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Comparative study on shoot and root growth performance of *Cephalostachyum pergracile, Bambusa polymorpha* and *Dendrocalamus hamiltonii* by nodal cutting method

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တင်းဝါး၊ ကျသောင်းဝါး နှင့်ဝါးဘိုးမျက်ဆံကျယ်ဝါးတို့၏အညွန့်နှင့်အမြစ်ထွက်ရှိမှုကို အဆစ်ဖြတ်ပိုင်းမျိုးပွားနည်းဖြင့် နှိုင်းယှဉ်လေ့လာခြင်း

ခင်ပပရွှေ၊ သုတေသနလက်ထောက် (၂)

သီရိတိုးခိုင်၊ တောအုပ်ကြီး

စာတမ်းအကျဉ်း

ဤသုတေသနစာတမ်းသည် တင်းဝါး၊ ကျသောင်းဝါး နှင့် ဝါးဘိုးမျက်ဆံကျယ်ဝါးမျိုးတို့၏အဖူးပါအဆစ်အပိုင်းနှင့် ဟော်မုန်းတို့၏ အကျိုးသက်ရောက်မှုအပေါ် နှိုင်းယှဉ်လေ့လာထားခြင်းဖြစ်ပါသည်။ အညွန့်နှင့် အမြစ်ထွက်ရှိမှုနှုန်းများကို ခန္ဓာပိုင်းမျိုးပွားနည်းတစ်နည်းဖြစ်သော အဆစ်ဖြတ်ပိုင်းမျိုးပွားနည်းကိုသုံး၍ စမ်းသပ်မွေးမြူပြီး သုတေသနပြုထားခြင်းဖြစ်ပါသည်။ ကနဦးစမ်းသပ်မှုအဆင့်တွင် ဝါးသုံးမျိုးတို့၏ အလယ်အဆစ်အပိုင်းသည် ထိပ်နှင့် အောက်ခြေအဆစ်အပိုင်းထက် ရှင်သန်မှုနှုန်း ပိုကောင်းသည်ကို တွေ့ရသည်။ အညွန့်သစ် မွေးမြူခြင်းအဆင့် နှင့် အမြစ်မွေးမြူခြင်း အဆင့်တို့တွင် ဟိုမုန်းအသုံးမပြုခြင်း (T1) နှင့် ဟိုမုန်းအသုံးပြုခြင်း (T2-T4) တို့နှင့်အတူ သဲ(M1)၊ သစ်တောမြေဆွေး(M2)၊ သဲ+သစ်တော မြေဆွေး(M3) အောက်ခံမြေ (၃) မျိုးတို့ကို အသုံးပြုစမ်းသပ်ခဲ့ပါသည်။ ရလဒ်များမှာ အညွန့် မွေးမြူခြင်းအဆင့်တွင် တင်းဝါးသည် အောက်ခံမြေနှစ်မျိုးဖြစ်သော သဲ(M1) နှင့် သဲ+သစ်တော မြေဆွေး(M3)တို့တွင် သိသာထင်ရှားစွာ ပြောင်းလဲမှုရှိ၍ သစ်တောမြေဆွေး (M2) အောက်ခံမြေထဲတွင် ထူးခြားစွာပြောင်းလဲဖြစ်ထွန်းမှု မရှိသည်ကို တွေ့ရပါသည်။ ကျသောင်းဝါးသည် သဲ (M1) အောက်ခံမြေထဲတွင်လည်းကောင်း၊ ဝါးဘိုးမျက်ဆံကျယ်ဝါးသည် သဲ+သစ်တော မြေဆွေး(M3) တို့တွင် သိသာထင်ရှားစွာ ပြောင်းလဲမှုရှိသည်ကို တွေ့ရသည်။ အမြစ်မွေးမြူခြင်း အဆင့်တွင်လည်း တင်းဝါးသည် အောက်ခံမြေနှစ်မျိုးဖြစ်သော သဲ(M1) နှင့် သဲ+သစ်တော မြေဆွေး(M3) တို့တွင် သိသာထင်ရှားစွာ ပြောင်းလဲမှုရှိ၍ သစ်တောမြေဆွေး(M2) အောက်ခံမြေထဲတွင် ပြောင်းလဲဖြစ်ထွန်းမှု မရှိသည်ကို တွေ့ရပါသည်။ ကျသောင်းဝါးတွင် သဲ+သစ်တော မြေဆွေး(M3) တွင် သိသာထင်ရှားစွာ ပြောင်းလဲမှုရှိသော်လည်း ဝါးဘိုးမျက်ဆံကျယ်ဝါးသည် အောက်ခံမြေအမျိုးအစားသုံးမျိုးလုံးတွင် သိသာထင်ရှား စွာပြောင်းလဲမှုမရှိ၍ အခြားဝါးနှစ်မျိုး တို့ထက် ပိုမိုကောင်းမွန်စွာ ရှင်သန်ဖြစ်ထွန်းနိုင်ကြောင်း တွေ့ရပါသည်။

