***Original Research Article***

# Effect of Planting Method and Density on Initial Growth of *Carya tonkinensis* – a Multipurpose Tree

**ABSTRACT**

*Carya tonkinensis* Lecomte is a multipurpose tree species, naturally distributing in India, China, and Vietnam. Extract from leaves of *C. tonkinensis* contains pinostrobin, pinostrobin and isosclerom, acting as anti-bacteria and anti-infection. It is used as traditional medicine. Seeds are edible and contain oil. In addition, seed cover can be used for activated charcoal. Therefore, growing *C. tonkinensis* may contribute to poverty reduction in mountainous areas. This study was to look for suitable planting method and density for growing *C. tonkinensis* in Sonla province, Northwestern Vietnam. There were three treatments in planting method including mixed planting between *C. tonkinensis* and *Chukrasia tabularis*, pure planting and scattered planting, and four treatments in planting density including 625 trees/ha, 830 trees/ha, 1,000 trees/ha and 1,100 trees/ha. Stem height and stump diameter ($D_o$) were measured at one year after planting, and death trees were counted for survival rate. The results indicated that scattered planting is the most suitable for *C. tonkinensis* and pure planting could also be applied. Meanwhile, planting density of 625 (spacing of 4 × 4 m) and 830 trees/ha (pacing of 3 × 4 m) are the best. After planting one year, survival rate achieved >90%, tree's growths were >80 cm in height and >0.8 cm in $D_o$. It is recommended that site preparation should be conducted by cutting bands of 2 m width and un-cutting bands of 2 m. In addition, seedlings of >1-year old, which are taller than 0.6 m, should be used to ensure higher survival and growths of planted trees.

*Keywords: Multipurpose, Non-timber forest products, Oil, Poverty reduction, Traditional medicine.*

## 1. INTRODUCTION

*Carya tonkinensis* Lecomte is a tree species belonging to family Juglandaceae. The species has natural distribution in India, China, and Vietnam [1]. In Vietnam, this species only distributes in narrow areas of Son La province in Northwest [2].

Extract from leaves of *C. tonkinensis* contains pinostrobin, pinostrobin and isosclerom, which function as anti-bacteria and anti-infection [3]. Therefore, *C. tonkinensis* is used as traditional medicine. Wood of *C. tonkinensis* is widely used by local people for housing and furniture making. Seeds are edible and contain high oil ratio. Oil is extracted from seeds for daily life. Seed cover can be used for activated charcoal [4]. It is known as a multipurpose tree species. The species is also known as a non-timber forest products.

Due to high values, the species has been widely harvested in nature and it is listed in Redbook of Vietnam, which needs to be preserved [2]. Initial researches on ecological characteristics [5] and seedling production [6-7] were conducted for *C. tonkinensis*. However, techniques for planting this species is not available and is still a gap for development and preservation.

The objective of this study was to search for suitable techniques to grow *Carya tonkinensis* Lecomte in Vietnam.

## 2. MATERIALS AND METHOD

### 2.1 Study Species

This study was conducted for *C. tonkinensis* (Vietnamese name of Mạy Châu), a native tree species of Vietnam. This is a big-sized tree, which may reach up 30 m tall and 70 cm diameter at maturity. *C. tonkinensis* is a deciduous tree, which sheds all leaves in winter (December-January). New leaves appear in spring with the same time of blooming. Fruits are ripen in July-August [4-5, 8]. Fruits have sizes of 2-3 cm in diameter, which change from green to brown/dark when ripen.

### 2.2 Study Site

*C. tonkinensis* was found to have natural distribution in only Son La province, Northwestern Vietnam. The species distributes in elevation zone of 600-1,000 m above sea level. Therefore, this study was conducted in Muổi Nọi commune, Thuận Châu district, Son La province with the suitable conditions for *C. tonkinensis*. The vegetation in this area is classified as evergreen broad-leaved forest [9]. There are four distinct seasons including spring (February-April), summer (May-August), autumn (September-November), and winter (December-January). The annual temperature

is 25°C and the annual precipitation is 1,760 mm. The site is fertile-forested soil with high organic matter and loam texture from natural secondary forest following sifting cultivation. Soil depth is 70-80 cm, and pH is 4.5-5. The site in on elevation of 680-720 m above sea level.

