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Effects of pot medium on seedling growths of *Cinnamomum balansae* H.Lec tree

Le Van Quang[1*], Nguyen Vien[2], Hoang Van Thang[3], Nguyen Thi Anh Nguyet[2], Vo Dai Nguyen[1], Tran Van Do[1]

Silviculture Research Institute, Vietnamese Academy of Forest Sciences, Hanoi, Vietnam[1]
Forest Science Centre of North Central Vietnam, Vietnamese Academy of Forest Sciences, Doan Hung, Phu Tho, Vietnam[2]
Vietnamese Academy of Forest Sciences, Hanoi, Vietnam[3]

Corresponding author: 1*

ABSTRACT— *Cinnamomum balansae* is an endemic species of Vietnam. The species has a high potential for poverty reduction because it contains essential oil of up to 170 US$/liter and has durable timber of up to 1,500 US$/m3. Six pot mediums were tested to evaluate their effects on the survival and growth of seedlings in the nursery stage. The survival rate, stump diameter, and height of seedlings were collected at 6 months of growth. The results indicated that pot mediums significantly affected the survival rate and growths of seedlings. The highest survival rate of 87.8% was recorded in pot medium of 98% forest soil collected from 0-30 cm soil layer and 2% NPK fertilizer (16% N: 16% P: 8% K) by volume (soil-NPK pots). While the lowest was found in the medium of 100% forest-soil pots (76.7%). The largest stump diameter and tallest seedling height were also found in soil-NPK pots with a mean stump diameter of 0.57 cm and seedling height of 50.8 cm. The smallest stump diameter (0.34 cm) and seedling height (34.9 cm) were also recorded in 100% forest-soil pots. It is concluded that fertilizer plays an important role in producing seedlings for *C. balansae*. Fertilizing NPK should be conducted to seedlings during the nursery stage.

KEYWORDS: Fertilizing, Nutrients, Seedling height, Stump diameter, Survival.

1. INTRODUCTION

Cinnamomum balansae H. Lec., an endemic species of Vietnam, is an evergreen tree, growing in natural forests. It can reach up to 100 cm in stem diameter and 30 m in height at maturity [1]. All organs of *C. balansae* contain essential oil with a current price of 150-170 US$/liter. Its timber has nice veins and is durable for furniture, and its price is up to 1,500 US$/m3. Due to valuable oil and timber, *C. balansae* has been over logged in natural forests. Therefore, it is now identified as endangered species on IUCN Red List [2] and as a rare species on Vietnam Red List [3].

Plantation establishment has been concerned recently to contribute to *C. balansae* conservation and poverty reduction in mountainous areas of Vietnam. Leaves and branches of *C. balansae* can be harvested for oil extraction after planting 5 years [4], which is well adapted to generate mid-term income for local farmers, contributing to sustainable development purposes. It is initially concluded that establishing *C. balansae* plantations in suitable edaphic conditions and ecological regions could contribute significantly to not only poverty reduction but also environment protection and forest carbon sequestration against global warming and climate changes.

To successfully establish forest plantations, high-quality seedlings play a central role. Root growth and

seedling establishment are tied together for seedling production success in a nursery. Seedling growth depends on surrounding environmental conditions, especially pot medium [5], [6]. A seedling responds to the environment and starts to develop roots and shoot. Seedlings can be exposed to stress just after transplanting to the pots because of environmental shock. Since, they are not fully coupled into the hydrologic cycle as water flows from the soil to plant roots, through the plant, and into the atmosphere [6]. These may lead to slow growth and a reduced survival rate [6], [7]. Seedlings with good developed roots and shoots are easier to adapt to the environment than less developed ones [6], [8]. Effects of surrounding environments on survival and growths of seedlings in the nursery are well-understood for many species [7], [9]. However, it is still a gap for *C. balansae* [10]. This study aimed at investigating the effects of pot mediums on the survival and growths of *Cinnamomum balansae* seedlings.