Comparative study on shoot and root growth performance of *Cephalostachyum pergracile, Bambusa polymorpha* and *Dendrocalamus hamiltonii* by nodal cutting method

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Abstract

This paper presents the effects of explants position and hormone of the selected bamboo species. viz.Tin-wa (*Cephalostachyum pergracile* Munro), Kyathaung-wa (*Bambasa polymorpha* Munro) and Wabo-myet-sangye-wa (*Dendrocalamus hamiltonii* Nees & Arn. Ex Munro).The survival rates, new shoots and roots growth performance of each species were recorded by nodal cutting method of vegetative propagation. At the initial stage, the survival rate of middle position was found better performance than that of terminal and basal positions among three species. The effects of hormone free (T1) and hormonal treatments (T2-T4) on three media, sand (M1), forest soil (M2) and sand + forest soil (M3) were investigated in multiplication and rooting stage. ANOVA revealed that there were significant differences in M1and M3 media for shoot and root formation of Tin-wa. There were significant differences in M1medium for shoot and M3 medium for root formation of Kyathaung-wa. There were significant differences in M3 medium for shoot but not on among three media for root formation of Wabo-myet-sangye-wa. Optimal survival rate was the Wabo-myet-sangye-wa than other species within the three media.

Keywords: bamboo, explants position, shooting, rooting, hormone

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1. Introduction

Bamboo is one of the fast growing plants in the plant kingdom. Bamboos are perennial woody members of the family GRAMINAE (Poaceae). It is also placed in the subfamily Bambusoideae. It is a wonderful gift of nature. There are giant, woody and grasses which are versatile and are fast growing and high yielding new able resources. There are 75 genera and 1250 species distributed in tropical, subtropical and temperate zones of the world (Sharma, 1980). Tropical Asia has been referred at as the center of bamboo diversity with as many as 45 genera and 750 species (Biswas, 1980).

The species of giant bamboos like Dendrocalamus and Bambusa, Myanmar may be the home and center of diversity for the said species (Htun, 2002). There are 14 species of bamboos in Myanmar which are commercially important in one way or another or in one locality or another depending on their uses (Htun, 1999). Myanmar is also endowed with extremely rich species and generic diversity of bamboo with about 102 species distributed among 23 genera (Kress, *et. al.*, 2003). Among them *Cephalostachyum pergracile* Munro, *Bambusa polymorpha* Munro and *Dendrocalamus hamiltonii* Nees & Arn. Ex Munro are three species which are the most important commercial species recorded.

Bamboo is widely regarded as the most important of the “non-timber” forest products in Myanmar and also throughout the tropical Asia. The rural Myanmar people cannot imagine existence without bamboo. It has high value in a wide range of applications as structural material, fiber and food. And also used for tools and implements for agriculture, pulp for paper, household utensil and for handicrafts. Bamboos with a wide diversity of species are found in almost all forest types of Myanmar, from sea level to the high mountains of 4,000 m. They are usually found growing mixed with other species and they formed under storey in high forests whereas almost pure bamboo forests are also found. The sizes or lengths or characteristics of species may be different depending on the ecological conditions in which the species grow.

The new shoot culm starts to emerge from the soil mostly at the beginning of the rainy season. Shoot elongation occurs during day and also in the night. The height of the culm results in mainly by elongation of the internodes. Internodal elongation begins at the basal portion of the culm and then gradually proceed at the top because of the intercalary meristerm present at the node. In tropical countries, elongation and growth occur more during the night (Osmaston, 1918). An emerging culm reaches full height of the specific species within 2-4 months (McClure 1966, Ueda 1960) in one year. But all emerging culms do not always develop into fully grown culms always.

