



## Silvicultural Characteristics Of *Dipterocarpus Rensus* In Thai Nguyen Province, Vietnam

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### Abstract

*Dipterocarpus rensus*, a long-exploited species in Thai Nguyen Province, Vietnam, is currently documented with only 244 individuals observed across scattered locations within strictly protected natural forests. This study aimed to elucidate the distribution and silvicultural characteristics of *D. rensus* in Thai Nguyen, providing essential insights for the conservation and sustainable development of its genetic resources. Our findings underscore a sparse population of *D. rensus* in Thai Nguyen, primarily concentrated within National Parks and Conservation Areas. The species composition formula for the natural distribution of *D. rensus* encompasses diverse tree species, including *Broussonetia papyrifera*, *Allospondias lakonensis* Pierre, *Choerospondias axillaris*, *Fagus sylvatica*, *Machilus velutina* Champ, *Canarium album*, *Engelhardtia chrysolepis*, *Peltophorum dasyrhachis*, *Alangium chinense*, *Vatica odorata*, *Duabanga grandiflora*, *Sargentodoxa cuneata*, *Amesiodendron chinense*, and *Nephelium chryseum*. The regenerative seedling composition is dominated by pioneer, fast-growing species such as *Broussonetia papyrifera*, *Allospondias lakonensis* Pierre, *Fagus sylvatica*, *Machilus velutina* Champ, *Zenia insignis*, *Engelhardtia chrysolepis*, *Archidendron clypearia*, *Pterospermum acerifolium* Willd., *Bischofia javanica*, *Vatica odorata*, *Duabanga grandiflora*, *Sargentodoxa cuneata*, *Broussonetia papyrifera*, *Aesculus assamica*, and *Amesiodendron chinense*. The study highlights the poor regeneration ability of *D. rensus*, emphasizing the necessity for research on cultivation techniques to effectively conserve and harness the genetic resources of this valuable species.

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**Keywords:** Conservation, *Dipterocarpus rensus*, regeneration, silviculture, species composition

### 1. Introduction

*Dipterocarpus rensus* locally referred to as 'Trai dau' or 'Sao xoay,' is a sizable tree with a broad distribution spanning elevations from 300m to 1,500m above sea level. This species is naturally found in India, Laos, Cambodia, Vietnam, Indonesia, China, and some other areas in Asia. Despite its extensive natural range, the population of *D. rensus* within this distribution is limited and dispersed, as noted by Singh et al<sup>1</sup>. Presently, the

species faces a severe threat of extinction in the wild, attributed to habitat loss and the impacts of deforestation for agricultural activities and logging.

In Vietnam, *D. rensus* is distributed in some mountainous provinces across the North, Central, and Central Highlands regions including Bac Kan and Thai Nguyen provinces in the northern part of the country, and are known as host natural populations of *D. rensus*. These provinces boast rich and diverse natural forest ecosystems, spanning low mountains, high mountains, and rocky terrains, encompassing areas such as national parks and nature reserves. These regions hold significant potential for eco-tourism and scientific research purposes, as acknowledged by the Ministry of Science and Technology in 2007<sup>2</sup>. However, the escalating demand for timber exploitation places considerable pressure on *D. rensus* populations, leading to a pronounced decline. This decline has severe repercussions on the availability of mother trees for seed sources and hinders the species' natural ability to self-regenerate in the wild. Directives such as No. 19/2004/CT-TTg, addressing solutions for wood processing industry development and wood product export, alongside initiatives like the Forestry Sector Restructuring Project, Forestry Law<sup>3-4</sup>, and the recent Vietnam Forestry Development Strategy for 2021 - 2030<sup>5</sup>, all underscore a collective commitment to biodiversity preservation, safeguarding native tree genetic resources, and fostering the cultivation of large timber forests with an emphasis on native tree species, including *D. rensus*.