### 2.3 Experiment Design

There are two experiments including (1) planting method and (2) planting density, which were designed in an area of 3.25ha.

In planting method experiment, there are three treatments as (a) mixed planting between *Chukrasia tabularis* and *C. tonkinensis*; planting density of 830 trees/ha (spacing of 3 × 4 m) with rate of 1:1 (415 trees of *Chukrasia tabularis* and 415 trees of *C. tonkinensis*) named as MP, (b) pure planting of *C. tonkinensis*; planting density of 830 trees/ha (spacing of 3 × 4 m) named as PP, and (c) scattered planting; applied where land is available on home gardens named as SP.

In planting density experiment, there are four treatments as (a) planting 625 trees/ha at pacing of 4 × 4 m, (b) planting 830 trees/ha at pacing of 3 × 4 m, (c) planting 1,000 trees/ha at pacing of 2.5 × 4 m, (d) planting 1,100 trees/ha at pacing of 3 × 3 m.

In both experiments, all applied techniques were the same as fully clear vegetation, planting hole of 40 × 40 × 40 cm, and applying 0.5 kg NPK/tree at planting (NPK=16:16:8). In 2016, tending was applied one in September-October. In 2017, tending was applied twice in April-May and September-October. Tending technique included weeding, tree climber cutting, and earthing.

For *C. tonkinensis*, 9 month-old seedlings were used, which had diameter of 0.5 cm and height of 45 cm. For *C. tabularis*, 8 month-old seedlings were used, which had diameter of 0.45 cm and height of 40 cm. All trees were planted in June 2016.

### 2.4 Data Collection and Analysis

Stump diameter ($D_o$) and stem height were measured at one year after planting for all trees in both experiments. In addition, death trees were counted for survival rate estimation.

ANOVA one-factor and post-hoc test were applied to evaluate effects of treatments on survival and growths of *C. tonkinensis* plantation. All analyses were conducted by using SAS 9.2 (SAS Institute Inc., Cary, NC, USA).

## 3. RESULTS

### 3.1 Planting Method

In treatment of mixed planting between *Chukrasia tabularis* and *C. tonkinensis*, the difference of survival rate of two specie was not significant. The rate was 87.3% for *C. tabularis* and 87.9% for *C. tonkinensis* (Fig. 1). Meanwhile, the differences of stem height and stump diameter ($D_o$) were significant different between two species (Fig. 1). Stem height was 73.2 cm for *C. tabularis* and 83.6 cm for *C. tonkinensis*. While, $D_o$ was 0.76 and 0.81 cm for *C. tabularis* and *C. tonkinensis*, respectively. The growths of *C. tonkinensis* were better than that of *C. tabularis*.

ANOVA one-factor analysis indicated that planting methods significantly effect on survival rate, stem height and $D_o$ (Table 1). Scattered planting had highest survival rate (93.3%), stem height (89.5 cm), and $D_o$ (0.93 cm). The values reduced to pure planting as survival rate of 90.5%, stem height of 85.4cm, and $D_o$ of 0.85 cm. The values were lowest in mixed planting as survival rate of 87.9%, stem height of 83.6 cm, and $D_o$ of 0.81 cm (Table 1).

### 3.2 Planting Density

Planting density had significant effect on survival rate of *C. tonkinensis* at one year after planting (Fig. 2). The highest survival rate of 91.7% belonged to planting density of 625 trees/ha, reduced to 90.4% in planting density of 830 trees/ha, to 89.4% in planting density of 1,100 trees/ha, and to 87.0% in planting density of 1,000 trees/ha (Fig. 1). The difference of survival rate between planting density of 625 and 830 trees/ha was not significant. While, the difference among others was significant.