The age of an individual culm is not related to clump age, as they sprout every year from the rhizome, which may be older in years. Culms are tender during the first year. They grow tough during the second years and are hard and mature in the third year, when they acquire full density and strength. After this age they start changing color. The age of a culm for harvesting is difficult to determine. Generally, culms that are 3-5 years old are considered “mature” (Liese, 1985). However, presence or absence of culm sheaths and nodal rootings, bud break and branching pattern, and color of culm are diagnostic morphological character for determining the age of culms (Banik, 1993 b). The age of culm should be determined for various utilization and selected culm felling in management of bamboo forest.

Nowadays, natural bamboo resources have being decreased owing to high rate of exploitation and utilization as well as deforestation. The rate of decreasing of edible bamboo resources is higher than that of non edible bamboo because young shoots are over exploited with increasing population and expending market. Like other edible bamboo species, *Dendrocalamus hamiltonii* Nees. is facing exploitation of young shoot and its population become decreasing.

Since supply of natural bamboo resources is not enough for increasing consumption, it is necessary to cultivate for sustainable utilization. However, seed supply is major limiting factor in bamboo cultivation because bamboos seldom flower and even when they do flower, most of seed are not fully developed or have weak viability (Yuming *et al.* 2001). Therefore bamboos can be reproduced by vegetative means.

The vegetative propagation methods for bamboo propagation are clump division, culm cutting, aerial induce root and branch cutting. For mass scale propagation, conventional vegetative propagation techniques are largely insufficient and inefficient. In this experiment, shoots were initiated from nodal part of lateral branch from one year old culm of bamboo three species for regeneration.

2. Objectives

The objectives of this research are as follows;

(1) To determine effect of explants position of three bamboos species by nodal cutting method, and

(2) To investigate the shoot and root growth performance by nodal cutting method.

3. Literature Review

Bamboo species are found along the entire Himalayan range. It prefers hill terrains and is mostly found in gullies in subtropical forest types, especially along the outer ranges of hills (Stapleton, 1994). It naturally distributes in tropical and subtropical climatic zones, India, Bhutan, Nepal, Myanmar and Thailand (Salam and Pongen 2008). In Myanmar, it naturally grows in Kachin State, Sagaing Region, Magwe Region and Mandalay Region. (Nyan Htun, 2005).

Bamboo can be propagated through sexual or asexual methods. Sexual method is propagation by using of seed, as in annual crops like rice, corn and bean. However, this method is unreliable and rarely known because seeds of bamboo are not available. Besides, it may take a century or even more for certain species to produce seeds, and the exact period for seed production is impossible to predict (Bareja, 2010). Rare seed production in bamboo requires propagation by vegetative methods (Ramanayake, 2006). There are several methods of vegetative propagation using rhizome, offsets, culm and branch.

Various methods of vegetative propagation like offset and rhizome planting, branch and culm cutting, layering, macro proliferation of seedlings and tissue culture, etc. are being practiced (Ahlawat *et.al.,* 2002; Koshyb and Gopakumar, 2005). Clump division or offset planting and rhizome planting are the traditional methods of bamboo propagation (Stapleton, 1994, Banik, 1995, Lantican, INBAR 2004). These methods are available to any conventional nurseryman and farmers (Bareja, 2010). The improved methods of vegetative propagation are branch and culm cutting, layering, macro proliferation of seedlings and tissue culture (Banik, 1995).

Macro proliferation is a simpler and effective procedure of vegetative propagation when bamboo seedlings are available (Koshyb and Gopakumar, 2005). McClure (1966) stated that two major rhizome types are found in bamboos; pachymorph and leptomorph. All clump forming bamboo species have pachymorph rhizomes, where as the entire non-clump forming species gave leptomorph rhizomes. Shigenmatsu (1960) mentioned that the pachymorph rhizome is typically a summer sprouting type for which mainly soil moisture and temperature is the limiting factor. Watanabe (1986) mentioned that, between the single-stemmed (leptomorph) and the densely clumped (pachymorph) forms, there are intermediate types (woody-pachymorph-diffuse) forming somewhat open clumps.

Bamboo growth is characterized by its increment in weight, length, volume and quality of the rhizome system underground and the culm above. The increase of culms, branches and rhizomes in diameter and wall thickness could have been achieved during the same period when the length growth of shoots and rhizomes occur because bamboo lacks secondary meristem. The buds on the middle and lower part of a stump usually are more vigorous and sprout earlier, and also have longer rhizome necks and could produce bigger shoots than those on the upper parts of the stump. The buds on a culm base of 1 or 2 years old usually are vigorous and could produce 1- 2 shoots while the buds at 3 - 4 years old a culm base almost lose the capacity to produce rhizome.

