecting Sen trung plus trees in Thua Thien Hue province**

The thesis selected 50 plus trees and developed distribution maps in Thua Thien Hue. The growth quality indicators of selected plus trees are good, 21.5 - 45.0 cm (D<sub>1,3</sub>), 19.0 - 30.0 m (H<sub>vn</sub>) and 13.0 - 20.0 m (Hdc).

#### **3.3.2. Some physiological characteristics of Sen trung seeds**

The average weight of 1,000 Sen trung seeds is 0.567 g. 1 kg of seeds can range from 1.61 to 1.92 million seeds. The purity of 5 seed samples varies from 40.4 to 50.2%. The germination rate of good seeds is from 39.7 to 52%.

#### **3.3.3. Completing propagation techniques of Sen trung species by seeds.**

- Treatment of Sen trung seeds before sowing has a significant effect on seed germination rate. Sen trung seeds are treated by soaking seeds for 8 hours in the water with an initial temperature of 60°C with the highest germination rate of 40.7%. Seeds start to germinate for 8-10 days.

- The effect of the potting mix to the survival rate of Sen trung in the nursery period is obvious. The potting mix (94% soil + 5%

manure + 1% NPK) and (89% soil + 10% decomposed animal manure + 1% NPK) are best used to propagate Sen trung seedlings by seeds.

- Different watering regime affects the growth of seedlings in nursery stage. In fact, depending on the weather conditions to choose the number of watering 1-2 times / day.

- Light shading has an effect on survival rate and growth of Sen trung seedlings in nurseries. In each stage, Sen trung seedlings have different lighting needs. In the period of 3 months of age, the percentage of light coverage of 50% has the best survival and growth rate but up to 6 months of age, 25% is the most suitable.

#### **3.3.4. Sen trung breeding techniques by cuttings**

- Growth stimulants IBA and NAA have a marked effect on the rooting ability of Sen trung cuttings (sig <0.05). The formula for using IBA 300 ppm has the highest rooting index of 41.18. This is the best formula used in the actual production of Sen trung cuttings.

- Types of cuttings have a significant effect on the rooting ability of Sen trung cuttings (sig <0.05). Formula 1 (top cuttings) had the highest rooting rate of 70.0% and highest rooting index is 34.67. Thus, formula 1 (top cuttings) has the highest root quality, best cuttings and is used to produce cuttings.

- Different types of substrates have a significant effect on the rooting ability of Sen trung cuttings (sig <0.05). It is possible to use cuttings of 100% soil level B or cuttings on 100% sand. However, in actual production, it is necessary to use a substrate of 100% of B-layer soil to cut Sen trung.

- Season of cuttings has a significant effect on the rooting ability of Sen trung cuttings (sig < 0.05). The appropriate season for planting Sen trung trees in Thua Thien Hue and the North Central region is in the summer.

### **3.4. DEVELOPING A MAP OF POTENTIAL AND SUITABLE DISTRIBUTION AREAS FOR FOREST RESTORATION WITH SEN TRUNG TREE SPECIES IN THUA THIEN HUE PROVINCE;**

### 3.4.1. Development of a distribution map of Sen truong species in natural forests in Thua Thien Hue province

After classifying data, the weighting factors and points corresponding to each distribution level are converted from Vector data to Raster data, then integrated step by step in GIS according to the equation

$$SI = (0,252 * LM + 0,126 * ND + 0,177 * LD + 0,118 * DDTD + 0,103 * DC + 0,072 * VTDH + 0,050 * DD + 0,102 * LR) \pi C_j$$

*In which, SI: Appropriate index of Sen truong distribution; LM: Average annual rainfall, ND: Annual average temperature, LD: Type of land, DT: Thickness of soil layer, DC: High belt; VTDH: Topographic location, DD: Slope, LR: Forest type.*

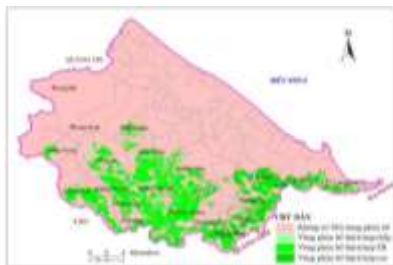
**Table 3.42.** Summary of Sen truong distribution area in Thua Thien Hue

Ordinal	Suitable point	Classification of distribution suitability	Area (ha)	Rate (%)
1	> 2,5	High appropriate	25.708,4	5,11
2	1,5 - 2,5	Medium appropriate	74.667,4	14,83
3	0,5 - 1,5	Low appropriate area	712,2	0,14
4	< 0,5	There are no Sen truong species	402.232,5	79,92
		<b>Total</b>	<b>503.320,5</b>	<b>100,00</b>