2. MATERIAL AND METHOD

2.1 Experiment

There were six treatments of pot mediums in this experiment including (*1*) a mixture of 99% forest-soil collected from 0-30 cm soil layer and 1% NPK fertilizer (16% N: 16% P: 8% K) by volume (CT2), (*2*) a mixture of 98% forest-soil and 2% NPK fertilizer (CT3), (*3*) a mixture of 70% forest-soil and 30% sawdust (CT4), (*4*) a mixture of 60% forest-soil and 40% sawdust (CT5), (*5*) a mixture of 50% forest-soil and 50% sawdust (CT6), and (*6*) 100% forest-soil (CT1). The soil mixture was filled in pots of 12 cm diameter and 15 cm height in size. There were four holes in the pot bottom for water running and air circulation. The experiment was designed in a completed random block with three replicates and each replicate contained 30 pots.

Ripen fruits of the *C. balansae* tree were collected from nature in northern Vietnam. Fruits with color turned from green to green-pink and black color were known as ripen fruits. The fruit cover was then removed manually to collect seeds (Figure 1A). Seeds were then soaked in 30oC water for 6 hours and sown in the sand bed. The sand bed was prepared with a sand layer of 15 cm, then seeds were sown randomly, and a sand layer of 0.5-1.0 cm was used to cover seeds. The watering was conducted twice a day in the morning and afternoon.

Germinated seeds with >4 mm root and >4 mm shoot (Figure 1B) were transplanted to pots. The transplanted process was conducted in three days for all six treatments of pot mediums. The pots were watered once a day in the morning and weeding was conducted once a week.

Figure 1. Seeds (A), germinated seeds (B) before transplanting to pots, and (C) at 6 months of growth.

2.2 Data collection

The number of death seedlings, survival seedlings, their stump diameter (Do), and height (H) were measured at 3 and 6 months of growth. At 6 months of growth, seedlings suitable for planting were evaluated by

standards as good growth, no disease, Do ≥ 0.4 cm, and H ≥ 40cm.

2.3 Statistical analysis

Differences among treatments were assessed by univariate analysis of variance (ANOVA) and post-hoc Tests. All analyses were conducted using SAS 9.2 (SAS Institute Inc., Cary, NC, USA, 2009).

3. RESULTS

Seedling survival rates at 3 and 6 months of growth were shown in Figure 2. The pot mediums significantly affected the survival rate. At 3 months of growth, the highest survival rate was found in CT2 (99.3%), significantly higher than that in CT1 (83.3%). While at 6 months of growth, the highest survival rate was found in CT3 (87.8%), significantly higher than that in CT1 (76.7%).

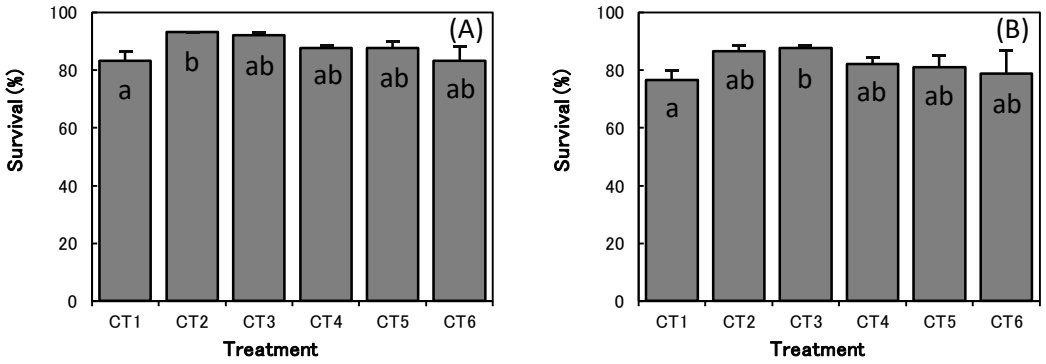

Figure 2. Survival rate at 3 (A) and 6 months (B) of growth. Different letters a, b in columns indicate a significant difference of means by ANOVA analysis and post-hoc test at p = 0.05. Bars indicate +SE (standard error)

The pot mediums significantly affected stump diameter (Do) at 3 and 6 months of growth (Figure 3). At 3 months of growth, largest Do (0.42 cm) was found in CT3, reducing to CT2 (0.37 cm), CT4 (0.29 cm), CT5 (0.27 cm), CT1 (0.25 cm), and CT6 (0.25 cm). At 6 months of growth, the largest Do was found in CT2 (0.58 cm) and CT3 (0.57 cm), reducing to CT4, CT5, and CT6 with the same Do of 0.46 cm, and the smallest Do of 0.34 cm was found in CT1.

