INTRODUCITON

1. Rationale

Production plantations in Viet Nam have been dramatically increased in terms of both quantity and quanlity for recent years. However the attension has been mainly paid to the production of small timbers of fast growing tree species of acacia, ecualyptus, benzoin (*Styrax tonkinesis*) and chempaka (*Manglietia glauca*) while demands for saw timbers for furniture production and exports are increasing.

The development of plantations for timbers necessitate, there have been a number of researches/studies on and development of demonstrations of timber plantations, but areas of timber plantations is still limited. This is not becuase of long rotation of timber plantation, slow revenue and high risk, there are also some big challenges of seed selection and improvement and seedling production and plantation techniques for fast growing native species which have not been paid much attension. Lack of scientific fundermantals to be unable to standardise technical guidelines for establishment of native species plantations for timbers.

Choerospondias axillaris is seen as a fast growing timber species, and its wide distribution. Its wood is not warping, easy to process for furniture, suitable to add to the list of timber species for forest plantation. However, *C. axillaris* has not been developed as its potentials. This is because of lack of the research results and technical advances in propagation and plantations for this species. To solve the above mentioned issues/constraints, contributing to development of forestry sector the provinces of Son La and Lao Cai, it necessitates to conduct the research project: **"Studies on some key scientific fundementals for establishment of timber plantation of *Choerospondias axillarix* (Roxb.) Burtt. Et Hill in the provinces of Son La and Lao Cai"** which in turn could significantly

contributes to the development of the species in terms of both theory and implication.

2. Theorical and implication significance

2.1. Theoritical significance: Providing scientific fundermentals for development of *Choerospondias axillarix* plantation for timber production in the two provinces of Son La and Lao Cai and other places where there are similar ecological conditions**.**

2.2. implication significance: Contributing to upgrading and enhancing technical guidelines for *Choerospondias axillarix* plantation for timber productions in Son La and Lao Cai**.**

3. Objective

Overall objective: to define scientific fundamentals for the development of *Choerospondias axillarix* plantion for timbe produciton in Son La and Lao Cai provinces.

**** Specific objectives:***

- define scientific fundermentals on biological, ecological and silviculture characteristics of *Choerospondias axillarix* in the studying region.

- define some technical measures of seed selection, seedling produciton and *Choerospondias axillarix* plantation for timber proeductions in the two provinces of Son La and Lai Chau.

4. New contributions:

Providing additional silviculture characteristics on composition structures, regeneration, leave and wood entonomies and timber physical characteristics of the species.

The study indentified some biophysical and ecological characteristics of the species in the period of nursery.

5. Scope of the study

5.1. Contents

The study mainly focused on some biological, ecological and biophysiological characteristics directly affecting to development of timber plantation of the species.

5.2. Area and location

The study was conducted in the provinces of Sơn La and Lao Cai.

6. Dissertation structure

The dissertation includes 131 pages, 34 tables and 30 figures. The disseration also comprises 95 references of which they are 53 reference documents in Vietnamese, 38 documents in English and 4 websites. Beside the sections of reference and annex, the dissertation is structured as follows:

Introduction: 4 pages;

Chapter 1.Litterature review: 19 pages;

Chapter 2. Contents, materials, and methodology: 23 pages

Chapter 3: results and disscussion: 70 pages

Conclusion, limitation and recomendations: 5 pages

Chapter 1. LITERATURE REVIEW

1.1. In the world

Choerospondias axillaris is a light demanding and fast growing timber species. This species is a multi-purpose species, providing both economic and ecological/forest restoration values. Therefore, this species has been studied for long time. There is globally consensus and agreement on its nomenclature, identification and morphology.

C. axillary in Vietnamese or Nepali hog plum in English is named scientifically as *Choerospondias axillaris* (Roxb.) Burtt & Hill, belonging to the family of Anacardiaceae of Rutales. There are 80 genus and about 600 species in the family, distributed mainly in tropical regions. In addition, this species has been found in South Europe, Asia and America.

Lecomte Henri (1932), a French botanist, described the mature trees which can reach 30 m in tall, its leaves seasonally abscise and can reach 1m in diameter; bark is strip brown, odd pinnate compound leaf includes 5-13 leaflets, leaflets is of 25 – 40cm. Leaflets are offset, the leaflets contain 8-10 pairs of small veins. Male flowers form mantle in branches or auxiliary leaves. Single flower in auxiliary leaf, pre-roofing type, dubious 10. Globular spherical has 5 cells, 5 very short stubby head, and slightly stubby head. Nuts 3cm long, 2cm in diameter. Jackson, J.K. (1987) also described *C. axillaris* as woody and seasonal deciduous species.