Xiao, (1986) stated that the culms, growing in an earlier stage of a year, usually can produce some new shoots from its base again in the current year, which are called the second time shoots. The majority of clump-forming bamboos grow at temperature ranges from 7˚C (sometimes 2˚-3˚C) - 40˚C. In general, high temperature accelerates the growth of bamboo while low temperature in habit it. The clump-forming types are generally present in the humid tropics mainly in places where the average temperature is higher than 20˚C, and where the altitude is less than 100 m above the sea level.

Numata (1987) stated that high temperature and humidity requirements are common characteristics of plants originating in the monsoon areas of South-East Asia. As the water requirement of bamboo is high, the amount of rainfall is also a limiting factor to distribution and the growth of bamboo. Rainfall is an important factor and 1,000 mm seems to mark the minimum annual precipitation required. For active growth of clump-forming type of tropical bamboos, more than 200 mm and monthly rainfall is required for at least 3months (Poudy, 1992).

Numata (1987) further observed that the best growth condition for bamboo is to be maintain six months with 100-200 mm monthly rainfall. This is quite different to non-clump forming type of bamboo which needs only 240 mm or so rainfall at the time of sprouting.

Growth process is close relationship between growth of shoots and precipitation on this connection, tropical bamboo need much rainfall than the bamboo which grow in temperate region. Some of bamboo species such as *Bambusa blumeanu, Dendrocalamus strictus* etc. have strong drought resistance, otherwise, *Bambusa polymorpha* and *Gigantochloa asper* prefer wetty site.

Most bamboos are found in well drained, sandy to clayey loam soils, derived from river alluvium of flat or gentle slop areas, *Bambusa polymorpha* and Bambusa bamboos grow on well drained and fertile soil under forest trees while *Bambusa tulda* and *Oxytenanthera olbociliata* are best suited for sandy soil (Uchimura 1987). Qureshi et. al., 1969 discussed that the soil pH of about 5.0 - 6.5 is the most suitable for bamboo, but some species may grow even at pH 3.5. Saline soil is not suitable for bamboo growth. A wide range of textural variation and soil depth, however, do not interfere in the normal growth of bamboo, provided the drainage, rainfall and temperature conditions are favorable.

According to Uchimura (1980), although bamboo prefers well-drained and aerated soils, it can also grow in swampy or wet areas. Soils high in nitrogen and oxides of phosphorous, potassium, calcium silicon best promote the growth of bamboo culms. Stamp (1926) classified climax community of Myanmar vegetation as an index of rainfall, bamboo forest is in the midst of regenerative vegetation because climax is dominated by tree vegetation, however, wet teak forest were is 1,500 - 2,300 mm annual rainfall and mother soil constructed by sand stone or sandy shale, is occupied with *Bambusa polymorpha* and *Cephalostachyum pergracile*, but *Dendrocalamus strictus* become index of clay soil in the dry teak forest.

4. Materials and Methods

4.1. Study area

Three positions (terminal, middle and basal) of nodal segments of one year old of *Cephalostachyum pergracile* Munro (Tin-wa), *Bambusa polymorpha* Munro (Kyathaung-wa) and *Dendrocalamus hamiltonii* Nees & Arn. Ex Munro (Wabo-myet-sangye-wa) were used as experimental materials. There were collected from Compartment No. 9 and 18, Ngaleik Reserved Forest, Moe-Swe Research Station, Pyinmana. This study area lies between approximately 19˚ 56' N and 95˚ 56' E at an elevation of 170 - 225 m above sea level. This ridge belongs to northern part of Bago Yoma. The soil is sandy loam texture with pH 5.76 - 6.77 (Moe, 2003). The experiments were carried out in Mist Chamber, Forest Research Institute, Yezin from May to October 2017. All explants were maintained at 25 - 32˚C (Tem:) and 90 - 100 % (RH) in it.

4.2. Data Collection and Analyses

The experiment was conducted using Completely Randomized Block Design (CRBD) with 4 replications and 4 treatments. The observations were recorded regularly for the survival percentage, shoot and root formation of each treatment. DYNA and FERTI-START with the three media, sand (M1), forest soil (M2) and sand + forest soil (M3) were used for shoot and root growth performance.