The research on *D. rensus* in Vietnam is currently limited, primarily focusing on a few seedling creation techniques, experimental planting in selected projects, and an initial compilation of technical guidelines for the species' cultivation. Notably, there is a paucity of information pertaining to silvicultural characteristics, the absence of a technical afforestation process, and a critical need for assessing genetic diversity through molecular markers. These aspects are crucial for the conservation and sustainable development of *D. rensus*, a rare and economically valuable tree species with high biodiversity. Recognizing the significance of conserving and developing the genetic resources of *D. rensus*, a rare wood species, the Thai Nguyen Provincial People's Committee has endorsed a research program focused on the genetic conservation and utilization of rare and high-value species, including *D. rensus*<sup>6</sup>. Therefore, this work aims to study the distribution and some silvicultural characteristics of the *D. rensus* species, for proposing measures to conserve and utilize the genetic resource of this species in Thai Nguyen province.

## 2. Materials and methods

### 2.2. Research Methods

#### *Line survey method*

Based on the topographic map and the current status of the forest resource map, we initiated a preliminary reconnaissance of the research area, referring to relevant documents and local officials and people who are familiar with the terrain to plan the field survey. Morphological characterization was described to identify the species, including the characteristics of the stems, leaves, flowers, and fruits, respectively. The investigation extended to mapping the distribution of these species within the study area. In order to systematically cover the extensive natural forest area of 76,481 hectares, the research team strategically established 282 transects spanning a cumulative length of 1851 km. These transects were laid out across five distinct ecological areas within the province, namely Dong Hy, Vo Nhai, Phu Luong, Dinh Hoa, and Dai Tu districts. During the survey expeditions, the identification of trees was facilitated through visual observation, employing distinguishing characteristics. This comprehensive approach allowed for a thorough exploration of the forest ecosystem and contributed to the acquisition of valuable data pertaining to the ecological composition of the region.

#### *Investigation of the typical sampling plot method*

At the points where the *D. rensus* trees have been distributed, sampling plots (SP) were established with an area of 1000m<sup>2</sup> (25 x 40 m) with the long side parallel to the contour line, and the short side perpendicular to the contour line. A total of 30 SPs belonging to 4 districts of Dong Hy, Dinh Hoa, Phu Luong, Dai Tu, and Vo Nhai were designated. In SPs, the following factors were also investigated.

#### *For mature trees ( $\geq 6$ cm in diameter)*

We used various parameters including tree species name, tree height (Hvn), under-crown height (Hdc), the diameter at breast height (D1.3), and crown diameter (Dt) for all tree species with D1.3  $\geq$  6 cm within the study plots (SPs). Initially, the species name was identified based on the local nomenclature in the field, and subsequently, the corresponding scientific name was cross-referenced. Unfamiliar plants were systematically sampled and subjected to assessment employing established expert methodologies. To quantify the height at the apex and under-crown, a Blum-Leiss ruler was used. The diameter measurement at 1.3 meters height utilized a glass caliper with engraved lines at millimeter intervals. The crown diameter was determined by

measuring in two perpendicular directions (East to West and North to South) using a tape measure. The resulting values were averaged using the arithmetic mean method to ensure accuracy and reliability.

***For the regenerated seedling layer (< 6cm in diameter)***

Investigating all regenerating seedlings of all species (including *D.rensus*) to determine the species composition of the regenerating seedling layers was conducted. For each typical SP, 5 small sampling plots (SSP) with an area of 25 m<sup>2</sup> (4 SSPs at the 4 corners and 1 SSP in the center of the SP) were established. Measurement criteria included: species name, height (Hvn), growth status, seedling quality, regeneration origin (buds, seeds), number of trees, and percentage of promising species with D1.3 < 6 cm. Promising regenerated seedlings are species of the target species, well-developed, with a height greater than the forest floor layer in that area (>=2 m). When investigating regeneration on SSPs, simultaneously determine the criteria of canopy coverage, average forest coverage and slope. Identifying promising regenerated trees: Promising regenerated trees are trees > = 2 m, growing well and capable of participating in the mature tree layers. Data from the field survey were analyzed using Excel version 2016.