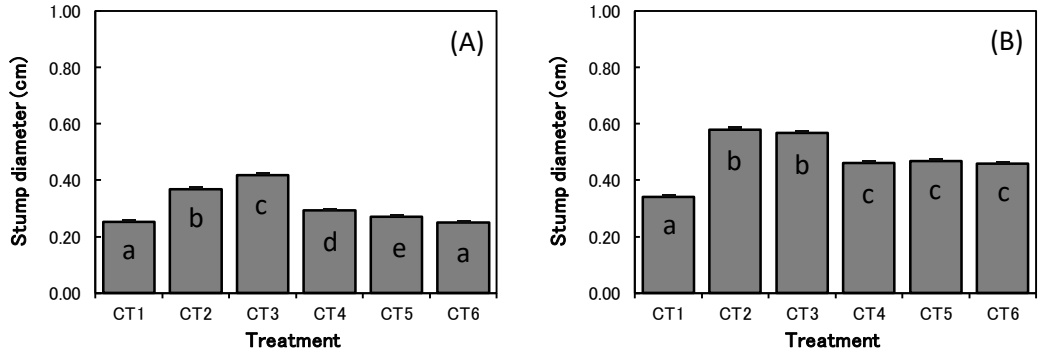

Figure 3. Stump diameter at 3 (A) and 6 (B) months of growth. Different letters [a, b, c, d, e] in columns indicate a significant difference of means by ANOVA analysis and post-hoc test at $p = 0.05$. Bars indicate +SE

The pot mediums significantly affected seedling height at 3 and 6 months of growth (Figure 4). At 3 months

of growth, the tallest seedlings (38.7 cm) were found in CT3, reducing to CT2 (31.5 cm), CT4 (23.7 cm), CT5 (22.8 cm), CT6 (20.3 cm), and CT1 (17.2 cm). At 6 months of growth, the tallest seedlings were found in CT3 (50.8 cm), reducing to CT2 (49.1 cm), CT6 (41.7 cm), CT5 (40.3 cm), CT4 (40.1), and CT1 (34.9 cm).

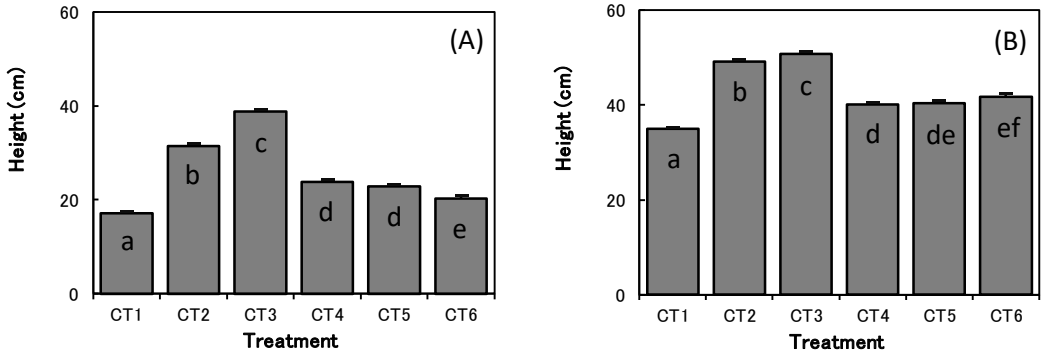

Figure 4. Stem height at 3 (A) and 6 (B) months of growth. Different letters [a, b, c, d, e, f] in columns indicate a significant difference of means by ANOVA analysis and post-hoc test at $p = 0.05$. Bars indicate +SE

At 6 months of growth, the ratio of seedlings suitable for planting was evaluated (Figure 5). The potting medium was significantly affected seedlings suitable for planting. The highest ratio (78.7%) was found in CT3, reducing to CT2 (74.3%), CT4 (63.2%), CT5 (52.0%), CT6 (48.0%), and the ratio in CT1 was only 12.9%.