These activities are done every week to determine using treatments and media for overall performance of three species. There were planted the 32 explants with one medium for one species. Therefore, the total number of sampled explants was 288. Data collection has been processed and accumulated by using Microsoft Office Excel 2013. Collected data has been statistically analyzed by using statistical software. Analysis of Variance (ANOVA) was done by using statistix version 8.0. Mean values were separated by using Least Significant Differences (LSD) test as 0.05 level.

Table 1. For shooting stage

No. of Treatment	DYNA (ml/g)	Duration (min)
T_1	-	-
T_2	10	5
T_3	10	10
T_4	10	15

Table 2. For rooting stage

No. of Treatment	FERTI-START (ml/g)	Duration (min)
T_1	-	-
T_2	5	1
T_3	5	3
T_4	5	5

5. Results and Discussions

Experiment I. Effects of explants position on each bamboo species in initial stage

Hormone free and sand medium were used in initial stage. The effects of explants position were described on survival percentage of one year old of nodal segments with three positions of each bamboo species. The survival percentage was influenced by different positions (terminal, middle and basal). Based on the results of each position, the middle position was found the best performance than other positions among three species (Figure 1).

This result is in agreement with K. Rajneesh, *et. al*., 2009 reported that nodal cutting took from one year old branches for nodal testing. P. Sharma, 2011 reported that 2-3 nodal segments of one year old were survived than two year old nodal cutting. In contrast to the finding of Dr. A, Sarita (2012) who reported that the highest survival percent was influenced by different levels of the hormone concentrations and duration in initial stage.

Table 3. Survival percentage of Tin-wa, Kyathaung-wa and Wabo-myet-sangye-wa at sand medium in initial stage

Species	Terminal (%)	Middle (%)	Basal (%)
C. pergracile	58.82	88.24	76.47
B. polymorpha	64.71	76.47	58.82
D. hamiltonii	29.41	76.47	47.09

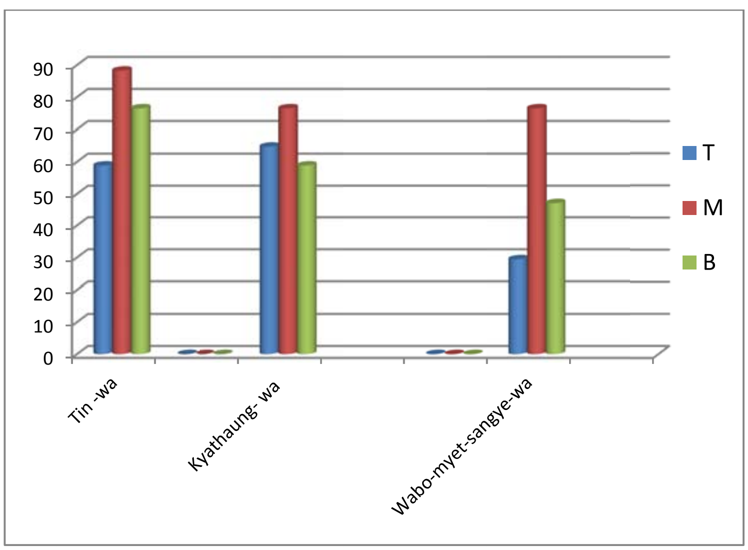

Figure 1. Effects of hormone free and sand medium on the explants of three position of one year old nodal cutting

Experiment II. Effects of shoot hormone and different media on the explants of middle position of one year old nodal cutting

The new shoots started to emerge from the soil mostly at the beginning of the rainy season. The starting emerging times were different among the species. That was second week of May for *B. polymorpha*, third week of May for *D. hamiltonii* and after third week May for *C. pergracile*. Statistically, there were significant differences among the means value of treatments in M1 and M3 media for Tin-wa, M1 medium for Kyathaung-wa and M3 medium for Wabo-myet-sangye-wa. Results on the shoots formation capacity from nodal segments were presented in (Table 4, 5, 6).

In sand medium (M1), there were significant among the treatments, T1 and T2 produced good results but T3 showed bad performance for Tin-wa. There were also significant among the treatments, T1 was the best but T4 was the poorest performance for Kyathaung-wa. But homogenous performance of treatments was on the Wabo-myet-sangye-wa. In forest soil medium (M2), there were not significant among the treatments for all species. In sand+forest soil medium (M3), there were significant among each treatment for Tin-wa and Wabo-myet-sangye-wa but not significant for Kyathaung-wa.

