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EFFECTS OF VEGETATIVE ORGAN AGE OF *Dendrocalamus barbatus* Hsueh & D.Z.Li AND *Thyrsostachys siamensis* GAMBLEAGE ON THEIR SURVIVAL RATE AND QUALITY OF ROOTED CUTTINGS

Pham Van Bon[1], Ninh Van Tuan[1], Nguyen Co Thanh[1], Pham Thi Man[1], Nguyen Van Quy[2]

[1]Southern Center of Application for Forest Technology and Science, FSIS, VAFS,
[2]Branch of Vietnamese Forestry University in Dong Nai province, Vietnam

ABSTRACT

The study aimed to investigate effects of age of offset (including rhizome and 2 - 3 internodes) and branch cutting on survival rate and quality of *D. barbatus* and *T. siamensis* rooted cutting. One-factor experiment was designed as a completely randomized block with 3 replicates. The results showed that the age of offset had no significant effect (P = 0.774) on the survival rate of *D. barbatus* but was significant (P < 0.001) for *T. siamensis*. The survival rate of three treatments of *D. barbatus* after 60 propagule days was quite high and the difference was not significant (71.1 - 77.8%). Meanwhile, the survival rate of juvenile offset (< 12 months) of *T. siamensis* (HGT1) was significantly higher than that of the other two treatments, HGT2 and HGT3 (82.2% versus 11.1% and 2.2%). Juvenile branch < 12 months of *D. barbatus* (HCL1) had a high survival rate after 120 propagule days (73.3%), significantly higher (P < 0.001) compared with 12 - 24 month-branch (HCL2) and > 24 month-branch (HCL3), 20.0% for both treaments. Rooting ability of *T. siamensis* branch was very poor, the best rooting rate was only 8.9% in HCT1 (< 12 months) after 120 propagule days and 0% in both treatments with older age. Age of vegetative organs have a significant effect on quality of rooted cutting for both species. The findings implied that juvenile plant parts were preferred for asexual propagation for bamboos and branch cutting should only be used to propagate for species with stout branches.

Keywords: Bamboo, branch cutting, offset, vegetative propagation

Ảnh hưởng của tuổi hom của Luồng và Tầm vông đến tỷ lệ sống và chất lượng cây hom của chúng

Nghiên cứu được thực hiện nhằm đánh giá ảnh hưởng của tuổi vật liệu giống đến tỷ lệ sống, chất lượng cây hom của 2 loài Luồng (*Dendrocalamus barbatus*) và Tầm vông (*Thyrsostachys siamensis*). Thí nghiệm 1 nhân tố được thiết kế theo khối ngẫu nhiên đầy đủ với 3 lần lặp lại. Kết quả nghiên cứu cho thấy, tuổi của hom gốc ảnh hưởng không ý nghĩa (P = 0,774) đến tỷ lệ sống của Luồng nhưng có ý nghĩa (P < 0,001) đối với cây Tầm vông. Tỷ lệ sống của 3 công thức hom gốc Luồng sau 60 ngày giâm đều khá cao và sai khác không đáng kể (71,1 - 77,8%). Trong khi, tỷ lệ sống của công thức hom gốc non (< 12 tháng tuổi) của Tầm vông (HGT1) cao hơn rõ rệt so với 2 công thức còn lại HGT2 và HGT3 (82,2% so với 11,1% và 2,2%). Hom

Từ khóa: Tre trúc, hom cành, hom gốc, nhân giống vô tính

cành < 12 tháng của Luồng (HCL1) có tỷ lệ sống cao sau 120 ngày giâm (73,3%), cao hơn có ý nghĩa (P < 0,001) so với hom có độ tuổi 12 - 24 tháng (HCL2) và > 24 tháng (HCL3), đều chỉ đạt 20,0%. Khả năng ra rễ của hom cành Tầm vông là rất kém, tỷ lệ ra rễ chỉ đạt 8,9% ở công thức HCT1 (hom < 12 tháng) sau 120 ngày và 0% ở cả 2 công thức còn có tuổi cao hơn. Tuổi vật liệu giống có ảnh hưởng rõ rệt đến chất lượng cây giống đối với cả 2 loài và 2 loại vật liệu nghiên cứu. Kết quả nghiên cứu chỉ ra rằng, sử dụng hom non (< 12 tháng) để nhân giống Luồng và Tầm vông là tốt nhất. Phương pháp nhân giống bằng hom cành là hiệu quả cho Luồng, nhưng không hiệu quả cho Tầm vông.

