Cinnamomum parthenoxylon (Jack) Meisn

Ecology and silviculture in Vietnam

Chaw Chaw Sein

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CIFOR

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Preface

Smallholders plant a wide range of tree species. In Vietnam, much of the planting involves the use of fast-growing trees geared towards the production of raw materials for the pulp and paper industry and woodchips. Vietnam's environmental policy puts much emphasis on restoring forest ecosystems, protecting ecological environments and conserving biodiversity, in particular indigenous species. The Vietnamese government is carrying out a large-scale 'reforestation' programme with the aim of improving local livelihood security, environmental sustainability and industrial wood supply. Smallholders are involved in plantation timber production through various schemes.

In general, smallholder plantations are successful but farmers often lack the appropriate technical knowledge for efficient tree management. The harvesting of forest products is usually the primary management activity, with other practices being less frequently conducted. As a consequence, growth rates may be suboptimal. The productivity of smallholder plantations can be improved by enhancing smallholders' management knowledge and skills, including species selection (site matching), silvicultural management to produce high quality products, and pest and disease management.

This manual is 1 of a series of 5, produced as part of the research project Strengthening Rural Institutions to Support Livelihood Security for Smallholders Involved in Industrial Tree-Planting Programmes in Vietnam and Indonesia, a scheme coordinated by the Centre for International Forestry Research (CIFOR). This project is funded by the Advisory Service on Agriculture Research for Development (BMZ/BEAF), through the German agency for international cooperation, Gesellschaft für Internationale Zusammenarbeit (GIZ) for the period 2008–2011. This manual brings together a wealth of information on *Cinnamomum parthenoxylon* (Jack) Meisn from several sources, with particular relevance to Vietnamese sites. However, in terms of growth and yield aspect, data for this species is limited, particularly from smallholder plantations. A concerted effort has been made to collect inventory data from research sites in smallholder indigenous species plantations in Phu Tho Province, Vietnam.

We believe this manual offers valuable assistance to smallholders and organisations involved in implementing tree planting programmes.

The authors

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We would like to express our deep gratitude to Christoph Kleinn, Sebastian Schnell and Nguyen The Dzung from the Institute of Forest Inventory and Remote Sensing, University of Göttingen, for their coordination of and contribution to field work and their scientific guidance. The administrative and scientific support of Kerstin Wydra, Centre for Tropical and Subtropical Agriculture and Forestry (CeTSAF) is gratefully acknowledged. We also thank our colleagues from the Institute of Tropical Silviculture and Forest Ecology, University of Göttingen, and the staff of the Silviculture Division, Forest Science Institute of Vietnam for their great help in data collection. We thank the anonymous reviewers for their thoughtful comments, Ahmad Dermawan for his continuous support, Owen Elias for his careful editing and many others who have provided invaluable contributions to the development of this manuscript. This publication was made possible through financial support from the Advisory Service on Agriculture Research for Development (BMZ/BEAF), through the German agency for international cooperation, Gesellschaft für Internationale Zusammenarbeit (GIZ).

1. Introduction

Due to heavy exploitation and deforestation, *Cinnamomum parthenoxylon* (Jack) Meisn has been exhausted and is very rare in Vietnam. Aside from its economic objectives, the Government of Vietnam's Five Million Hectare Reforestation Project aims to protect the environment, restore forest ecosystems and conserve biodiversity. The preservation of native indigenous species is of special significance to the country (FSIV and JICA 2003).

2. Description of the species

2.1 Taxonomy

Botanical name: *Cinnamomum parthenoxylon* (Jack) Meisn
Family: Lauraceae
Subfamily: Lauroideae
Vernacular/common names:
Re huong (Vietnam), Huang zhang (China), Saffrol Laurel, Martaban camphor (English), Dalchini, Ohez, Gondhori (India), Karawe, Hmanthein (Burma), Kayu (Sabah, Malaysia).
Source: http://www.woodworkerssource.com (18 August 2011)

2.2 Morphological characteristics

Cinnamomum parthenoxylon is a large, evergreen tree species, capable of reaching a height of 30 m and a diameter at breast height of 60–70 cm. The bark is silvery grey, smooth and slightly fragrant. The leaves occur singly, possess three basal veins and are located onalternating sides of the stem The leaves' upper layer is glabrous, whereas the lower layer is brilliantly green and slightly fragrant. The leaf measures 8–10 cm long and 4–6 cm wide. The inflorescence is apical, whereas the perianth is 6-lobed, oblong and tomentose on both sides. The fruit is ovoid and green when young, turning blackish green when ripe. The fruit possesses only one seed, which has a pale brown coat (Kha 2004).