This result is in agreement with Ueda, K. 1960 reported that the shoot to emerge from the soil mostly at the beginning of the rainy season in tropical region. In contrast to the finding of A, Sarita, *et.al.*, 2008 who observed that the direct shoot regeneration with 7mg/l BAP. In addition, shoots were grown on 3mg/l BAP for further multiplication and development. J, Brar *et. al*., (2014), effects of different concentrations and combination of Benzyneaminopurine (BAP) and Napthaleneacetic (NAA) on shoot multiplication. Single node cuttings of (10 cm) length consisting one axillary bud from 3-4 weeks of incubation of nodal segments were used the explants for shoot multiplication. K, G, Arvind, (2014) observed that media supplemented with 5 mg/l BAP concentrations were induced to suppress shoot elongation.

Table 4. Shoot formation of Tin-wa (*C. pergracile*) in three media

Treatment	M1	M2	M3
T_1	3.7500 a	4.0000 a	4.0000 a
T_2	3.7500 a	4.0000 a	3.0000 b
T_3	1.7500 b	4.0000 a	2.7500 bc

T_4	2.7500 ab	3.7500 a	2.2500 c
P	0.0083	0.4262	0.0001
CV%	25.46	6.35	11.79

Table 5. Shoot formation of Kyathaung-wa (*B. polymorpha*) in three media

Treatment	M1	M2	M3
T_1	3.2500 a	2.7500 a	3.2500 a
T_2	2.5000 ab	2.7500 a	2.5000 a
T_3	2.0000 ab	2.5000 a	2.5000 a
T_4	1.7500 b	2.0000 a	3.2500 a
P	0.1678	0.7462	0.5262
CV%	39.39	43.97	34.05

Table 6. Shoot formation of Wabo-myet-sangye-wa (*D. hamiltonii*) in three media

Treatment	M1	M2	M3
T_1	0.7500 a	2.2500 a	1.2500 b
T_2	1.5000 a	2.2500 a	2.7500 a
T_3	2.0000 a	3.0000 a	3.5000 a
T_4	1.7500 a	3.2500 a	0.0000 c
P	0.4407	0.4720	0.0000
CV%	73.28	40.55	32.66

Experiment III. Effects of rooting hormone and different media on the explants of middle position of one year old nodal cutting

The effects of rooting hormone and durations influenced on rooting formation of each bamboo species. ANOVA revealed that there were significant differences in roots formation among M1and M3 media, not on the M2 medium for Tin-wa and there were also significant differences the mean values in M3 but not on the M1 and M2 media for Kyathaung-wa (Table 7, 8). There were no significant differences in roots formation among three media ($p < 0.05$) for Wabo- myet-sangye-wa (Table 9). Comparison within the three media, Wabo-myet-sangye-wa was good performance than other species (Table 10).

In sand medium (M1), there were significant among the treatments, T4 produced good results but T2 and T3 showed bad performance for Tin-wa. There were no significant among the treatments for Kyathaung-wa and Wabo-myet-sangye-wa. In forest soil medium (M2), there were no significant among the treatments for all species. In sand+forest soil medium (M3), there were significant among each treatment for Tin-wa and Kyathaung-wa but no significant for Wabo-myet-sangye-wa. Survival rate of optimal root did the Wabo-myet-sangye-wa than other species within the three media (Figure 2).

This observation was similar with that of Dick and Magingo (2012) reported that rooting ability of cuttings varied among node positions. In contract to the finding of Hentig and Gruber's reported that adventitious root formation was influenced by NAA dosage for nodal cuttings. Zhang, *et.al.,* (2010) stated that IBA (> 5 mg/l) may be more effective in plantlet rooting of *D. hamiltonii*. The shoots were individually cut about 1.5 inches above the base and discarded while the 'propagules' (shoot cut) were separated again and placed in soil medium containing IBA at different concentrations (80, 100, 120) µM for induction of roots.