I. INTRODUCTION

The demand of bamboo timber for processing in Vietnam is increasing, while the supply of raw materials is decreasing. Currently, up to 35 - 40% of processing facilities are having to operate in moderation due to not being able to actively use raw materials. The source of bamboo timber for processing in our country is still mainly exploited from natural forests, this supply has been exhausted due to unreasonable exploitation and overexploitation (Lam, 2020). Therefore, expanding the scale of bamboo plantations in the direction of specialized cultivation to ensure supply for processing is an indispensable requirement.

D. barbatus and *T. siamensis* are two species of bamboo that are widely grown in Vietnam due to their using value. *T. siamensis* is widely grown in the southern provinces, providing raw materials for building houses, agricultural tools, handicrafts and edible bamboo shoots are also very popular (Nghia, 2005). While *D. barbatus* has a natural distribution in the North, it has become the most commonly grown bamboo species in this region and is considered as a poverty alleviation tree for mountainous people. *D. barbatus* timber is commonly used for construction (pillars, beams), board proceessing, and paper materials (Nghia, 2005). *D. barbatus* has been introduced to the South, where the climate is different from its natural distribution area but it has revealed good adaptation in this site (fast growth, high shoot production and less susceptible to pests and diseases) (P.V. Bon, field observation, August 2019).

The most commonly used material for growing bamboo species in Vietnam is the offset used directly after separation from the mother plant. This method has been applied for a long time, suitable for households for scattered planting and in household gardens but it is not suitable for large-scale planting due to high labor cost, low multiplier. Branch cuttings has also been applied but only just for few species. In general, research on bamboo propagation techniques in Vietnam is still relatively limited both in terms of species and content of research. To expand bamboo plantation, first of all, it is necessary to have appropriate propagation techniques for each species. Banik (2008) showed the effect of age and type of vegetative organs on their rooting ability depending on the species. This study aimed to evaluate the effect of age and type of plant parts on their survival rate and quality of two of the most valuable bamboo species in Vietnam. The study did not use growth regulators, so it is very suitable for rural households to apply.

II. MATERIALS AND METHODS

2.1. Study site

Trials were established at Phu Hoa ward, Thu Dau Mot district, Binh Duong province in the

Southeast, Vietnam (10^o28'N and 106^o41'E). The climate here is tropical with a wet season from May to November and dry season from December to April. Annual mean rainfall was around 2600 mm and mean temperature was 26.5^{o}C. The propagule was implemented in the midle of dry season (February).

2.2. Materials

Vigour offsets (including rhizome and 3 - 4 internodes) and branch cuttings (3 - 4 nodes with swollen) of *D. barbatus* and *T. siamensis* at three level of age (less 12, 12 - 24 and over 24 months) was collected from commercial plantations in Binh Phuoc province for *D. barbatus* and Binh Duong for *T. siamensis*, both locations in the Southeast region, Vietnam. *T. siamensis* was very popularly planted this region while *D. barbatus* naturally distributes in the North but after being introduced into this region, they revealed good adaptation. Classing age of offsets and branch cuttings was based on colour of culm internodes, sheaths and roots.

2.3. Experimental design

One species consisted of two separate experiments, one with offsets and the other with branch cuttings. Each experiment included 3 treatments equivalent to 3 age levels mentioned in the study materials section. For offset, three treatments of *D. barbatus* were namely HGL1, HGL2 and HGL3; and HGT1, HGT2 and HGT3 for *T. siamensis*. The treatments of branch cutting trials were HCL1, HCL2 and HCL3; and HCT1, HCT2 and HCT3 for *D. barbatus* and *T. siamensis* respectively. A completely randomized block design was applied for each trial, with three replicates, 15 offsets or branches per replicate.

2.4. Treating offsets and branches

Offsets and branch cuttings after sharing from their mother were removed sheaths of rhizome and then they were directly put into pots with a mix of soil and coconut fibre (1:1). No use fungicide or/and hormon.

2.5. Shading and watering

The first 3 - 4 weeks, cuttings were covered by shading net with reducing 70% of sunshine intensity, then completely opened. Using an automatic watering system with misting, the time between 2 waterings was 20 minutes, each watering time was 60 seconds. The internal between 2 waterings gradually increased over time and was adjusted according to weather conditions.