C. axillaris is naturally distributed in number of countries of Butan, Campuchia, India, Laos, Japan, Nepal, Thailand and Viet Nam. The species can be found both in flat to mountainous areas, and from low elevation of 300 m to a high elevation of 2000m (cited by Triệu Duy Điệt, 1995)

1.2. In Viet Nam

There are some common names of *C. Axillaris* in Viet Nam, such as Lat xoan, Nênh, Xoan trà, Xoan rừng, Mắc miễu, Xoan đào, Xuyên cóc, Sơn trà and Mắc nhừ, but the name of Xoan nhừ is the most common name (Lê Mộng Chân và Lê Thị Huyên, 2000). According to Vũ Văn Chuyên (1976, 1987) and some other authors, *C. axillaris* is belonged to the genus of Choerospondias of family of Anacardiaceae of Rutales, Rosidae, Magnoliopsida, Magnoliphyta. There are 18 genuses and 56 species being named and identified belonging to the family of Anacardiaceae in Viet Nam.

Lê Mộng Chân and Lê Thị Huyên (2000) discribed *C. axillaris* as follows: a medium tree, at mature it can reach 20 m in tall and 50cm in diameter. Bark is black, dark brown shell, striped. Young stem and young shoots are dark brown or brownish brown, brownish spots, usually change tops. Double feathers feather once odd, 25-40cm long, sprouting, including 7-13 leaflets opposite, 4-12cm long, 2-4.5cm wide. Flowers of different

races origin, male flowers and bisexual masculine fake group of 4-12 cm long mace, the flowers grow odd in the leaf ax near the branches. 3cm long oval pods, 2cm in diameter, ripe yellowish brown, sour, top with 5 small brown spots. Hard, sticky shell, 5 holes.

C. axillaris is widely distributed in many ecological areas in Vietnam, often found in Ha Giang, Tuyen Quang, Yen Bai, Lao Cai, Lang Son, Thai Nguyen, Vinh Phuc, Ha Tay, Ninh Binh, Quang Tri, Dak Lak, Gia Lai, Kon Tum, ... Fast growing trees, especially in the period from 1 to 5 years old. Average growth in height from 1.5 to 2 m a year and growth in diameter from 1.5 to 2 cm a year. Five-year-old trees can reach to a height of 7 - 8m and a diameter of 7 - 10cm; A 10-year-old tree, with a diameter of up to 20 cm, then growth rate gradually slows down (Do Huy Bich et al., 2003).

1.3. General Evaluation

The study on the species *C. axillaris* has been carried out very early and relatively comprehensive in the world, including researches on plant taxonomy, morphological characterization, ecology, distribution, seed selection, propagation and plantation techniques. These research results have contributed significantly to the development of *C. axillaris* in the world in the past years, especially in Nepal, Thailand, etc. However, the species of *C. Axillaris* is mainly planted for fruits and restoration purpose, leading to lack of research on and attention to intensive timber plantation teachniques for saw timber purpose.

In Vietnam, number of research on *C. Axillaris* is limited and Xoan is relatively few, the past research mainly focused on its classification of plants, morphological characteristics and distribution. Studies on the physiological and ecological characteristics of *C. axillaris* species have not been paid much attention. The results of research on new afforestation are limited to some propagation techniques from seeds, plantation for pit poles,

thus some experience in plantation techniques have been gained for this species in the Northeast region. Studies on harvesting and processing of fruits of this species is very few, mainly on its chemical and medicinal properties of leaves, bark and roots, lack of studies on physical properties of, harvesting and procesing of its timbers and its market as well.

Althought *C. Axillaris* is a timber species of high economic, medicinal and environmental values, it has not been developed as its potential. This is because of lack of information on the characteristics of silviculture, biophysiology, ecology and techniques of propagation and planting, leading to the lack of technical guidelines for timber plantation of species and no exsiting demonstration of *C. axillaris* plantaiton for exchanging experience and lession learnt. Therefore, it necessites to conduct this study.

Chaper 2. CONTENTS AND METHODOLOGY

2.1. Contents

2.1.1. Studies on some biological characteristics of the species

The study focused on morphological characteristics, distribution, ecology, stand structure, physiology, natural regeneration, *C. axillaris* wood anatomy and properties.

2.1.2. Studies on germination techniques for the species

Including studies on propagations from cuttings and seeds

2.1.3. Selection of plus trees and provenance trails

Including selection of plus trees and provenence trails

2.1.4. Studies on plantation techniques for timber

Trails on planting densities, plantation mode, ferterlization affecting to *C. axillaris* growing.

2.1.5. Proposing addtional technical measures for timber plantation

2.2. Approach and methodology

2.2.1. Approach

Forest is a complete ecosystem with its relative stability and its components are always closely intertwined. Thus it should not seperate the species from other species in the stand, it should be seen as an integrity component of forest ecosystem. It needs a systemetic approach which integrate both individual and stand ecosystemetic approach to solve the issues.

2.2.2. Methodology

2.2.2.1. General method

The study used comprehensive and integrative methods. They are methods of collection and review of secondary data/information, field surveys to collect data of nature forest stands where *C. axillaris* is distributed, analyses in the labotory, experimental designs and data analysis. All the data was analysed by statisitics with respect to the biological rules/principles to minimize mistakes and errors.