Table 7. Root formation of Tin-wa (*C. pergracile*) in three media

Treatment	M1	M2	M3
T_1	0.3333	0.3333 a	1.0000*
T_2	0.2500*	0.5000 a	0.7500
T_3	0.2500*	0.1250 a	0.6250
T_4	0.7500	0.5000 a	0.3750
P	0.1345	0.3774	0.1100
CV%	146.78	164.41	58.79

Table 8. Root formation of Kyathaung-wa (*B. polymorpha*) in three media

Treatment	M1	M2	M3
T_1	0.0000 a	0.3333 a	0.5000
T_2	0.3750 a	0.2500 a	0.3750
T_3	0.2500 a	0.3750 a	0.1250*
T_4	0.1250 a	0.1250 a	0.6250
P	0.4284	0.7873	0.2257
CV%	264.50	149.89	146.55

Table 9. Root formation of Wabo-myet-sangye-wa (*D. hamiltonii*) in three media

Treatment	M1	M2	M3
T_1	1.0000 a	0.8333 a	0.5000 a
T_2	0.6250 a	0.5000 a	0.6250 a
T_3	0.8750 a	0.5000 a	0.8750 a
T_4	0.8750 a	0.6250 a	0.8750 a
p	0.3226	0.7516	0.4184
CV%	50.43	87.33	67.62

Table 10. Survival percentage of Tin-wa, Kyathaung-wa and Wabo-myet-sangye-wa in three media

Species	M1	M2	M3
C. pergracile	21.88	28.13	40.63
B. polymorpha	18.75	28.13	28.13
D. hamiltonii	58.13	59.38	62.5

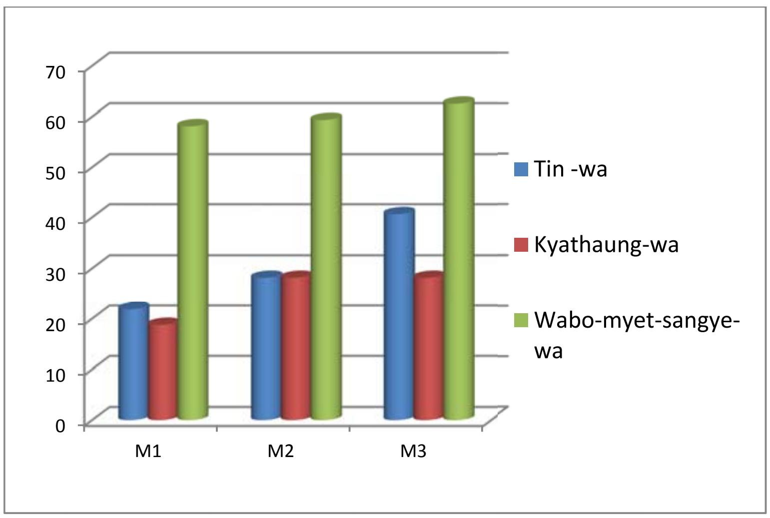

Figure 2. Effects of rooting hormone and different media on survival percentage of the explants of middle position of one year old nodal cutting

6. Conclusion

The results of the experiments indicated that the following conclusions could be drawn. The middle position of nodal segments with axillary bud was showed the highest survival rate among three positions of each species. For new shoots formation, statistically, the result of the comparative assessment revealed that hormones free (T1) and treatments (T2 to T4) showed non-significant among each species in forest soil medium (M2). There were significant differences in sand medium (M1) and sand + forest soil (M3) medium among root formation of Tin-wa. Similarly, there was significant difference in root formation of Kyathaung-wa at sand + forest soil (M3) medium among treatments. But there were non-significant differences in root formation of Wabo-myet-sangye-wa among three media. Optimal survival percentage was revealed for Wabo-myet-sangye-wa followed by Tin-wa and Kyathaung-wa in sand + forest soil (M3) medium.

Further study with those above mentioned various segments should be tested. Effects of hormone for some concentrations and durations on growth performance of other bamboo species of nodal segments should be tested in more detail. Environmental factors affecting bamboo growth, such as rain fall, relative humidity, temperature, which influence on new shoots production capacity of some commercial species should be studied.

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Appendices

Appendix I. Procedure established from preparation the explants material to rooting stage of bamboo species

Preparation of explants material

Initial stage

Shooting stage

Rooting stage

Appendix II.