2.3 Distribution

Cinnamomum parthenoxylon is widely distributed in Vietnam at elevations above 200 masl. It grows amongst other tree species such as *Michelia* spp., *Phoebe* spp., *Gironniera subaequalis, Vatica tonkinensis* etc. Sometimes *Cinnamomum parthenoxylon* can be found growing in groups of 5–7 trees in secondary forest. It usually occupies the upper story of the forest canopy and forms a high percentage of the species present.

Figure 1. *Cinnamomum parthenoxylon* leaves
Photo by Nguyen The Dzung

Figure 2. *Cinnamomum parthenoxylon* habitat
Photo by Chaw Chaw Sein

Cinnamomum parthenoxylon can grow in many soil types, though its appearance may be affected. On basalt it develops a reddish or yellowish brown hue whereas on shale, degenerated rock and acid magma rock it develops a yellowish red colour.

Original climate conditions are:
- Average annual rainfall: 1500–2300 mm
- Rainy season (≥ 100 mm/month): 6–7 months
- Average annual temperature: 21.5–23.0 °C
- Average highest temperature in the hottest month: 32–33 °C
- Average lowest temperature in the coldest month: 10–14 °C (Kha 2004).

The genus comprises several hundred species which occur naturally in Asia and Australia. *Cinnamomum parthenoxylon* is naturally distributed in China, India, Indonesia, Thailand and Vietnam. In Vietnam the species is found in tropical evergreen rainforests up to 700 masl, on sheltered slopes, growing on deep, well-drained, fertile soils (JICA 1996).

2.4 Ecological range

In Vietnam, *Cinnamomum parthenoxylon* is frequently found in secondary forest in Cao Bang, Dac Lak, Gia Lai, Ha Tinh, Hoa Binh, Kon Tum, Lang Son, Nghe An, Phu Tho, Thai Nguyen, Tuyen Quang and Yen Bai provinces. It is suitable to tropical-humid, monsoon climates and is widely distributed in ecological zones with a mean annual rainfall of 800–2,500 mm, a mean annual temperature of 20–22 °C and an elevation of 50–1,500 m.

Cinnamomum parthenoxylon grows on many soil types. It exhibits fast growth on deep, sandy and well-drained soil, under medium forest cover. The tree regenerates strongly from seeds and can also regenerate from coppice. Natural and coppice regeneration are good in secondary forests. The tree grows particularly fast during 15–25 years of age. Whilst young, the trees prefer slight shading, when mature they are light demanding (JICA 1996).

2.5 Wood characteristics

The wood of *Cinnamomum parthenoxylon* is rather soft with distinctive yellowish sapwood and orange heartwood. Heartwood occupies about 80% of the diameter, the year rings being 4–6 mm in thickness. The specific density of the wood is 500 kg/m^3 when it is dried. It is also resistant to termites and insects (JICA 1996).

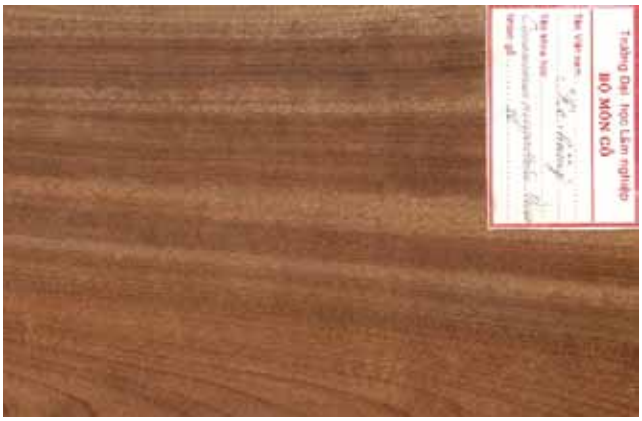

Figure 3. Wood of *Cinnamomum parthenoxylon*
Photo by Nguyen The Dzung

2.6 Uses

The wood is used for construction, to make household utensils, flooring strips, wood carvings and implements, and is a good timber for boat building. The trunk bark and leaves contain an essential oil which is traditionally used to treat liver ache, dyspepsia, backache, impotence, anemorrhoea and to enhance blood circulation. As *Cinnamomum parthenoxylon* possesses a deep taproot and an evergreen crown, it can be used for watershed management plantation (JICA 1996).