### 3. Results and Discussion

#### 3.1. Morphological characteristics of the *Dipterocarpus rensus*

The large tree exhibits a distinctive spherical canopy, characterized by a straight cylindrical trunk reaching heights of 30-40 m with an approximately 100 cm diameter. Its bark presents a gray-white with many large pores. In the research area, a limited number of trees were identified, with only one specimen reaching a maximum diameter of 60 cm (very few, 1 tree) and a height of 30 m (Figure 1).







**Figure 1.** *Dipterocarpus rensus* population and scatter trees

The leaves of this species are simple in structure, featuring a spaced-out arrangement with whole or wavy edges. The leaf blades are rough in texture, and parallel veins are distinctly visible on both sides. The main veins are adorned with numerous bristles, while the side veins exhibit 15-20 pairs. When dry, the leaves assume a dark brown coloration. Leaf size presents variation depending on the position beneath the canopy. In the lower canopy, leaves measure 20.4-48.5 cm in length and 11.7-26.8 cm in width. In the mid-canopy, leaves range from 20.4-48.5 cm in length and 11.7-28.6 cm in width. At the uppermost part of the canopy, leaves measure 20.5-48.5 cm in length and 11.5-28.7 cm in width (Figure 2).

The stipules, characterized by their elongated, egg-shaped form, are reddish-brown and covered with numerous white hairs. Stipules measure 6-18 cm in length and promptly fall off.



**Figure 2.** *Dipterocarpus rensus* leaves

The *D.rensus* reproduces sexually through flowers, which usually appear seasonally and are found in mature trees. The process of pollination and fertilization takes place in the flower. After the flower fades, the ovary in the flower will develop into a fruit. The flowers of the *D. rensus* species are self-flowering flowers, usually



growing in clusters, with yellow petals and a light scent. Usually grows in leaf axils. When the flower fades, the petals will turn dark brown. The 5 sepals have 2 petals that develop to form petals. When they fall, the two sepals help the fruit to spread far away (Figure 3).

The fruit of *D. rensus* takes on a slightly round and ovoid shape, with an average length of 2.99 cm and an average width of 2.59 cm. The structure includes five elongated petals, each with two wings that develop into large and extended fruit petals. Each sepal bears three prominent veins. The two major fruit petals measure 15-25 cm in length and 2-3 cm in width (Figure 4). In its early stage, the fruit displays a light green color, transitioning to yellow-green when ripe, and ultimately turning brown when fully mature. On average, one kilogram of wingless fruits comprises approximately 72 individual fruits.



**Figure 3.** *Dipterocarpus rensus* flowers



**Figure 4.** *Dipterocarpus rensus* fruits

### 3.2. Distribution characteristics of the *Dipterocarpus rensus* species

The findings from the investigation on the distribution of *D. rensus*, categorized by route and forest status, are presented in Table 1.

**Table 1.** Summary of distribution of *Dipterocarpus rensus* by routes

Areas	Number of routes	Length of routes (km)	Number of trees	D1.3	
				Min	Max
Dong Hy	58	353.6	17	7	20
Vo Nhai	60	667.0	16	6	38
Phu Luong	30	250.5	145	6	60
Dinh Hoa	56	430.72	23	6	53
Dai Tu	78	149.6	43	6	50
<b>Total</b>	<b>282</b>	<b>1851.4</b>	<b>244</b>	<b>6 - 7</b>	<b>20-60</b>

The results showed that 244 *D. rensus* trees have been found naturally distributed in survey lines in 5 districts. The distribution of *D. rensus* is significantly influenced by human impact. The investigations reveal that *D. rensus* is primarily found in well-protected zones, including the National Park area in Dai Tu and strictly preserved regions such as the community forest in Dong Tam hamlet, Tuc Chanh commune, Phu Luong district, and the Conservation area in Vo Nhai, Deo Re ATK Dinh Hoa hamlet. In contrast, in other areas, *D. rensus* trees persist but are scattered and exist in very small numbers.