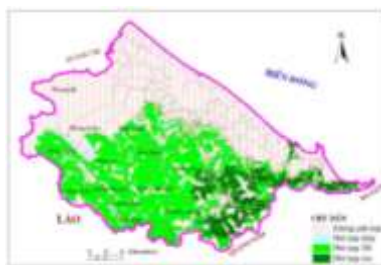
The area of the study area is assessed as having Sen truong distributed in natural forest is 101,088.0 ha (accounting for 20.08%). Most of the area assessed as appropriate is an average of 74,667.4 ha (accounting for 14.83%). The locations of Sen truong species distributed in nature at a high level are concentrated mainly in Thuong Nhat, Thuong Lo and Huong Loc communes (Nam Dong district), Loc Tri, Loc Thuy and Loc Dien communes (Phu Loc district) under the management of Bach Ma National Park.

### 3.4.2. Developing an appropriate map for Sen truong species in Thua Thien Hue province

The area classified as suitable for Sen trung species is 215,921.82 ha (accounting for 42.9%). Most of the area is assessed as appropriate with an average level of 170,679.45 ha (33.91%).



**Figure 3.20.** Prediction map of areas with Sen trung distribution in natural forests in Thua Thien Hue province



**Figure 3.21.** Classification map suitable for species Sen trung

### **3.5. PROPOSAL OF SOLUTIONS TO CONSERVATION AND DEVELOPMENT OF SEN TRUNG SPECIES IN THUA THIEN HUE PROVINCE**

*3.5.1. SWOT analysis in conservation and development of Sen trung species in Thua Thien Hue province*

*3.5.2. Solutions to conservation and development of Sen trung species in Thua Thien Hue province*

*3.5.2.1. General solutions*

*a. Solutions for forest protection and management:*

Protection forest management boards, national parks, and nature reserves strengthen forest protection and management, strengthen coordination between forest rangers and interdisciplinary forces. Increasing investment, concentrating resources, training capacity for the whole force. Planning areas for strict protection, signs, marking on the field and application of GIS in monitoring conservation of Sen trung and other rare species.

*b. Solutions to propaganda and raising awareness of people about conservation of biodiversity:*

*c. Solutions to policies and livelihoods:* Land policies and forestry land planning; Financial policies.

***3.5.2.2. Solutions to management and planning for conservation and development of Sen trung species in Thua Thien Hue province***

#### *a. New planting solution*

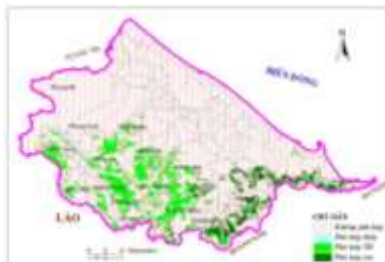
Based on the appropriate map overlaid with the forest status map layer to identify new planting sites with pure and mixed planting methods in accordance with the planning of 3 forest types of Thua Thien Hue province. The results show that the area of the study area is proposed to be classified as suitable for afforestation of Sen trung species with 91,821.1 ha (accounting for 18.25%).

#### *b. Forest enrichment solution*

The basis for identifying forest enrichment area by Sen trung tree species is based on the natural distribution map overlaid with the forest status map layer to identify forest enrichment sites. The results show that the proposed area of decentralization is suitable for forest enrichment with Sen trung species of 82,269.76 ha (accounting for 16.35%).



**Figure 3.22.** Proposed map of Sen trung forest planning



**Figure 3.23.** Proposed map of forest enrichment by Sen trung

#### *c. Solutions for zoning for forest regeneration and forest protection and management*

The basis of this solution is based on the natural distribution map overlaid with the forest status map layer to identify the locations of zoning for regeneration, only implemented on the current status of unstocked forests. This area is about 41,830.96 ha (accounting for 8.31%) that can be implemented technical solutions for natural regeneration.

#### *d. Solution to plant scattered trees*

##### **3.5.2.3. Technical solutions**

#### *a. Solutions for Sen trung conservation techniques*

There are a few special-use forests with natural distribution of Sen trung species and poor natural regeneration. Therefore, it is necessary to combine Ex-situ conservation methods for planting in

the areas outside the natural distribution of the species. In the method of ex situ conservation, it is widely cultivated by dispersed planting methods and agroforestry. The best form of management has been according to each household or contracting to specialized forest protection groups and self-management groups, but must be associated with a clear benefit mode.

*b. Technical solutions for Sen trung species development*

From the research results of the topic, together with the selective reference of research results, the thesis proposes technical guidelines for planting Sen trung trees from the stage of identifying conditions for planting, seeding and seedling creation. and take care to nurture plantations for the purpose of conservation and species development in Thua Thien Hue province.