2.2.2.2. Detail method

*** method to study on morphology, ecology and distribution:**

Morphological characteristics: Observation, description of stem, leaf, flower, fruit of 6 mature trees in natural forest in Chieng Bo, Thuan Chau, Son La and Nam Tha, Van Ban, Lao Cai. Ecological characteristics, distribution: (i) Climate characteristics: Meteorological data are inherited. (ii) Terrain features: including elevation, direction and gradient determined using topographic mapping combined with handset GPS. (iii) Soil characteristics are determined through soil profiles in the survey plots according to the guidelines of the National standards.

*** Methods to study on composition structure and regeneration:**

According to the typical survey plot (OTC) method, there are 30% OTC distribution in Lao Cai (OTC) (in Sa Pa: 8, Moc Chau: 7) and Son La 15 OTC (Moc Chau: 5, Phu Yen: 5 and Thuan Chau: 5). The area of OTC is 2.500m^2 to collect information of woody species: identification of species,

the growth parameters (D1,3, Hvn) as common forest survey methods applied in forestry. Each OTC established 5 subplots (ODBs) of $4m^2$ (2mx2m) to collect information on the regeneration tree species: name of species, height (Hvn), quality and origin of regenerated trees. 60 plots of 6 trees were established (Son La: 30 6-tree plots and Lao Cai: 30 6-tree plots) to study the relationship between *C. axillaris* and other tree species.

*** Method to observe and record phenological events (leafing, flowering and fruiting pattern):** 3 mature trees in each provinces that are normal and not effected by insects and disease trees were selected to observe the phenological events of flowering, leafing, fruiting, fruiting cycle patterns in consecutive 3 years

*** Method to study biophysical characteristics:** Leaf anatomy was conducted by sample observation and counting on the OLYMPUS microscope. The study used the method of Grodzinxki A. M. and Grodzinxki D. M. (1981) to count chlorophyll contents and the method of Arnon's formula (1949) to quantify chlorophyll content and the method of Maxcop to determin heat resistance.

*** Method to study on wood antonomy and physical properties:** wood anatomy structure was observed by eyes and the SZ 40 stereoscopic with magnifier of 10 to 20 times (rough sample) and microscopes, with magnifier of 40 to 1000 times (microscope). The structural features were described by IAWA proposed by E. A. Wheeler, P. Baas and P. E. Gasson (1989), with reference to the describtion of anatomy of Nguyen Dinh Hung (1990).

Wood physical properties were determined by Vietnam national standards (TCVN) and compared with classification criteria of broadleaf proposed by Nguyen Dinh Hung (1977).

*** Method to study on seed germination techniques:**

- Research on physiological characteristics of *C. axillary* seeds: seeds were tested by the method which is applied to test tropical and subtropoical forest species seeds.

- Seed germination treatments: 3 treatments CT1: Seeds burnt; CT2: Soak seeds soaked in hot water 1000C and CT3: seeds soaked in water (normal temparature). Each formula repeats 3 times with of 100 seeds per formula per time.

- Determination of shading effects: 4 treatments: CT1: no light, CT2: lighting 25%, CT3: lighting 50% and CT4: lighting 75%.

- Determination of effects of irrigation regimes: 4 treatments were used: CT1: twice irrigations a day (morning and afternoon) with amount of 3-4 liters / m2, CT2: once irrigation a day: 3 - 4 liters /m^2, CT3: once irrigation in 2 days 3-4 liters / m^2 and CT4: once irrigation in 3 days with amount of 3-4 liters / m^2.

- Determination of tube contents: 5 treatments: CT1: 98% surface soil + 2% super phosphate, CT2: 93% surface soil + 5% manure + 2% super phosphate, CT3: 88 % Surface soil + 10% manure + 2% super phosphate, CT4: 83% surface soil + 15% manure + 2% super phosphate and CT5: 78% surface soil + 20% manure + 2 % supper phosphate.

The treatments of shading, irrigation and tube contents were designed as blocks with 3 replicates, with 49 trees per treatment per replicate.

*** Method to study on cutting techniques:**

(i) Effect of stimulant: The experiment consists of 13 formulations, including: IBA, IAA powder with 4 concentrations: 0.5%; first%; 1.5%; 2% and NAA water with 4 concentrations of 500 ppm; 1.000 ppm; 1,500 ppm; 2,000 ppm and 01 control formula (no drug).

(ii) The impact of seasons was set at 4 periods in March, June, August and December with 1.5% IBA as growth regulator.

Experimental formulas of effect of stimulants, effect of seasonal cuttings were designed by blocks with 3 replicates with sample size of 49 cuttings per formula per replicate;

*** Slection of plus tree:** The selection of plus trees was followed by the regulation of QPN15-93 and the forestry sector standard of 04TCN147-2006

* **Provenence trails:** 8 provenences were tested. Provenence trails were designed in block with 3 replicate. The area for each provenence is 600 m^2 in Bảo Yên - Lào Cai and Thuận Châu - Sơn La.

*** Method to study on plantation techniques:** 3 experiments were conducted in Thuận Châu - Sơn La; the experiements were designed by block with 3 replicates, area of each fomular is 1.500 m^2.