Planting density significantly affected on stem height and $D_o$ of *C. tonkinensis* (Table 2). The difference between planting density of 625 and 830 trees/ha was not significant for both stem height and $D_o$, and it was not difference between planting density of 1,000 and 1,100 trees/ha for $D_o$ (Table 2). At planting density of 625 trees/ha, plantation was tallest with height of 84.6 cm and biggest $D_o$ of 0.89 cm. Growths reduced in planting density of 830 trees/ha (83.2 cm height and 0.85 cm $D_o$), then plantation of 1,000 trees/ha (80.8 cm height and 0.78 cm $D_o$), and plantation of 1,100 trees/ha (79.2 cm height and 0.76 cm $D_o$).

## 4. DISCUSSION

Planting native forest tree species takes decades to have final products such as fruit, timber. In this study, only initial results were shown. However, such results are valuable for planting *C. tonkinensis*, as no researches have been conducted. Mixed species in this study was *C. tabularis*. This is known as a slow-growing tree species in Vietnam [10]. After planting one year, *C.*

*tonkinensis* grew better than *C. tabularis* (Fig. 1). However, the surplus is small. Therefore, *C. tonkinensis* could also be considered as a slow-growing tree species. At planting, *C. tonkinensis* had $D_o$ of 0.5 cm and height of 45 cm. One-year growth increment ranged 35-48 cm for height and 0.26-0.43 cm for $D_o$ regardless of experiments. These indicate slow growing of *C. tonkinensis*, even fertilization was applied at planting with 0.5 kg NPK/tree. Therefore, a long duration of tending should be taken care to ensure survival rate and growths. There have no records on effect of fertilization on growth of *C. tonkinensis*. Efficiency of fertilizing 0.5 kg NPK/tree applied in the present study was not clear. The fertilizer may not support growth and survival of *C. tonkinensis* as soil in the present study site is depth and quite fertile. In practical application, such high amount of fertilizer may be costly and inapplicable to poor condition of local ethnic people. Further studies on fertilization should be conducted before practical application.

The survival of planted trees depends on ecological characteristics of species, seedling quality, and environments [11]. Seedlings of *C. tonkinensis* were >0.4 m tall at planting, which were healthy enough for initial growth. In addition, natural conditions in the study site are not harsh as high annual rainfall (>1,700 mm), high relative humidity (80–85%) and not too high and/or too low temperatures, those supported growth of planted trees leading to high survival rate. It was recorded that death trees were from seedlings with not so good quality at planting, even the best seedlings were selected for experiments. This may suggest that seedlings of *C. tonkinensis* for planting should be older than on year and they should be taller than 0.6 m in height at planting to ensure higher survival rate. In this study, clear cutting vegetation was applied for planting *C. tonkinensis*. Probably, it seems not suitable as *C. tonkinensis* requires shading at some levels for seedlings and saplings. Therefore, site preparation should not be conducted by clear cutting. Band cutting should be introduced. For example, cutting bands of 2 m and un-cutting bands of 2 m could be used. Then, shading from vegetation in remained bands will support better growth and survival of *C. tonkinensis* as applied many other forest tree species [12]. In addition, it would be environmental-friendly approach to reduce $CO_2$ emission to the atmosphere, causing global warming and climate change, and to reduce soil erosion.

After planting one year, trees are still small and there were no crossing of tree's crown and also root system. Therefore, competition among planted trees for growing space seems to be negligible. However, the difference of survival rate, stem height, and $D_o$ was significant in both experiments. This may be explained by difference completion between planted trees and surrounding vegetation and environment. The main purpose in mixed planting is to shade planted trees. Therefore, supplemented trees must be faster-growing tree species to have large and tall crown enough for shading. However, in this study supplemented tree as *C. tabularis* grew slower than *C. tonkinensis* (Fig. 1), indicating not suitable specie selection at the beginning. Therefore, other supplemented

trees should be selected other than *C. tabularis* in further study.