## **CONCLUSIONS AND RECOMMENDATIONS**

### **1. CONCLUSIONS**

#### **1.1. Biological and silvicultural characteristics of Sen trung species**

Sen trung is a large evergreen tree, straight, round, 40 m in height, 80 cm in diameter. The bark is gray or gray-brown, the flesh is pale yellow, 5-8 cm thick. Young branch is cylindrical, thin, golden brown without feathers, has clearly fallen leaves traces, branches growing horizontally. The leaves are single-spaced, long, oval or oval egg-shaped, with short pointed tips, broad wedge-shaped bases or nearly circular, intact or small serrated. Young pink brown leaves have a red border. The inflorescences are shaped like cotton, in armpit leaves near the tip of the branch, 10 - 20 cm long. Flowers pattern 4 - 6, original stations, sepals are a narrow and elongated strip on the outside. The calyx and the corolla are covered in smooth fluff inside. Petals 4 - 5, with oval size 2 mm x 1 mm; Flowers of 4-6, single flowers, 5-6 hose filamentous stigmas. Fruit follicle globular, the remaining sepals have the big size with the fruit, 2.5 mm diameter, 2.5 - 5 mm long, in light brown when ripe. Sen trung has flowers and fruits in May to July. The time of budding and young leaves is from February to the end of April. The development time of young to old fruits starts from June and ends in October. Fruit ripens and falls from August to October.

- Sen trung species is often scattered way along the brook, stream from 10 to 100 meters in the state of evergreen forest with canopy cover from 0.4 to 0.8. Sen trung is distributed in places with

topography from the foot to the mountain near the stream, with the height of less than 1,110 m above the sea level, the annual average temperature is from 21.5 to 25.2 °C, the middle air humidity average annual average of 83 to 87%, rainfall of 2.773 - 3.642 mm / year and distributed on red-yellow ferralit soils with soil thickness from 80 to 100 cm, mechanical composition of soil is mainly light to medium average, pHKCl level from 4 - 4.5, humus content from 1.8 to 2.74%.

- High tree layer formation in forest states where Sen truong is distributed ranges from 29-56 species. Sen truong is not ecologically dominant species. Sen truong's concentration is low. There are 25 species of plants that appear with Sen truong species, in which the group of plants that grow together which is very common can be chosen to plant mixed forests with De gai sapa, Tram trang, Cho den. The natural regeneration ability of Sen truong species under the forest canopy is very poor.

## **1.2. Research and assessment of the plantation forest status, management, conservation and threats, risk of Sen truong species decline in natural forests in Thua Thien Hue province;**

- Thua Thien Hue has been proactive and active in the management, protection, strengthening of patrol, supervision and coordination with local communities to prevent in time violations of forest protection and management, protection biodiversity conservation and good implementation of forest fire prevention and fighting. The study has identified 5 threats and risk of direct decline of Sen truong species which are illegal logging, encroachment of forest land for cultivation, forest fires, limited awareness of the community and construction. infrastructure development.

- Area of Sen truong plantation is seriously reduced. The rate of successful models is low. Household-based management is the most common method. on small scale. scattered in home gardens in the form of pure or intercropped with agricultural crops. The source of Sen truong seed being used has not been selected. There are two common methods of plantation forest: monoculture and mixed plantation between Sen truong trees and Acacia or native plants.

- In the model of a pure plantation of Sen truong species in the period of 2.5 years of age, the average growth in diameter is 1.52 cm/tree/year and growth is 1.53 m/tree/year. In the period of 7 and 17 years of age, the diameter growth is from 1.4 to 1.9 cm/tree/year and the height growth is from 1.1 to 1.6 m/tree/year. In mixed models of 18.5 years of age, average growth in diameter is from 0.68 to 0.95 cm/tree/year, growing height is from 0.65 to 0.86 m/tree/year.

## **1.3. Regarding selection of plus trees and completion of propagation techniques of Sen truong species**

- The thesis selected 50 plus trees of Sen truong species in Thua Thien Hue province. The plus trees have both  $H_{dc}$  of 15.5 m or more and have a better growth rate than the average population of both diameter



and height The rate of timber utilization (% Hdc) is greater than 60 %, ICL is greater than 60.

- The average weight of 1000 Sen trung seeds is 0.567 g. 1 kg of seeds ranges from 1.61 to 1.92 million seeds, with an average of 1.764 million seeds. Seed purity varies from 40.4 to 50.2%. The germination rate of good seeds is from 39.7 to 52%.

- Sen trung propagation techniques by seeds: The seeds were treated by immersing in warm water (60 °C) for 8 hours, and properly rinsed and drained with controlled humidity. The treated seeds are mixed with disinfected sand (for the proportion seed/sand of 1:2) and then sowed in a damp sand bed. After 30 days of special care, when the seedlings reach around 3 cm of height, with 3 - 4 leaves, the seedlings are pruned and transplanted into the treated plastic soil-bags. The best composition of plastic container is 94 % of B layer soil + 5 % of treated manure + 1 % NPK. Sprinkling with clean water for 1 - 2 times per day depending on weather conditions. The seedlings are shaded for about 50 % in the period up to 3 months of age, aiming for the best seedling growth. The shade shall be changed to 25% at 6 months of age.