(i) planting densities: 3 formulars: CT1: 834 seedlings/ha; CT2: 1.100 seedlings/ha and CT3: 1.650 seedlings/ha

(ii) Plantation modes: 2 formular: CT1: pure plantation and CT2: mixture with *A. Magium* by lines with propotion of 1:1.

(iii) Ferterlization: 4 formulars CT0: no ferterlizer; CT1: 200g super phosphate + 200g NPK (5: 10: 3); CT2: 400g super phosphate; CT3: 200 g NPK (5: 10: 3).

Data was collected once a year in December. Growth parameters were collected are survival rate, stump diameter and top height.

*** Data analysis**: Data was analysed by statistical methods in forestry by using Excel, SPSS.

Chapter 3. RESULTS AND DISCUSSION

3.1. Some biological characteristics of *C. axillaris*

3.1.1. Its morphology

Xoan nhu is common name the species of *Choerospondias axillaris* (Roxb.) Burtt. Et Hill, of the Anacardiaceae family, which is a subject of this study.

C. axillaris is large timber species with height of about 20-35m, a seasional decidious species, large and straight stem with diameter (D1.3) of over 1m. Bark is very thick grayish brown, odd pinate compound leaf, each compound leaf contains 7 to 15 leaflets. Leaflets are opposited and each leaflet has 8-10 pairs of small veins, the root slightly deviated tapered head, the edges are sparse or raw. Male flowers are bisexual, reddish purple and clustered. Female flower are alone in the armpit. Fruits are egg or spherical shape, 2-3 cm in length, 1 to 1.5 cm wide, as ripen it is yellow-brown. These results are consistent with previous morphological discriptions. The difference compared to previous studies is that this species is a large timber tree species, not medium one.

3.1.2. ecological characteristics and distribution

C. axillary is widely distributed and scatteredly occured in primary and secondary forests. *C. axillary* is relatively abundant in secondary forests after loggings and occured at different elevations, but is concentrated at altitudes of less than 1,000 m asl., where the average temperature is around 22.80 C, rainfall of 1,200 mm to 3,400 mm, air humidity from 68.9% to 95%.

C. axillary is mainly distributed on the reddish-brown feralite soils developed on the parent rocks of mica and gnite, to the type of yellowish-brown feralite developed on the chlorite-degraded shale, from the poor soil to the medium soil, suitable with acidic soil (pH_{KCL} 3.55-4.25), the organic matter content (OM) is quite high (2.07% - 3.19%); Total nitrogen content (Nts) is quite high (0.11% - 0.17%); Total and absorable K_2O in the soil from medium to fairly while P_2O_5 is poor.

3.1.3. Stand structure characteristics

Natural forests, where *C. axillary* occurs, are classified as mixed broadleaved evergreen broadleaved forests recovered after many years of exploitation, with average stock volume and quite diverse in species

compositions. *C. axillary* is not a highly ecologically significant species in the natural forest of distribution (IV = 1.2-6.0%). This index does not varies with high elevations (Sapa, Thuan Chau, Moc Chau) or lower belt (Phu Yen, Van Ban), but decreases as the diversity of species composition and number of species in stands with *C. axillary* increase.

The forest layer structures are quite similar cross the study sites with variation in $\overline{H_{vn}}$ from 6.8 to 23.9 m, the highest layer is the A1 layer > 20 m to the A2 layer: 10 - 20 m and the lowest is the A3 layer <10m. *C. axillary* is almost absent in the A3 layer due to its ecological characteristics of light demanding trees from juvenile stage.

3.1.4. Phenology

The phases of *C. axillary* flowering and fruiting in the two provinces of Son La and Lao Cai are slightly different. *C. axillary* falls its leaves in Winter from November to February next year; *C. axillary* shoots around late of February to early May and leafs at late of February to July. *C. axillary* has annual fruit-bearing cycles, buds and flowers from April to September and fruit in April. By October, the fruits ripen from late August to early November.

Characteristics	**Phenomenon**	**Months**											
		1	2	3	4	5	6	7	8	9	10	11	12
Vegetative organs	Shooting												
	Leafing												
	Leaf falling												
Reproductive organs	Budding												
	Flowering												
	Fruiting												
	Fruits ripening												

Figure 3.1. Phenological events and pattern of *C. axillary* in Son La

Characteristics	Phenomenon	Months											
		1	2	3	4	5	6	7	8	9	10	11	12
Vegetative organs	Shooting												
	Leafing												
	Leaf falling												
Reproductive organs	Budding												
	Flowering												
	Fruiting												
	Fruits ripening												

Figure 3.2. Phenological events and pattern of *C. axillary* in Lao Cai

3.1.5. Physiological characteristics

C. axillary's leaves of young to mature trees range 177.5μm -292.3μm in thickness. The upper cuticle and epidermis layers are thicker than the lower cuticle and epidermis layers. The epidermis is 17.2 μm - 42.1 μm thick. The upper cuticle has a thickness of 11.0μm - 23.4μm. Leaf and cuticle thickness increase with age and relatively stable at 4 years of age. In soft tissues of the leaves, the palisade parenchyma cells is nearly equal to or thicker than spongy mesophyll cells depending on the age of the plant. The thickness of the palisade parenchyma tissue is 67.8μm - 121.9μm. The spongy mesophyll tissue thickness is 65.2μm - 96.2μm. The number of stomata per area unit of mm^2 is 85 - 161 / mm^2, from 2 years old the number of stomata in the leaves does not change much. The total chlorophyll content in leaves is 2.53 -2.88 mg / g of fresh leaves, rate of dla/dlb at 2 years old varies from 2.6 to 2.9, is 3.0 at the age of 4, and from 3.0 to 3.7 at the age of 6: 3 age.