2.6. Measurement and assessment

Survial, mortality and quality of survival cuttings were observed after 60 propagule days for the offset trials and 120 days for the branch trials. Quality of rooted cuttings was assessed by visuality in number of sprouts, colour of leaves and classified three categories namely good, average and poor.

2.7. Statistical analysis

Plot mean values of survival, each quality category were calculated. For each trial, univariate analysis of variance of plot mean survival percentage was implemented with replicate as the block factor and offset or branch cutting as the treatment. Where the difference among treatments was significant at P < 0.05, the Duncan's multiple range test was applied to determine which treatment differed significantly.

III. RESULTS

3.1. Offset

The difference of survival rate among treatments of *D. barbatus* was not significant (P = 0.744) but the difference was very significant (P < 0.001) among treatments of *T. siamensis*. The percentage of survival offsets of *D. barbatus* was quite high for all three treatments, from 71.1 to 77.8%. While *T. siamensis* had a high survival rate of juvenile offsets (82.2%) but that was very low in two older treatments (HGT2 and HGT3), only 11.1% and 2.2%, respectively (Table 1).

The age of offset significantly affected the quality of live offsets for both studied species. For *D. barbatus*, although the survival rates among treatments were similar, the percentage of good quality offsets varied greatly, 91.4% for HGL1 treatment but only 45.5% and 0.0% for HGL2 and HGL3, respectively. Similarly for *T. siamensis*, the good quality offset rate of treatment HGT1 reached 94.6%, whereas that of the both of HGT2 and HGT3 treatments were 0.0% (Table 1). The difference in the quality of offsets can be clearly seen in Fig. 1a for *D. barbatus* and Fig. 1b for *T. siamensis*.

Table 1. Survival rate and quality of offsets of *D. barbatus* and *T. siamensis* after propagating 60 days

Treatment	Age of offset (month)	Percentage of survival offset	Quality of survival offset		
			Good	Average	Poor
D. barbatus					
HGL1	< 12	77.8	91.4	-	8.6
HGL2	12 - 24	73.3	45.5	51.5	3.0
HGL3	> 24	71.1	-	96.9	3.1
P-value		*0.744*			
T. siamensis					
HGT1	< 12	82.2[a]	94.6	5.4	0
HGT2	12 - 24	11.1[b]	0	100	0
HGT3	> 24	2.2[c]	0	100	0
P-value		*< 0,001*			

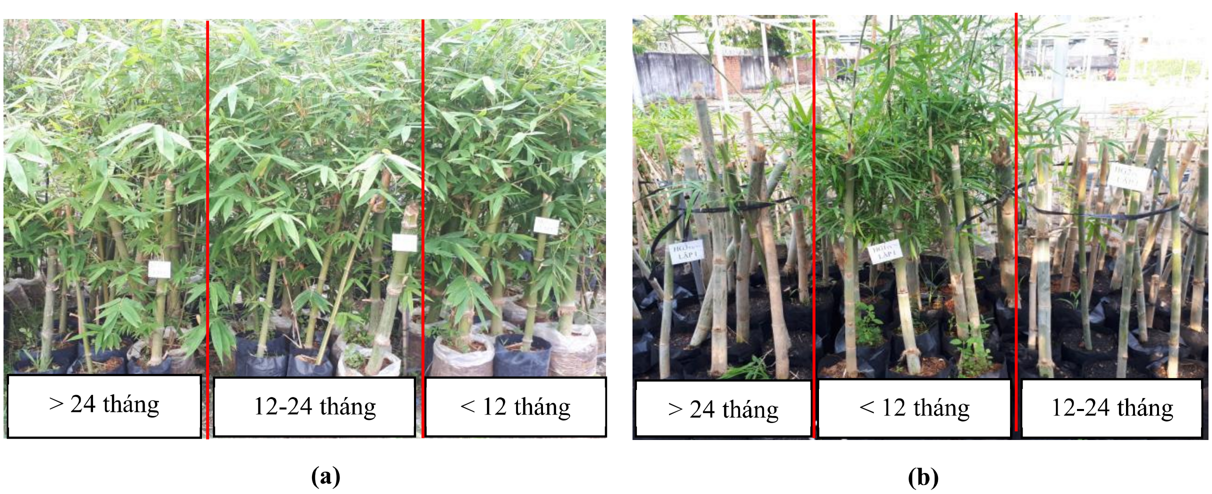


Figure 1. Offset of *D. barbatus* (a) and *T. siamensis* (b) after propagule 60 days