3. Seed production

3.1 Seed collection

Good seeds are selected from seed orchards, seed production areas and mother (plus) trees in order to attain a superior quality tree, with a straight stem devoid of disease. The optimum time for seed collection is as soon as the seed has reached maturity. If not collected then, the seed may over-ripen and not germinate well, or be susceptible to insect attack if fruit or pods stay on the tree too long. Seed collection should be conducted when pods or fruit are still on the tree.

Cinnamomum parthenoxylon flowers during the period March–May, with the fruits ripening in

February–March the following year. When ripe, the fruits take on a black colour. Collected fruits should be kept for 2–3 days more, before the pulp is removed and the seeds acquired. Seeds can be stored together in layers 5–10 cm thick and left to dry in a cool place. Owing to the difficulties encountered in storing *Cinnamomum parthenoxylon* seeds they are usually sowed immediately. The number of seeds in 1 kg is about 3200–3500. The primary germination rate is over 70%.

3.2 Seed preparation

Before sowing, seeds are treated with Benlat C (concentration 0.3%) for 20 minutes to prevent fungi, and then submerged in water which has been heated to 40–45°C for 10–12 hours. Seeds are then incubated in wet sand beds.

3.3 Seed storage and viability

Seeds contain oil and easily loose germination capacity if temperature, moisture and sunshine are unfavourable. As seeds of *Cinnamomum parthenoxylon* are difficult to conserve, they should be sown immediately after collecting. If not immediately sowed, collected seeds should be stored in moist sand in a proportion of 2 parts of sand: 1 part of seeds within 1 month. Each kilogram of seeds should be capable of producing 1500–2000 seedlings.

4. Propagation and planting

4.1 Sowing

Within 5–7 days of incubation, the seeds split and should be sown into tube pots or beds. Seeds sown in beds should be spaced at 1 phalange between every 2 seeds, and then covered with a layer of soil 1 cm thick, before the beds are overlain with straw. Seeds sown in pots should be planted one seed to each pot, with a mixture of 85–90% nursery soil combined with 10–15% well-decomposed manure.

It is necessary to keep the sown pots moist and shaded with plants or nets to ensure no more than 40–50% sunlight. The seeds should germinate after 15–20 days and when the seedlings are 3–4 months old the sunlight should be reduced to 30–40%.

Weeding and the application of additional fertiliser (nitrogen/phosphorus/potassium [NPK] 1%) should be carried out once a month. The containers should be changed 20 days before out planting and sprayed with Daconil 75 WP (0.15%) mixed at 8 litre/100 m^2 to prevent root boring. After that, the plants should be sprayed once every 15 days.Seedlings can be planted out in the field at 6–7 months old, 30–35 cm high and with a root neck of 0.4–0.5 cm diameter. The plants should be checked for pests, disease or other damage (FSIV and JICA 2003).

4.2 Preparation of planting site

Cinnamomum parthenoxylon is best suited to deteriorated forest or shrub land which still maintains a semblance of its former forest condition. Generally, preparing the level of site cultivation will result in better tree growth and survival. The degree of slope and intensity of soil compaction are the main factors influencing the potential for site cultivation. Before cultivating, it is important to reduce the existing vegetation by slashing or burning in order to improve the ease of machinery access and effective soil cultivation.

Cultivation provides a better soil tilth for planting and can be achieved with a wide range of implements. Cultivation should be planned for a period when the soil is not too wet, thereby avoiding soil compaction and damage to the structure of the soil. Cultivating well in advance of planting will allow the soil to settle.