Table 3.1. Chlorophyll content in leaves at different ages

Age	**Chlorophyll content** (mg/g of fresh leaves)			
	a	**b**	**a + b**	**a/b**
Nature tree	2,76	0,76	3,52	3,6
18 years old	2,68	0,72	3,40	3,7
C. axillary of 10 years old	2,80	0,77	3,57	3,6
C. axillary of 8 years old	2,48	0,72	3,20	3,4
C. axillary of 6 years old	2,43	0,73	3,16	3,3
C. axillary of 4 years old	2,20	0,74	2,94	3,0
C. axillary of 2 years old	2,00	0,70	2,70	2,9
C. axillary of 1 year old	1,94	0,72	2,66	2,7
C. axillary of 6 months old	1,80	0,71	2,53	2,6
Regeneration of C. axillary	2,12	0,76	2,88	2,8

Thus, from the anatomical characteristics and chlorophyll contents in the leaves reveal that C. axilllarry is slightly light demanding tree as less than 4 years old and it becomes more ligh-demanding after that and full light-demanding whet it is 6 years old.

C. axillary's leaves are not damaged when the temperature is below 40^{o}C.

3.1.6. Natural regeneration

The total number of regeneration seedlings and saplings in the surveyed stands is quite high, with an average number of 28,215 trees/ha in Lao Cai, and 1,071 trees/ha (8.9%) for regeneration seedlings and saplings. Son La has an average of 43,055 trees/ha, with average tree rotation of 2,500 trees/ha (5.8%). The natural regeneration capacity of *C. axillary* under forest canopy is poor and not included in the main regeneration composition, only 3.8% in Lao Cai and 1.9% in Son La.

Regenenration originals of seeds in Lao Cai (87.3%), Son La (81.3%) and shoots 12.7% and 18.7%, respectively. The percentage of seed regenerated from seeds was 82.6% and 78.2%, respectively.

The quality of seedlings and saplings of species belonged to upper layer is moderate. In Lao Cai, seedlings and saplings classified to A grade is 32.8% and 36.8% for Son La. The average quality of regenerated trees was

highest in the total number of surveyed trees. In Lao Cai, the percentage of B-grade was 46.3% and Son La was 51.0%. The number of regenerated trees of low quality (C grade) were low in all the study sites. For *C. axillary*, the percentages of seedlings and saplings graded as A were 40.3% in Lao Cai and 40.7% in Son La.

The distribution of seedlings and saplings, including C. axillary seedlings and saplings, by height concentrated at the height of <1m and some < 2m, saplings in the upper class of 2-3m are very few due to lack of light.

From the above results, the potential of natural regeneration of the forests including *C. axillary* is medium in both quantity and quality.

3.1.7. Wood antonomy and wood physical properties

C. axillary's wood has heartwood and sapwood but this difference is not much, mainly due to the color, the sapwood is grayish white, heartwood is pink beige, uniform, clear tree rings due to its half vascular rings. Wood is average in weight (0.67 g/cm3), straight grain. Therefore, the wood is easy to work, processing, suitable for furniture and it is also suitable for polywood.

The physical properties of *C. axillary* wood are not superior to those of the same group (medium volume group). There is no particular mechanical difficulty in the production of boards and thinboards in our country (volume of wood suitable for thinboard production is recommended from 0.4 to 0.7 g / cm^3).

3.2. Techniques for propagation

3.2.1. Propagation from seeds

1kg of seeds contains from 1,050 to 1,200 seeds, with an average of 1,125 seeds a kg with a coefficient of variation of 4.4%. Ratio of good seeds if 95.4 ± 0.6%.

The treatment method of *C. axillary* seeds before sowing had significant effects on germination time, and germination rate (Sig F = 0.00

<0.05). *C. axillary* seeds treated by soaking in water at an initial temperature of 100^0C for 8 hours or treatment by burning, seeds start to germinate on day 3 to day 4 and germination duration is of 15 to 18 days. The highest germination rate is over 90%.

Shading affects to the survival rate, growth of diameter and height in the nursery. *C. axillary* seedlings have different light needs vary with their ages with a trend that young trees slightly shade torelance, it becomes more light torelance as geting older. The shading rate of 50% is most appropriate for *C. axillary* growth and height in the first 4 months, and the shading of 25% is suitable afterward.

Different watering regimes affect different diameter and height growth. Watering once a day at among of 3 - 4 liters/m^2 in the early morning lead to the highest survival rate, and seedling size and seedling height in the nursery.