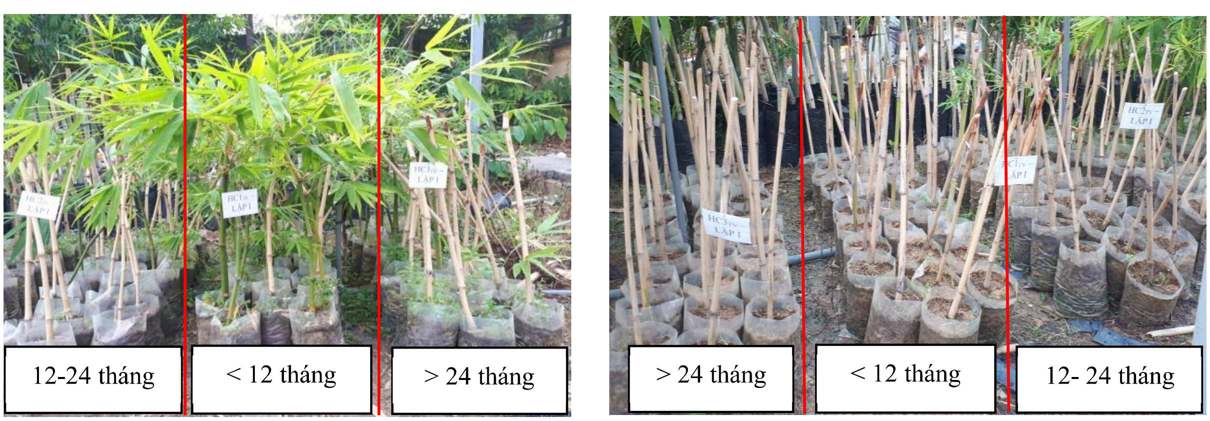
3.2. Branch cutting

D. barbatus had a high rooting rate in the juvenile age treatment, HCL1 (73.3%), significantly higher (P = 0.005) compared with the two older age treatments (HCL2 and HCL3), but only 20.0% for both treatments. Rooting ability of branch cutting of *T. siamensis* was very poor. The highest rooting rate in the treatment of juvenile cutting (HCT1) was only 8.9% and no rooted cutting in two remaining treatments (Table 2).

Table 2. Rooting rate and quality of rooted cuttings of *D. barbatus* and *T. siamensis* after propagating 120 days

Treatment	Age of branch cutting (month)	Percentage of rooting branch cutting	Quality of rooted branch cutting		
			Good	Average	Poor
		D. barbatus			
HCL1	< 12	73.3^{a}	93.9	6.1	-
HCL2	12 - 24	20.0^{b}	33.3	22.2	44.4
HCL3	> 24	20.0^{b}	-	33.3	66.7
P-value		*0.005*			
		T. siamensis			
HCT1	< 12	8.9^{a}	-	-	100
HCT2	12 - 24	0.0^{b}	-	-	-
HCT3	> 24	0.0^{b}	-	-	-
P-value		*0.012*			

The age of branch cutting had significant effects on the quality of rooted cuttings. This was evident for *D. barbatus*. The percentage of rooted cuttings with good quality accounted for 93.9% in treatment HCL1, whereas it was only 33.3% for treatment HCL2 and 0.0% for treatment HCL3 (Table 2). Fig. 2a showed a clear difference in the quality of cuttings between treatment HCL1 and the other two treatments. All rooted cuttings of treatment HCT1 of *T. siamensis* were of poor quality (few leaf sprouts) (Fig. 2b).



(a) (b)

Figure 2. Branch cutting of *D. barbatus* (a) and *T. siamensis* (b) after propagule 120 days