4.3 Planting

Cinnamomum parthenoxylon are planted at varying distances and in various densities ranging from 250 trees/ha to 1100 trees/ha. In Vietnam, it is common to plant *Cinnamomum parthenoxylon* in rows, 2.0–2.5 m wide, with rows spaced 6 m apart and trees spaced 3 m apart. Mixed planting with other broad-leaved species is possible and results in high productivity. Planting is usually done in pits 40 cm deep and 40 cm in diameter. About 15 days before planting, two-thirds of the pit is filled with soil and the area around the planting hole is clean weeded. In Vietnam, *Cinnamomum parthenoxylon* is planted in spring (February–April) and autumn (July–September) in the northern provinces, and in the

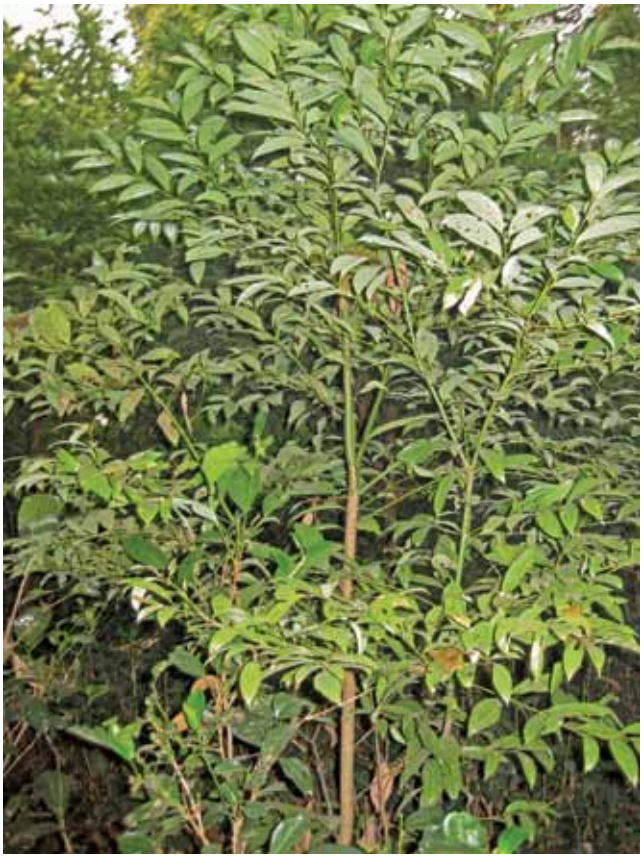

Figure 4. Three-year-old *Cinnamomum parthenoxylon* plantation in Phu Tho Province, Vietnam
Photo by Chaw Chaw Sein

Figure 5. Sixteen-year-old *Cinnamomum parthenoxylon* plantation in Phu Tho Province, Vietnam
Photo by Chaw Chaw Sein

rainy season (September–November) in the central provinces and high plateau (Kha 2004).

5. Plantation maintenance

5.1 Weeding

Weed control is necessary to reduce the competition for water and nutrients between trees and weeds. Competition from weeds severely decreases early tree performance, and weed growth can be prolific in subtropical and tropical regions. Weed control before planting and for at least 12 months after should be considered essential for successful plantation establishment. A 2 m wide weed-free strip along each planting row should be established during the first 2 years. Weed control conducted by manual weeding or by herbicide has been shown to improve stand productivity. A minimum of weeding twice a year during the first 2 years of plantation growth is encouraged. After that, on the more productive sites, weed growth is suppressed by the development of the upper stories of the tree canopy, whereas on poorer sites weed control is necessary for a longer period of time.

5.2 Fertilising

Trees require nutrients to live and thrive; when a soil is nutrient poor, trees will not reach their full potential, will be more susceptible to disease and insect problems, and will have a shorter lifespan than similar, well-fertilised trees. Fertiliser products aimed at providing trees with the appropriate nutrients abound. Generally, fertiliser is applied at the time of planting and 6 months after planting. The most commonly used fertilisers are NKP and those based on micro-organisms. An indicator of the need for fertilisation is the history of the nursery. Trees in nurseries that are fertilised on a regular

basis rarely need supplemental fertiliser applied on transplantation. Fertiliser is most effective when applied just prior to a good rainfall. The best fertiliser for common soil environments is not yet established, nor is there an acceptable financial cost–benefit analysis for fertiliser application.

5.3 Refilling

In the first year, dead trees are refilled, with the initial refilling taking place 2 months after planting and the secondary refilling being done after 11–12 months. If the survival rate is less than 70% further refilling is necessary for large scale plantations. In the second and third years, tending is done twice a year: once at the beginning of the rainy season and once at the end. This mostly involves the complete removal of vegetation and the piling up of soil around the roots to a width of 0.8–1.0 m.