- The stem-cuttings technique of *Homalium ceylanicum* Gardner) Benth is applied to transplant into substrate of 100 % B layer soil; soaked for 10 minutes in 300 ppm IBA (Indole-3-butyric acid) to increase the rooting ability of the cuttings; the suitable season for stem-cutting *Homalium ceylanicum* (Gardner) Benth is Summer (from June to August).

#### **1.4. Developing distribution and appropriate maps of Sen trung species in Thua Thien Hue province**

The thesis developed a distribution map of Sen trung trees in the natural forest and a suitable classification map for forest restoration with this species in Thua Thien Hue province on the basis of integrating remote sensing image and method FAHP into GIS. Area of Sen trung distributed in natural forest is 101,088.0 ha, accounting for 20.08% of the total natural area of the province. The area of a decentralized research area assessed as suitable for Sen trung species is 215,921.82 ha (accounting for 42.9%).

#### **1.5. Proposing solutions to preserve, restore and develop Sen trung species in Thua Thien Hue province**

The thesis has proposed general solutions to forest protection and management, people's awareness of biodiversity conservation, policies and livelihoods; solutions to planning, conservation and sustainable development of Sen trung species in Thua Thien Hue province. The thesis has proposed to add some major technical measures from the stage of selecting seeds, identifying the conditions for planting to produce seedlings, planting and tending plantation forests as a basis for completing cultivation techniques for Sen trung species in Thua Thien Hue province.

## **2. EXISTING**

(1) The thesis has not adequately studied the growth and development of the characteristics of Sen trung species as well as some other techniques of breeding and planting;

(2) Despite of the concept "*technical approach close to nature, in accordance with laws of nature*," the research results of the thesis cannot be solved completely in this view;

(3) The thesis has not yet researched and identified the age of technological maturity, predicting the output and income of the model of planting sawlog forests.

### **3. RECOMMENDATIONS**

(1) It is necessary to thoroughly continue to solve the above-mentioned problems and apply the proposed solutions of the thesis into actual production;

(2) It is necessary to continue to study to improve the technical methods of intensive forest planting to supply sawlog and to build a system of seed forests and nurseries to provide high-quality breeds;

(3) There is a need to identify the age of technological maturity for the model of sawlog plantation forests and to predict the output and income of the model.

## LIST OF PUBLISHED SCIENTIFIC ARTICLES OF THE THESIS

1. Vu Duc Binh, Nguyen Van Loi, Le Xuan Truong (2017), "Research on structural characteristics and relationship between *Hainan homalium* (*Homalium ceylanicum* (Gardner) Benth) and other species in natural forests of Nam Dong and Phu Loc districts, Thua Thien Hue province", Journal of Forestry Science, No. 3, October, 2017, Vietnamese Academy of Forest Science, Hanoi, page. 96-104.
2. Vu Duc Binh, Nguyen Van Loi, Nguyen Thi Thanh Nga (2018), "Effect of ecological factors on the distribution of *Hainan homalium* (*Homalium ceylanicum* (Gardner) Benth) in Thua Thien Hue province", Journal of Agriculture and Rural Development - Ministry of Agriculture and Rural Development, No. 6, 2018, page 122-129.
3. Vu Duc Binh, Nguyen Van Loi (2018), "Study on biological characteristics and distribution of *Hainan homalium* (*Homalium ceylanicum* (Gardner) Benth) in natural forests of Phu Loc, Nam Dong district, Thua Thien Hue province". Hue University Journal of Science: Agriculture and Rural Development No. 3A, Volume 127, 2018, page 67-80.
4. Vu Duc Binh, Nguyen Van Loi, Nguyen Thi Thanh Nga, Ha Van Thien, Nguyen Hai Thanh (2018), "Research on propagation techniques of *Homalium ceylanicum* (Gardner) Benth by seeds and cuttings in nursery stage", Journal of Agriculture and Rural Development - Ministry of Agriculture and Rural Development, No. 20, 2018, page 141-149.
5. Vu Duc Binh, Nguyen Van Loi, Nguyen Thi Thanh Nga, Le Cong Dinh (2019), "Assessing ecological suitability of *Hainan homalium* (*Homalium ceylanicum* (Gardner) Benth) and proposing conservation, planning solutions in Thua Thien Hue province", Journal of Agricultural Science & Technology, University of Agriculture and Forestry, Hue University, Volume 3, number 1-2019, page 1013-1024.