IV. DISCUSSION

The study results showed significant effects of species, type and age of plant parts on their rooting ability. *D. barbatus* offsets had high rooting rates in all three treatments while *T. siamensis* gave a high proportion of rooting in young age treatment but very low rates in both older treatments. The branch cutting of *D. barbatus* under 12 months of age (HCL1) had a higher rooting rate significantly higher than the other two older age treatments. Whereas, *T. siamensis* cuttings did not root or had a very low rooting rate in all three treatments. Several previous studies have also reported similar results. Kaushal *et al.* (2011) research on propagation of 8 bamboo species by cutting method also showed that the rooting rate was significantly different among species, of which the highest was *B. vulgris* and the lowest was *D. asper*. Khoi *et al.* (2010) reported the rooting rate of offsets of *T. siamensis* and *Bambusa* sp "Tre dua in Vietnamese" in the same area and propagation time was 91.1% and 16.6%; and 77.8% and 8.9% for offsets under 12 months and 12-to 24 months respectively. The results of this study are very similar to the results of our study on *T. siamensis*. Regarding branch cuttings, Huyen (2015) also showed that the rooting rate of *D. barbatus* cuttings with 6 - 12 months in contrast site, north region, Vietnam as 79.2 - 94.8% depending on the concentration of growth regulators of NAA (α-naphthalene acetic acid) used. Dzung and Nguyet (2021) reported similar results for *Dendrocalamus dienbienensis*. The percentage of rooting of cuttings under 12 months of age ranged from 70.0 to 83.3% depending on the concentration (250 - 1.500 ppm) of growth regulator IBA (indole-3-butyric acid) used. Both *D. barbatus* and *Dendrocalamus dienbienensis* are species with thick stem walls, stout branches with rhizomatous swelling at bases. Banik (2008) reported that the rooting rate of cuttings of *T. oliveri* with small branches similar to *T. siamenis* was relatively low, only 20 - 35%. Combining our results with earlier findings, it can be confirmed that branch propagation is only suitable for bamboo species with thick walls and large branches, not suitable for species with small branches such as *Thyrsostachys* sp.

The age of vegetative organs affects their rooting ability has been shown in some earlier studies. However, the effect was different mong species. Joshi *et al*. (2012) and Gaintait *et al*. (2016) showed that the 1-year-old culm was the most suitable for breeding *B. balcooa*. While the 1.5 - 2 year old culm of *B. vulgaris* exhibited the highest rooting rate (Bhol and Nayak, 2012; Hossain *et al*., 2006; Senyanzobe *et al*., 2013). Similarly, Senyanzobe *et al.* (2013); and Elbasheer and Raddad (2013) also succeeded in breeding two species *Araundinaria alpine* and *Oxytenanthera abyssinica* with 2-year-old culms. However, there were also some species that were capable of rooting with higher age, *D. asper* (Singh *et al*., 2004) and *B. vulgaris* (Islam *et al*., 2011) as examples. The 5-year-old culm of these two species were still able to take root. Even so, young shoots and culms are still preferred for propagation for all bamboo species because they are quick to root and have a high ability to produce effective shoots, an important criterion in vegetative propagation (Elbasheer and Raddad 2013). Bhatnagar (1974) also came to the general conclusion that 1-year-old cuttings are sufficient for asexual propagation of bamboo species. In the same opinion, Banik (1995) also recommended not to use cuttings older than 2 - 3 years old for propagation because they produced few shoots. Our study, it was obvious that less - 1-year-old offsets of *T. siamensis* gave more effective than older offsets. For *D. barbatus*, although three all offset treatments had results equally in a term of survival rate but quality of rooted offsets reduced considerably assosiated with increasing their age. Thus we should only use offset with less 2 years old for propagule this species.

Selecting propagation material for each species, the current results combine earlier findings, it is easy to realize that the suitable propagation method for *T. siamensis* is using offsets less than 1 year old. While *D. barbatus* can be used both offsets and branch cuttings simultaneously. However, the use of branch cutting will bring higher efficiency due to low cost, higher multiplier. Dzung *et al.* (2018) showed that growth in diameter, height and shoot production rate of cuttings for *Dendrocalamus dienbienensis* were only 10.2%, 7.5% and 5.1% worse than offsets after 36 months, respectively. On a small scale, offsets can be used but only those under 2 years old for breeding.

V. CONCLUSION

The age of propagating material affected their rooting ability depending on the species and type of plant parts. Offsets of *D. barbatus* showed a relatively high rooting rate in all 3 age classes, rooting rate from 71.1 - 77.8%. While *T. siamensis* only had a high rooting rate (82.2%) with offset under 12 months, older ones had a very poor rooting capacity (only from 2.2 - 11.1%). For branch cuttings, *D. barbatus* had a high rooting rate in less 12-month branches (73.3%) but only 20.0% in older cuttings. Branch cuttings of *T. siamensis* rooted poorly in all three categoris of age studied, the highest rooting rate was only 8.9% for cuttings under 12 months. The age of the propagating material greatly influenced the quality of the cuttings for both material shorts of both species.

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Email tác giả liên hệ: bonttud@gmail.com

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