Effects of tube contents to survival rate of *C. axillary* during nursery stage is not very significant. Use nutritional supplement with 88% nursery soil + 10% manure + 2% super phosphate and 83% nursery soil + 15% manure + 2% super phosphate are both best formulars for growth of height and diameter at the nursery stage.

3.2.2. Cutting techniques

The use of growth regulators is a necessary measure for C. axillary cuttings to increase the success of propagation by cuttings. IBA stimulant with the concentration of 1.5-2% brings the highest efficiency.

Season also significantly affects the rooting rate of cuttings. Cuttings in June had the highest rooting rate (71.4%), number of roots per stem and best root length. Cuttings in December gave the lowest rooting rate (38.1%), the number of roots per stem and shortest roots.

3.3. Selection of plus trees and provenence trails

3.3.1. Selection of plus trees

40 trees were selected in 8 provinces: Dien Bien; Thai Nguyen; Lao Cai; Lang Son; Bac Giang; Phu-Tho; Son La and Yen Bai.

3.3.2. Provenance trails

Table 3.2. results of provenence trails of *C. axillary* at 28 months old

Location	Provenence	Sur. rate (%)	$\overline{D_{00}}$ (cm)			$\overline{H_{vn}}$ (cm)		
			$\overline{D_{00}}$	S	S%	$\overline{H_{vn}}$	S	S%
Bao Yen - Lao Cai	Bac Giang	71,0	5,56	1,96	35,3	3,35	0,68	20,4
	Đien Bien	72,8	5,50	1,76	32,0	3,40	0,71	20,8
	Lang Son	70,0	5,88	1,57	26,8	3,55	0,80	22,5
	Lao Cai	70,7	8,52	2,22	26,1	4,32	0,81	18,9
	Phu Tho	78,3	6,06	1,90	31,4	3,35	0,65	19,3
	Son La	78,6	6,18	2,33	37,8	3,77	0,88	23,4
	Thai Nguyen	83,3	5,24	1,69	32,2	3,16	0,61	19,2
	Yen Bai	79,2	6,19	1,94	31,3	3,74	0,81	21,6
Thuan Chau - Son La	Bac Giang	77,0	4,41	1,56	35,4	2,59	0,73	28,0
	Đien Bien	67,4	4,52	1,70	37,6	2,78	0,94	33,7
	Lang Son	77,5	4,66	1,80	38,7	2,76	0,82	29,9
	Lao Cai	73,9	6,46	2,69	41,6	3,63	1,19	32,8
	Phu Tho	84,8	4,60	1,85	40,2	2,79	0,74	26,5
	Son La	79,8	4,90	2,09	42,8	3,10	1,01	32,6
	Thai Nguyen	82,4	4,16	1,69	40,6	2,55	0,74	29,1
	Yen Bai	76,4	4,90	1,59	32,3	3,00	0,69	23,2

After 28 months of age in Bao Yen (Lao Cai) and Thuan Chau (Son La), the origin of Van Ban (Lao Cai) is better than the other provenances in both diameter and height. All the provenances have a high survival rate, but there is big variation in diameter and height in each provenance.

3.4. Plantation techniques

3.4.1. Plantation density

The study tested 3 formulars of densities: CT1: 834 seedlings/ha; CT2: 1.100 seedlings/ha and CT3: 1.650 seedlings/ha.

Table 3.3. effects of planting densities to survival rate at 28 months old

Formular	Survival rate (%)	S%	Sig F
CT1	77,8	3,6	0,93
CT2	76,2	9,7	
CT3	79,0	5,6	

One factorial analysis shows that it is not significant (Sig.F = 0,93) for survival rates between the densities.

Table 3.4. Effects of densities to growth of C. axillary at 28 months old

Formular	Diamter (cm)				Height (m)			
	$\overline{D_{00}}$	S	S%	Sig	$\overline{H_{vn}}$	S	S%	Sig
CT1	4,79	1,49	31,0	0,055	2,80	0,71	25,2	0,689
CT2	4,57	1,36	29,8		2,82	0,62	21,9	
CT3	4,82	1,31	27,2		2,78	0,63	22,9	

Variance analysis shows that it is not significant (Sig.F = 0,055 and 0,689) for growth of diameter and height between densities.

It concludes that the densities did not significantly affect to survival rates and diameter and height growth of C. axillary at 28 months old.

3.4.2. Plantation methods

Planting methods were designed with 2 formulas: CT1: pure plantation and CT2: mix plantation with *A. mangium* in rows with a ratio of 1:1.

Table 3.5. Effects of planting methods to survival rate of C. axillary at 28 months old

Formula	Survival rate (%)	S%	Sig F
CT1	75,5	7,9	0,42
CT2	78,6	6,6	

ANOVA results show that there is no significant difference between plantation methods (F = 0,42), or the methods of plantation did not significantly affect to survival rates of *C. axillary.*

ANOVA results show that there is sigficant difference in growth of diameter and height between plantation methods (Sig. F =0,00< 0,05). The best method is mix plantation with *A. mangium.*

Table 3.6. Efffects of plantation methods to growth of *C. Axillary* at 28 months old.