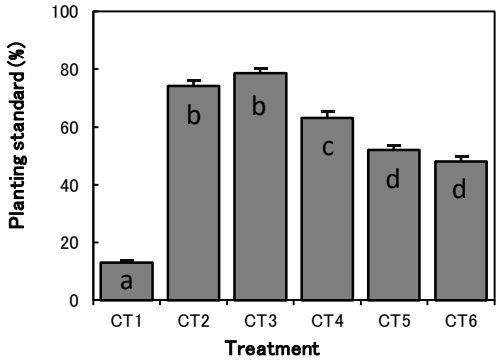

Figure 5. Seedling ratio suitable for planting. Different letters [a, b, c, d] in columns indicate a significant difference of means by ANOVA analysis and post-hoc test at $p = 0.05$. Bars indicate +SE

4. DISCUSSION

In the present experiment, seeds were pre-germinated in a sand bed and germinated seeds were then transplanted to pots. Growing environments were changing considerably [11], [12] from sand to soil, soil-NPK, and soil-sawdust. Soil-NPK mediums support nutrients for seedlings leading to the highest survival rates at both 3 and 6 months of growth in CT2 and CT3. Meanwhile, there was no nutrient in sawdust, which functioned only increasing soil pores for air circulation and water penetration, and therefore more or less environment and nutrients in both soil (CT1) and soil-sawdust (CT4, CT5, and CT6) pots were similar, leading to similar and significantly lower survival rate compared to that in CT2 and CT3 (Figure 2).

At 6 months of growth (Figure 1C), stump diameter and seedling height were largest in soil-NPK mediums (CT2 and CT3), then soil-sawdust mediums (CT4, CT5, and CT6), and lowest in sole-soil medium (CT1). This is related to water holding capacity, air circulation, and especially fertility to support seedling growths

[12], [13]. The highest fertility in CT2 and CT3, then at CT4, CT5, and CT6 as sawdust was gradually decomposed by time to release nutrients to the soil. While it was not a case in CT1. This may indicate that fertilizing seedlings after transplanting germinated seeds to seed pots should be conducted. However, how much fertilizing is not clear yet and further study should be considered. Since too much fertilizing may cause seedlings death and abnormal growth [14].

Seed germination and seedling success are affected by internal and external factors [12], [15], [16], [17]. The external factor was tested in the present study as a potting medium representing nutrient requirements. While internal factors indicate plants' characteristics as light-demanding species, shade-tolerant species, or shade-intolerant species. Even though, most species require shading for some levels at the initial seedling stage. Therefore, further studies on shading seedlings in the nursery should be conducted to produce better seedlings, ensuring successful plantation establishment. Again, the nutrient requirement is important in producing seedlings for C. balansae, which is indicated in the ratio of seedlings suitable for plantation establishment (Figure 5). Since the highest ratio of 78.7% was found in CT3 which had 2% of NPK in pot medium, using 100% forest-soil pots led to only 12.9% seedlings suitable for plantation establishment.

NPK is a mixed fertilizer of N (16%), P (16%), and K (8%). While there may be possible that seedlings of C. balansae may not require all three nutrients (N, P, and K) and/or at different ratios [19]. Therefore, further study on different nutrients and different nutrient doses should be conducted to have a higher survival rate and seedling growths suitable for plantation establishment. While less causing fertilizer loss by leaching, leading to environmental problems and economic concerns in seedling production [20].

5. CONCLUSIONS

Effects of pot mediums on seedling survival and growths were studied for Cinnamomum balansae, an endemic species of Vietnam. The results indicated that at 6 months of growth seedlings in pot medium of 98% soil and 2% N:P:K (16:16:8) had the highest survival rate (87.8%), stump diameter of 0.57 cm, and seedling height of 50.8 cm, which were significantly better than that of other treatments. In addition, seedlings achieving planting standards was 78.7%, also significantly higher than that in other treatments. These research results have shown the importance of nutrients N, P, and K in the success of seedling production for C. balansae.

To produce seedlings of C. balansae, germinated seeds were sown in pots filled with a mixture of 98% forest soil collected from 0-30 cm soil layer and 2% NPK fertilizer by volume. The seedling bed must be watered one a day in the morning, and weeding should be conducted one a week. In addition, fertilizing seedlings should also be conducted until one month before plantation establishment.

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