5.4 Pruning

The purpose of pruning is to encourage trees to develop a straight stem and more valuable, knot-free trunks. High density plantations will have lower pruning costs than lower density plantations. The greater the initial distance in the tree spacing, the more artificial pruning will be necessary to produce a clear bole. The closer the spacing of trees in a higher density plantation, the more they will be forced into an upright growth habit. The resultant lack of light will increase natural pruning of the lowest branches.

Pruning some branches increases the growth rate of the remaining branches (Ramos *et al.* 1998). In contrast, careless pruning can significantly reduce growth, introduce disease and reduce timber value. When the trees reach 2 years of age, pruning in late winter can begin to develop a single stem. Pruning should be done with great care in order to avoid damage to the branch collar and the branch bark bridge, which can lead to disease. Pruning tools should always be cleaned and sharpened to ensure a clean, smooth cut.

5.5 Thinning

Thinning is the selective process of removing some trees in order to afford the remaining trees the opportunity to maintain a steady growth rate. Poorly formed trees and species of lower value may also be selectively removed through thinning. If there is a lot of variation in growth and survival, thinning may be necessary only in areas where the trees are very thick. As one of the primary goals of thinning is to maintain a steady growth rate, it is imperative that the growth rates of the trees are monitored.

In tropical tree plantations, thinning is usually conducted from a relatively early stage of stand development (Lamprecht 1989, Evans and Turnbull 2004). Plantations need to be conscientiously managed to enhance stand quality and promote wood production. Tending operations such as thinning are typically used to increase production of usable-sized trees (Zeide 2001). Thinning can also provide an intermediate financial return from the removed trees (Evans and Turnbull 2004). Producing higher quality, large-diameter timber usually requires at least one thinning (Lamprecht 1989). Regular thinning should be conducted when the plantation is 3, 5 and 7 years old.

6. Growth and yield

6.1 Growth in diameter and height

Height and diameter are important inventory measures for estimating tree volume. In this study,

Table 1. Growth in diameter and height of *Cinnamomum parthenoxylon* in 25 sample plots in Phu Tho Province, Vietnam (with age classes 2, 3, 5, 11 and 17 years)

Number of plots	Statistic	Number of trees/ha	diameter (cm)	Height (m)	diameter increment (cm/year)	Height increment (m/year)
25	Minimum	541	1.7	1.9	0.6	0.6
25	Maximum	2 291	13.5	11.5	1.5	1.8
25	Mean	985	8.2	7.3	1.1	1.0
25	Standard Deviation	565	4.6	3.7	0.3	0.3

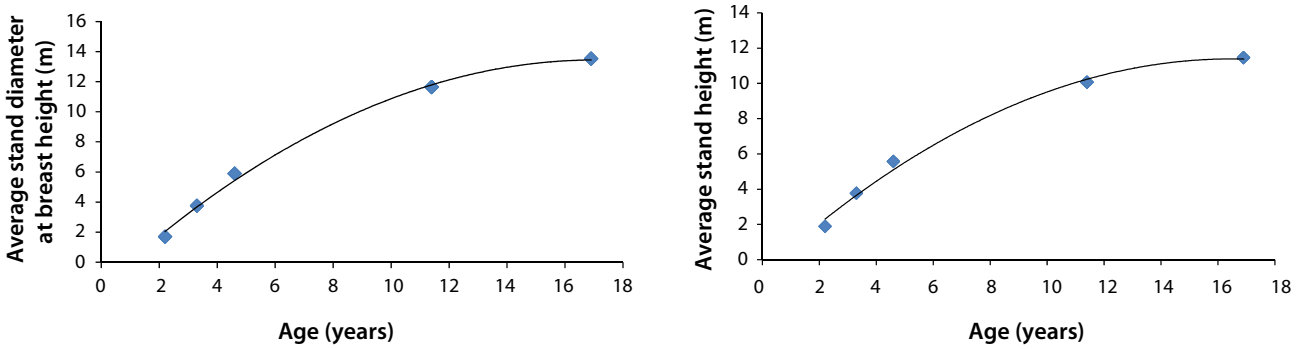

Figure 6. Growth in diameter and height of *Cinnamomum parthenoxylon* in different age classes in sample plots in Phu Tho Province, Vietnam (Michailow's growth function)

Michailow's growth function was used to estimate the diameter and height of the stand.