**Table 2.** Summary of *Dipterocarpus rensus* distribution according to altitude and forest states

SPs	Dong Hy		Dinh Hoa		Phu Luong		Dai Tu		Vo Nhai	
	Altitude (m)	Forest states	Altitude (m)	Forest states	Altitude (m)	Forest states	Altitude (m)	Forest states	Altitude (m)	Forest states
1	388	IIB	390	IIIA1	68	IIIA2	835	IIIA2	334	IIB
2	468	IIB	300	IIIA1	78	IIIA2	782	IIIA2	340	IIB
3	470	IIB	200	IIB	60	IIIA2	625	IIIA2	122	IIB
4	492	IIB	149	IIB	332	IIIA2	525	IIIA1	62	IIIA1
5	385	IIB	170	IIB	248	IIIA2	185	IIIA1	65	IIB
6	522	IIA	120	IIB	269	IIB	195	IIIA1	349	IIB
7	450	IIA	96	IIB	130	IIA	166	IIIA2	449	IIIA1
8	480	IIA	360	IIIA1	163	IIIA1	186	IIIA2	325	IIIA2
9	490	IIB	100	IIB	179	IIB	85	IIB	275	IIIA1
10	513	IIB	116	IIB	227	IIA	88	IIIA1	239	IIB
11	380	IIB	102	IIA	230	IIA	157	IIB	247	IIA
12	425	IIA	140	IIB	275	IIB	200	IIIA1	265	IIIA1

As presented in Table 2, it can be seen that 60 SPs established in 5 districts of Thai Nguyen province have naturally distributed *D. rensus* trees at altitudes from 60 to 850m above sea level. Specifically in 5 areas: Dong Hy: From 385-522m; Vo Nhai: From 62-449m; Phu Luong: From 60-332 m. Dinh Hoa: From 96-390 m; Dai Tu: From 85-885 m. The *D. rensus* is distributed in many forest states in the study area. The main states included: IIA; IIB; IIIA1 and IIIA2, of which the forest state that accounts for the most is IIB forest recovered after slash-and-burn cultivation, accounting for 45% of investigated SPs (27 SPs).

### 3.3. Characteristics of the species composition and their distribution

The results summarized in Table 3 show that the *D. rensus* tree is still available in small areas in Tuc Chanh, Dai Tu (National Park) Dinh Hoa (ATK area) with ecologically significant formations within the system. The species composition coefficient is greater than 5%. The *D. rensus* participates in the species composition with the main species: *Broussonetia papyrifera*, *Allospondias lakonensis* Pierre, *Choerospondias axillaris*, *Fagus sylvatica*, *Machilus velutina* Champ, *Canarium album*, *Engelhardtia chrysolepis*, *Peltophorum dasyrhaichis*, *Alangium chinense*, *Vatica odorata*, *Duabanga grandiflora*, *Sargentodoxa cuneata*, *Amesiodendron chinense*, *Nephelium chryseum*. The areas where *D. rensus* species grow together are very small and fragmented. The main cause of this decline is human impact as well as the conversion of land use purposes.

**Table 3.** Summary of mature tree layer's species composition at the survey sites

Areas	Species composition
Dong Hy	12,58 Du + 7,12 DDX + 6,42 XN + 4,8 DG - <b>2,78 ChN</b> + 66,30 LK
Vo Nhai	9,14SC + 6,11 MC + 5,91 DG + 5,91 XN + 5,68 TT + 5,46 LV - <b>2,45 ChN</b> + 59,34LK
Phu Luong	<b>48,64 ChN</b> + 10,99 C + 5,42 MC + 34,95 LK
Dinh Hoa	7,26 XN + 6,63 CT + 5,59 TT + <b>5,34 ChN</b> + 5,15 DG + 5,08 TB + 64,95 LK
Dai Tu	15,1 TM + 11,0 DG + 7,7 TrM + <b>7,3 ChN</b> + 7,2 TC + 51,7 LK

Note: Du: *Broussonetia papyrifera*; DDX: *Allospodias lakonensis* Pierre; XN: *Choerospondias axillaris*; DG: *Fagus sylvatica*; SC: *Machilus velutina* Champ; MC: *Sargentodoxa cuneata*; TT: *Canarium album*; LV: *Peltophorum dasyrhachis*; ChN: *Dipterocarpus rensus*; CT: *Engelhardtia chrysolepis*; TB: *Alangium chinense*; TM: *Vatica odorata*; TrM: *Amesiodendron chinense*; TC: *Nephelium chryseum*; LK: Other species.