## 5. CONCLUSION AND RECOMMENDATION

*Carya tonkinensis* is a multipurpose tree species, which can be used for poverty reduction in Northwestern Vietnam. Pure planting with density of 625 or 830 trees/ha should be used in forested fertile soil. It can also be planted scattered in the gardens or on the fragmented land areas. Healthy seedlings of >1-year old and taller than 0.6 m should be used for best initial growth and survival.

Further studies on planting method such as planting on bands, and on fertilization should be conducted. In addition, the results in the present study were initial. Therefore, further data collection and growth observation should be conducted to the established models for better conclusion about planting method and density for *C. tonkinensis* and to have guideline for practical application.

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**Table 1. Survival rate, stem height, and stump diameter ($D_o$) of *C. tonkinensis* in different planting methods at one year after planting**

| Planting method | Survival rate (%) | Height (cm) | $D_o$ (cm) |
|---|---|---|---|
| Mixed planting | 87.9 ±0.7[a] | 83.6 ±0.06[a] | 0.81 ±0.00[a] |
| Pure planting | 90.5 ±1.3[ab] | 85.4 ±0.09[b] | 0.85 ±0.01[b] |
| Scattered planting | 93.3 ±1.0[b] | 89.5 ±0.09[c] | 0.93 ±0.01[c] |

Different letters[a, b, c] in a column indicate significant difference of means at $p$ =0.05.

**Table 2. Stem height and stump diameter ($D_o$) of *C. tonkinensis* in different planting densities at one year after planting**

| Planting density (trees/ha) | Height (cm) | $D_o$ (cm) |
|---|---|---|
| 625 | 84.6 ±0.46[a] | 0.89 ±0.02[a] |
| 830 | 83.2 ±0.23[a] | 0.85 ±0.01[a] |
| 1,000 | 80.8 ±0.24[b] | 0.78 ±0.01[b] |
| 1,100 | 79.2 ±0.49[c] | 0.76 ±0.01[b] |

Different letters[a, b, c] in a column indicate significant difference of means at $p$ =0.05.

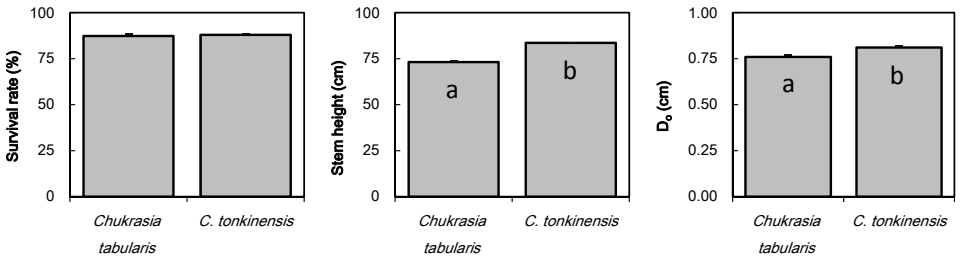


**Fig. 1. Survival rate, stem height, and stump diameter ($D_o$) in treatment of mixed planting at one year after planting. Bars indicate ±SE. Different letters[a, b] indicate significant difference of means at $p$ =0.05.**

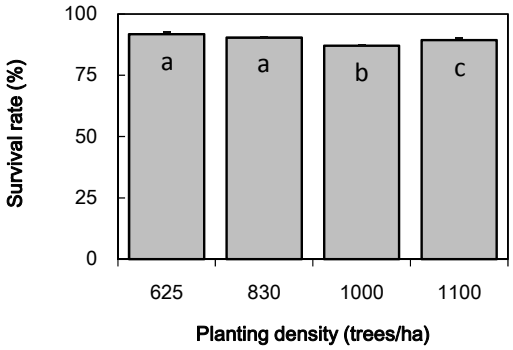


**Fig. 2. Effects of planting densities on survival rate of *C. tonkinensis* at one year after planting. Bars indicate ±SE. Different letters[a, b] indicate significant difference of means at $p$ =0.05.**