Table 1 presents growth in diameter and height of samples from 25 *Cinnamomum parthenoxylon* plots.

The annual growth in diameter and height from 1 to 17 years of age is nearly identical. These plantations were evaluated to determine the mean annual increases. They achieved a minimum increase in diameter of 1.7 cm and height of 1.9 m at 2 years of age and a maximum increase in diameter of 13.5 cm and height of 11.5 m at 17 years of age.

Figure 7 illustrates average annual increases in diameter and height with regard to age. The average annual increases in diameter of *Cinnamomum parthenoxylon* are from 0.6 cm/year to 1.5 cm/year, with an average of 1.1 cm/year. The average annual increases in height are from 0.6 m/year to 1.8 m/year, with an average of 1.0 m/year.

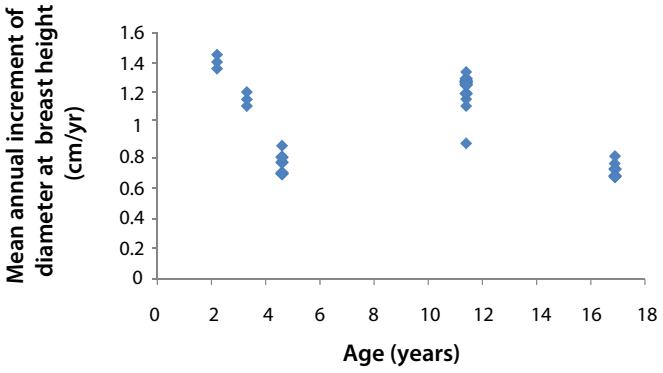

Figure 7. The average annual increase in diameter and height of *Cinnamomum parthenoxylon* in different age classes in sample plots in Phu Tho Province, Vietnam

6.2 Productivity

In order to estimate stand volume, single stem volume must be estimated first. To estimate stem volume for *Cinnamomum parthenoxylon*, the data used previously for assessing the relationship between height and diameter were analysed. The total volume of each *Cinnamomum parthenoxylon* sample tree was calculated using the following general model:

$$V = g \times h \times f$$

In this study, the rotation of *Cinnamomum parthenoxylon* is 17 years. Chapman-Richards' generalisation of Bertalanffy's growth model (Richards 1959) was used to estimate stand volume:

$$V = a.[1 - \exp(-b.age)]^{c}$$

Table 2 presents result of productivity in 25 *Cinnamomum parthenoxylon* sample plots.

The samples yielded minimum increases in volume of 0.7 m^3 at 2 years of age and 53.1 m^3 at 17 years of age giving an average of 23.4 m^3/year in volume for these plantations.

Figure 8 illustrates the average annual increases in volume with regard to age. The average annual increases in volume of *Cinnamomum parthenoxylon* are from 0.3 m^3/year to 4.4 m^3/year, with an average of 2.1 m^3/year for every variable.

Table 2. Productivity of *Cinnamomum parthenoxylon* in sample plots in Phu Tho Province, Vietnam

Species	Number of plots	Statistic	Number of trees/ha	Stem volume (m^3/ha)	Volume increment (m^3/ha/year)
Cinnamomum parthenoxylon	25	Minimum	541	0.7	0.3
	25	Maximum	2291	53.1	4.4
	25	Mean	985	23.4	2.1
	25	Standard Deviation	565	21.1	1.4