According to Table 4, the regenerating species composition in the research areas includes many species similar to the mature tree layer. In areas with the distribution of *D. rensus*, the number of regenerated seedlings of the *D. rensus* is naturally concentrated in the areas where the mother trees have remained, such as Tuc Chanh-Phu Luong, My Yen-Dai Tu and Phu Dinh-ATK Dinh Hoa areas. The tree species that often accompany the regenerating seedling of *D. rensus* are: *Broussonetia papyrifera*, *Allospodias lakonensis* Pierre, *Fagus sylvatica*, *Machilus velutina* Champ, *Zenia insignis*, *Engelhardtia chrysolepis*, *Archidendron clypearia*, *Pterospermum acerifolium* Willd, *Bischofia javanica*, *Vatica odorata*, *Duabanga grandiflora*, *Sargentodoxa cuneata*, *Aesculus assamica*, *Amesiodendron chinense*, etc.

**Table 4.** Summary of seedling layer's species composition at the survey sites

Areas	Species composition
Dong Hy	33 Du + 14,9 DDX + 9,7KLN + 7,9DG + 5 MT - <b>3,3 ChN</b> + 26,2 LK
Vo Nhai	19,6 DG + 14,5 Ph + 7 Nh + 6,7TM + 5,7 LM - <b>4,7 ChN</b> + 41,8LK
Phu Luong	<b>20,08 ChN</b> + 17,5MC + 13,9DDX + 10,3Du + 6 DG + 32,22LK
Dinh Hoa	17 DDX + 12,8 DG + 8,2 XN + 7,3 MĐ + 6,8 LM + 5,6 ChT - <b>3,7 ChN</b> + 38,6 LK
Dai Tu	21 TM + 19 DG + <b>14 ChN</b> + 6,5 Ke + 4,5 TrM + 35 LK

Note: Du: *Broussonetia papyrifera*; DDX: *Allospodias lakonensis* Pierre; DG: *Fagus sylvatica*; KLN: *Machilus velutina* Champ; MT: *Zenia insignis*; ChN: *Dipterocarpus rensus*; ChT: *Engelhardtia chrysolepis*; MD: *Archidendron clypearia*; LM: *Pterospermum acerifolium* Willd; Nh: *Bischofia javanica*; TM: *Vatica odorata*; Ph: *Duabanga grandiflora*; MC: *Sargentodoxa cuneata*; TrM: *Amesiodendron chinense*; Ke: *Aesculus assamica*; LK: Other Species.

In the study area, the shrub layer did not have much coverage, the average coverage of this layer in the areas was 16.7%. However, the level of impact on regenerating seedlings was still significant because the regeneration density of all tree species in general and *D. rensus* tree in particular was very low. Shrub species include the following species: *Alchornea rugose*, *Glochidion zeylanicum*, *Psychotria rubra* Poir, *Rhaphis cochinchinensis*, *Melastoma candidum*, *Dichroa febrifuga* Lour, *Callicarpa dichotoma*, *Spilanthes acmella* L. Mur., *Maesa perlaris*, *Eurycoma longifolia*, *Callicarpa cana*, *Ardisia crenata*, *Breynia fruticose*, *Eupatorium odoratum*, *Ficus heterophyllus*, *Tabernaemontana divaricate*, *Melochia corchorifolia*, *Clerodendron cyrtophyllum*, *Solanum torvum*, etc.,

In addition to the influence of shrubs on the regeneration of forest populations where *D. rensus* is naturally distributed, the herbaceous layer and extra-layer vegetation also have a degree of influence through the coverage of the ground-cover layer. This. The forest floor and extra-layer vegetation in the study area have an average coverage of 15.4%. The layer of shrubs, herbaceous and extra-layer vegetation has created a coverage of over 32.1%, causing a significant impact on the growth of regenerated plants. The herbaceous layer and extra-layer vegetation includes a number of the following species: *Pothos repens*, *Alocasia macrorrhizos*, *Achyranthes aspera*, *Lophatherum gracile* Brongn, *Cyclosorus parasiticus*, *Amorphophallus konjac*, *Cheilocostus speciosus*, *Commelina communis*, *Amomum xanthioides*, *Selaginella tamariscina*, *Argyria acuta* Lour, *Erythralum scandens* Blume, *Tetrastigma planicaule*, *Derris elliptica*, etc.