Formula	Diamter (cm)				Height (m)			
	$\overline{D_{00}}$	S	S%	Sig.F	$\overline{H_{vn}}$	S	S%	Sig.F
CT1	4,70	1,59	33,9	0,00	2,93	0,76	25,9	0,00
CT2	5,14	1,37	26,7		3,10	0,72	23,2	

Plantation methods have been significantly affected to both diameter and height growth of C. axillary at 28 months old and the method of mix plantation of *A. mangium* and *C. axillary* with ratio of 1:1 is the best method for diameter and height growth.

3.4.3. Ferterlizer trails/application

4 fertilization treatments were tested: CT0: no fertilizer; CT1: 200g super phosphate + 200g NPK (5: 10: 3); CT2: 400g super phosphate; CT3: 200 g NPK (5: 10: 3).

With the value (F = 0.56), the fertilizer had no effect on survival rates.

Table 3.7. Effects of fertilizer to survival rate of C. axillary at 28 months old

Formula	Survival (%)	S%	Sig F
CT0	77,5	8,6	0,56
CT1	80,2	7,2	
CT2	84,2	6,1	
CT3	82,7	2,6	

ANOVA results and Ducan Multivariate Test show fertilizer significantly affected to diameter and height growth.

The formulas of 200g Super phosphate + 200g NPK (5: 10: 3) (CT1) and 400g superphosphate (CT2) is the best one.

Table 3.8. Effects of fertilizers to growth of C. axillary at 28 months old

Formula	Diameter (cm)				Height (m)			
	$\overline{D_{00}}$	S	S%	Sig.F	$\overline{H_{vn}}$	S	S%	Sig.F
CT0	4,83	1,89	39,1	0,00	3,00	0,87	28,9	0,00
CT1	5,57	1,84	33,1		3,36	0,93	27,8	
CT2	5,32	1,90	35,7		3,22	0,96	29,7	
CT3	4,98	1,91	38,3		3,05	0,90	29,6	

The results show that the formulas of CT1 and CT2 positively impacted to the growth of diameter and height of the species, but the difference in growths of these two formulas is not significantly.

3.5. Techincal measures for timber plantation of *C. axlliaris* in Son La and Lao Cai.

- Soil that is suitable for *C. Axillary* plantation is fair in humus and nitrogen, medium to fair in potassium, and poor in P and acidic. C. axillary adapts well to areas of elevation of less than 1,000m, average temperature of 22.8^0C, minimum temperature of 6.9^0C and maximum temp. of 41.8^0C, rainfall from 1,200 mm to 3,400 mm year and the humidity varying from 68.9% to 95%.

- Seed sources: Seeds can be collected from plus trees or mother trees in natural forests whose stem is streight, diamter larger 25 cm and height under canopy $\geq$ 1/2 of top height, branches are small, foliage balanced, no pest and disease, yearly flowering and fruiting. Time to collect seeds is from August to November.

- Seedlings from seeds: seeds were processed and cleaned before sowing in moist sand. Before sowing, the seeds were soaked in hot water 100^0C for 1 hour in 8 hours, picking and then clean seed by clean water before sowing. Seeds begin to germinate after 3 to 4 days and germination can last up to 18 days. The germination rate is over 90%. It requires to periodically weed and break clods. The tube contents of 88% of the topsoil + 10% of manure + 2% of super phosphate or 83% of topsoil + 15%

manure + 2% super phosphate are best for seedlings. Watering in the early morning with an amount of 3-4 liters / m^2.

- Shading: Shading 50% of seedling bed should be conducted in the first 4 months and then it should decrease shade to 25% as seedlings get 6 months old

- Vegetative propagation: It is possible to propagate by cuttings, but IAA 1% or IBA 1.5% require. The most suitable season is June.

- Planting techniques: it is possible to plant C. axillary in pure plantation or mix it with native broadleaf species of cana (C. album), Styrax tokinensis, Castanopsis sp.... Pure plantations should be carried out on bare land with density from 1,100 seedlings/ha. It can be planted along lines/belts or in patches of bare land (minimum area of 500 m^2), density of 830 trees / ha. Initial fertilization of 200 g super phosphate + 200 g NPK (5: 10: 3) or 400 g super phosphate / hole should be applied as planting.

- Tending and maintainance techniques: plantation should be tended and maintained at least in first 3 years, vegetation clearing and earthing up should be carried out twice a year and application of 200 g of NPK. From the fourth year onwards, it should reduce forest cover to less than 0.1.

CONCLUSION, LIMITATION AND RECOMMENDATIONS

1. Conclusion

1.1. Biological characteristics

- *C. Axillary* is a large timber tree species, about 20-35m in height, leaves fall seasonal, large and streight trunk, diameter can be over 1m. Bark is thick and brownish-brown or pinkish brown, longitudinally cracked and shredded, inner bark is pink and 2cm thick; resin is gray color. Odd pinnate compound leaf is 30-40 cm long, with 7 - 15 leaflets. Leaflets are opposite leaflet is thin and each has 8-10 pairs of small veins, 5-10 cm in length, 2 - 4.5 cm wide, oval, slightly offset root tip, spiky edges or short stalk, 5-6 mm long. Mixed flowers, other original, oval-shaped or spherical fruits, 2 -

3 cm long, 1 - 1.5 cm wide, ripe yellowish brown. Hard kernels have 5 holes on the top, carrying 2 - 4 active embryos.