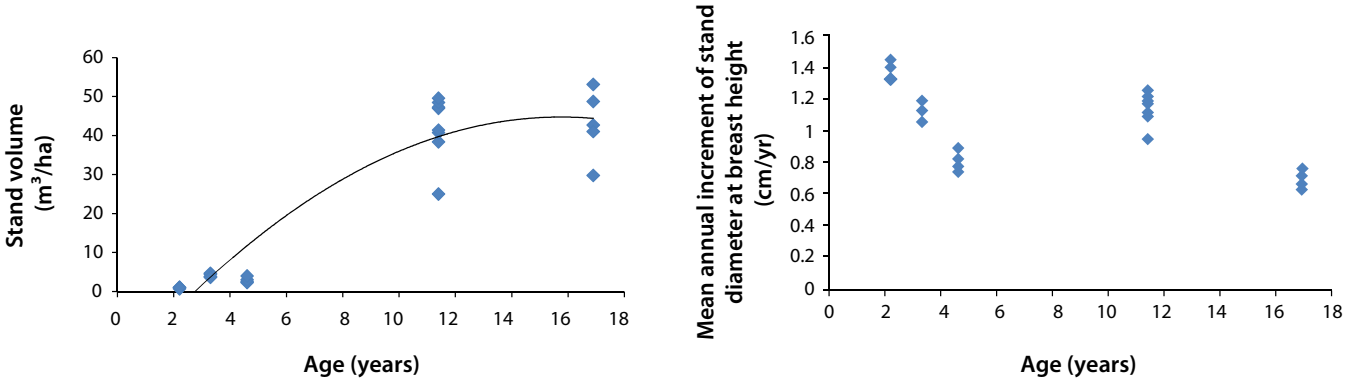

Figure 8. Average stand volume and average annual increase in volume of *Cinnamomum parthenoxylon* in different age classes in sample plots in Phu Tho Province, Vietnam

Table 3. *Cinnamomum parthenoxylon* schedule of activity for smallholder plantations in Phu Tho Province, Vietnam

Year	Operations	Activities
E–1	1. Obtain seeds	From seed orchards, seed production areas and mother (plus) trees
	2. Raise plants in nursery	Bare rooted or container plants
	3. Prepare site	Slash and logging debris removed, oles excavated (40x40x40 cm)
E Planting	1. Spacing	Wide spacing is used; mixed planting with other broad-leaved species is possible and results in higher productivity.
	2. Planting system	Along contour lines on slopes and in straight lines on flat terrain, plant at varying distances and in various densities ranging from 250 trees/ha to 1100 trees/ha
	3. Fertilising	Fertiliser should be applied at planting time and 6 months later.
E+1 Tending	1, Weeding	Weed control by manual weeding or herbicide application; Weeding at least twice a year during the first 2 years of plantation growth is encouraged.
		2 months after planting for the first time,
	2. Refilling	end of the second year for the second time
E+2	Pruning	When the trees reach 2 years of age, pruning should be done carefully to avoid injury to the tree or damage to the branch collar.
E+3	Thinning	Poorly formed trees and species of lower value should be selectively removed through thinning.
		Regular thinning is conducted when the plantation is 3, 5 and 7 years old.
E+20 or more years	Harvesting	The tree reaches the size or quality of timber which fetches a good price.
		Native species have a long rotation period.

E = Year of plantation establishment

6.3 Rotation

As it has a relatively long rotation period of 20–25 years, the decision of when to harvest the timber of *Cinnamomum parthenoxylon* depends on local markets and climate conditions. The trees can be harvested earlier if threatened by drought, pests or disease, but are usually harvested when the trees reach the right size or quality to fetch a good price.

7. Schedule of activity

Table 3 presents a suggested schedule of operations and activities for smallholder plantations of *Cinnamomum parthenoxylon* in Vietnam.

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This manual summarises information on the ecology and silviculture of the species *Cinnamomum parthenoxylon* (Jack) Meisn, with an emphasis on Vietnam. It also encompasses growth and yield data from published sources, as well as collected from sites under smallholder plantations in Phu Tho Province. This manual is 1 of 5 that guide smallholder tree planting of five selected tree species in Vietnam. The other four species are: *Acacia* hybrid, *Acacia mangium* Willd, *Erythrophloeum fordii* Oliver and *Eucalyptus urophylla* S.T. Blake.

Vietnam's environmental policy puts much emphasis on the objective of restoring forest ecosystems, protecting ecological environments and conserving biodiversity, in particular indigenous species. The Government of Vietnam is currently carrying out a large scale 'reforestation' programme, with the aim of improving local livelihood security, environmental sustainability and industrial wood supply. Smallholders are involved in plantation timber production through various schemes. Generally, these efforts have been effective, even though smallholders often lack the appropriate technical knowledge and management skills. Consequently, the quality and quantity of wood products may be suboptimal. The productivity of smallholder plantations can be improved by enhancing smallholders' management knowledge and skills, including species selection (site matching), silvicultural management to produce high quality products, and pest and disease management.

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