In the fact that the utility of the *D. rensus* tree lies in its timber, particularly in India where the wood is commonly employed in the production of plywood, tea chests, packing crates, and railway sleepers<sup>1</sup>. In Yunnan, the wood finds application in civil construction<sup>7</sup>. Additionally, this species offers the potential for oil extraction, with the harvested oil being utilized in shipbuilding and torch production, owing to the wood's oil content. Plantations of *D. rensus* have been established in Indonesia<sup>8</sup>, and the species is also found in parks



across its natural range. Due to the strong impact of humans on mining activities many years ago, it has led to the depletion of many tree species in the surveyed locations, resulting in a diminished diversity of tree species in Thai Nguyen province. Despite covering routes totaling more than 1,850 km, the survey recorded a mere 244 *D. rensus* trees with a diameter at breast height exceeding 6 cm - a notably alarming number. The observed diversity in sampling plots with the presence of *D. rensus* trees is comparatively low, aligning with findings from research on the silvicultural characteristics of the *Excentrodendron tonkinensis* tree<sup>9</sup>. This diversity is also lower than that reported in studies on the silvicultural characteristics of *Castanopsis piriformis* in Lam Dong province<sup>10</sup> and *Diospyros mun* trees in Cuc Phuong National Park<sup>11</sup> in this country. Notably, the tree species identified in the composition are predominantly of low economic value. *D. rensus*, a large tree capable of reaching heights up to 50 meters<sup>1</sup>, thrives in lowlands, wet evergreen forests, and mountain forests. In Malaysia, these trees are encountered in oak forests and may occur either in pure stands or more commonly in mixed forests. Presently, the species' habitat faces a reduction in both area and quality, as documented in studies such as Chua et al<sup>12</sup>. Recently, Conservation efforts for *D. rensus* have been implemented globally through various approaches. The species is conserved *ex-situ* in two locations<sup>13</sup>. *Ex-situ* collection is also conducted within the species' natural range in protected areas. In Malaysia, the status of *D. rensus* is considered to be of little concern<sup>12</sup>. *Dipterocarpus* species, in general, are recognized as conservation-priority species in several countries within their native distribution range<sup>14</sup>. In Indonesia, specific regulations dictate that *Dipterocarpus* spp. can only be exploited when its diameter reaches at least 50 cm. Recommendations emphasize the importance of preserving remaining individuals in situ, protecting the species' habitat, and conducting assessments of diversity and genetic structure. Moreover, it is advised to monitor the decline of individual species and their habitats, along with the monitoring of *D. rensus* timber exploitation and trade<sup>8</sup>. The research outcomes pertaining to the distribution and silvicultural characteristics of *D. rensus* in this study serve as a foundation for proposing technical solutions to establish a model for future *D. rensus* planting. Our findings have shown a low regeneration density for tree species in general, and particularly for *D. rensus* seedlings. Consequently, there is a need for research on breeding techniques to produce high-quality seedlings for afforestation initiatives.

## 5. Conclusion

In summary, *D. rensus* is a large tree with scattered distribution in Dong Hy, Phu Luong, Vo Nhai, Dinh Hoa and Dai Tu districts of Thai Nguyen province, Vietnam. The results revealed 244 *D. rensus* trees naturally distributed in investigation routes in 5 districts, at altitudes from 60 to 850 m above sea level. They are naturally distributed in the main forest states including IIA; IIB; IIIA1 and IIIA2, of which forest status accounts for the most, IIB - forest state recovered after slash-and-burn cultivation fields accounts for 45% (27 SPs).

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