- *C. axillary* is widely distrbuted in almost every provinces, more often found on the elevation of less 1000m in Ha Giang, Tuyen Quang, Yen Bai, Lao Cai, Son La, Lai Chau, Lang Son, Thai Nguyen, Vinh Phuc, Ha Noi. , Ninh Binh, Quang Tri, Dak Lak, Gia Lai, Kon Tum.

- *C. axillary* has a wide ecological range, average temperature is about 22.80 C, the daily temperature amplitude is 7.90C - 9.80C, the rainfall is from 1.444 mm - 1.764 mm with the number of rain days from 125 - 152 days, air humidity 68.9% - 95%. *C. axillary* is able to grow on many different soil types from reddish brown feralite developed on mica an gnite to yellowish brown feralite soil developed on chlorite metamorphic. *C. axillary* grows well soil with fair in humus and nitrogen, low P content and from medium to good potassium and acidicity.

- Natural forests where there is C. axillary being distributed, it does not play an important value of the forest species composition (IV) of 1.2 - 6.0%. C. axillary is hardly occured in the A3 layer in term of forest structure profile.

- The natural regeneration of *C. axillary* under the forest canopy is poor and seedlings and saplings are mainly regenerated from seeds. Seedlings and saplings mainly concentrated at height level of <1m.

- C. axillary is a deciduous tree species in winter from November to February; sprouting is from late February to early May, leafing starts at the end of February to July, budding and flowering is from April to September, fruiting is in April to October, ripening in late August to early November.

- Some indicators of anatomical structure (thickness, vascular tissue, absent tissues, stomata ...) of *C. axillary* leaves tend to increase with age. The total chlorophyll content and the rate of dla/dlb increases with age,

indicating that the light requirements of the species changes with the age, it is slightly shade tolerance when it is less than 2 years old, but it demand more light afterward and become full light demanding whet it is over 6 years olds.

C. axillary's wood has its gravity of 0.67 g / cm^3; It is suitable for the production of thin boards and boards (0.4 to 0.7 g / cm3 is recommended).

1.2. Propagation techniques

- Collect fruits when they turn from green to yellow. After preliminary cleaning, seeds are exposed to slight sunlight for 2-3 days and the weight of 1,000 seeds is 0.89kg, 1kg of seeds has from 1,050 to 1,200 seeds, the percentage of good seeds is 95%.

- *C. axillary* seeds before sowing should be treated in 100^0C hot water for 8 hours or by burning. It takes 3 to 4 day for seeds to start germination and it lasts for 15-18 days, the germination rate is over 90%.

- At the nursery stage, *C. axillary* is less 4 months old, the appropriate shading rate is 50%, its light demand gradually increase and when it is 6 months, shading rate should be reduced to 25%. The best tube content is 88% of topsoil + 10% of manure + 2% of super phosphate or 83% of topsoil + 15% manure + 2% super phosphate. Watering should be carried out once a day in the morning with amount of 3-4 liters / m^2.

- It is possible to vegetatively propagate by cuttings, but IAA 1% or IBA 1.5% should be used as stimulant. The most suitable season for vegetative propagation by cuttings in C. axillary is June.

1.3. Selection mother trees and provenence trails

- 40 plus trees were selected in 8 mountainous provinces in the north to provide germination materials.

- 8 provenances were trailed in Bao Yen (Lao Cai) and Thuan Chau (Son La). The difference between the provenances after 28 months of plantings, the provenance of Van Ban (Lao Cai) show the best.

1.4. Technical measures for timber plantation

It was initially shown that C. axillary was better if mixed with A. *mangium* and applied 200g super phosphate + 200 g NPK (5: 10: 3) or applied 400 g super phosphate/hole.

1.5. Proposal of addtional technical measures for timber plantation

Selective inheritance of some relevant results and based on the results of the study, the study proposed technical guidelines containing all the steps for C. axillary plantation for timber production, namely seed/germination material selection and improvement, identification of site conditions, seedling production, planting and tending and maintanace of *C. axillary* plantations.

2. Limitations

- There is not enough research on the growth and development characteristics of *C. axillary* and techniques of seedling productions and planting.

- Experimental trails in nursery, of planting densities, planting methods and fertilizition are one factorial experiments, while the development and growth of C. axillary are depended on number of factors, but the study did not conduct multi-factorial experiment yet.

- 3 to 4 years is short time to monitor and investigate growth and develpement of C. axillary, thus the results and conclusions are just initial ones.

3. Recommendations

It need to continue tending, protection, monitoring of provenances and experiments to obtain more comprehesive and reliable assessment.

Completion of the technical guidelines for large timber plantation of *C. axillary*.

Continue to investigate the limited issues/shortcomings as mentioned above.