ANOVA for shoot formation of Tin-wa in sand medium

Source	***DF***	***SS***	***MS***	***F***	***P***
V001	3	11.0000	3.66667	6.29	0.0083
Error	12	7.0000	0.58333		
Total	15	18.0000			

DF **Degree of Freedom,** ***SS*** **Sum of Squares,** ***MS*** **Mean Sum of Squares,** ***F*** **F test,** ***P*** **significant level: p < .05000** , Grand Mean 3.0000   CV 25.46

ANOVA for shoot formation of Tin-wa in forest soil medium

Source	*DF*	*SS*	*MS*	*F*	*P*
V001	3	0.18750	0.06250	1.00	0.4262
Error	12	0.75000	0.06250		
Total	15	0.93750			

***DF* Degree of Freedom, *SS* Sum of Squares, *MS* Mean Sum of Squares, *F* F test, *P* significant level: p < .05000**

Grand Mean 3.9375 CV 6.35

ANOVA for shoot formation of Tin-wa in sand +forest soil medium

Source	*DF*	*SS*	*MS*	*F*	*P*
V001	3	6.50000	2.16667	17.33	0.0001
Error	12	1.50000	0.12500		
Total	15	8.00000			

***DF* Degree of Freedom, *SS* Sum of Squares, *MS* Mean Sum of Squares, *F* F test, *P* significant level: p < .05000**

Grand Mean 3.0000 CV 11.79

ANOVA for shoot formation of Kyathaung-wa in sand medium

Source	*DF*	*SS*	*MS*	*F*	*P*
V001	3	5.2500	1.75000	2.00	0.1678
Error	12	10.5000	0.87500		
Total	15	15.7500			

***DF* Degree of Freedom, *SS* Sum of Squares, *MS* Mean Sum of Squares, *F* F test, *P* significant level: p < .05000**

Grand Mean 2.3750 CV 39.39

ANOVA for shoot formation of Kyathaung-wa in forest soil medium

Source	*DF*	*SS*	*MS*	*F*	*P*
V001	3	1.5000	0.50000	0.41	0.7462
Error	12	14.5000	1.20833		
Total	15	16.0000			

***DF* Degree of Freedom, *SS* Sum of Squares, *MS* Mean Sum of Squares, *F* F test, *P* significant level: p < .05000**

Grand Mean 2.5000   CV 43.97

ANOVA for shoot formation of Kyathaung-wa in sand+forest soil medium

Source	*DF*	*SS*	*MS*	*F*	*P*
V001	3	2.2500	0.75000	0.78	0.5262
Error	12	11.5000	0.95833		
Total	15	13.7500			

***DF* Degree of Freedom, *SS* Sum of Squares, *MS* Mean Sum of Squares, *F* F test, *P* significant level: p < .05000**

Grand Mean 2.8750   CV 34.05

ANOVA for shoot formation of Wabo-myet-sangye-wa in sand medium

Source	*DF*	*SS*	*MS*	*F*	*P*
V001	3	3.5000	1.16667	0.97	0.4407
Error	12	14.5000	1.20833		
Total	15	18.0000			

***DF* Degree of Freedom, *SS* Sum of Squares, *MS* Mean Sum of Squares, *F* F test, *P* significant level: p < .05000**

Grand Mean 1.5000   CV 73.28

ANOVA for shoot formation of Wabo-myet-sangye-wa in forest soil medium

Source	*DF*	*SS*	*MS*	*F*	*P*
V001	3	3.1875	1.06250	0.89	0.4720
Error	12	14.2500	1.18750		
Total	15	17.4375			

***DF* Degree of Freedom, *SS* Sum of Squares, *MS* Mean Sum of Squares, *F* F test, *P* significant level: p < .05000**

Grand Mean 2.6875   CV 40.55

ANOVA for shoot formation of Wabo-myet-sangye-wa in sand+forest soil medium

Source	*DF*	*SS*	*MS*	*F*	*P*
V001	3	29.2500	9.75000	26.00	0.0000
Error	12	4.5000	0.37500		
Total	15	33.7500			

***DF* Degree of Freedom, *SS* Sum of Squares, *MS* Mean Sum of Squares, *F* F test, *P* significant level: p < .05000**

Grand Mean 1.8750   CV 32.66

Appendix III.

ANOVA for root formation of Tin-wa in sand medium

Source	*DF*	*SS*	*MS*	*F*	*P*
V001	4	1.66667	0.41667	1.93	0.1345
Error	27	5.83333	0.21605		
Total	31				

***DF* Degree of Freedom, *SS* Sum of Squares, *MS* Mean Sum of Squares, *F* F test, *P* significant level: p < .05000**

Grand Mean 0.3167   CV 146.78

ANOVA for root formation of Tin-wa in forest soil medium

Source	*DF*	*SS*	*MS*	*F*	*P*
V001	4	1.01042	0.25260	1.10	0.3774
Error	27	6.20833	0.22994		
Total	31				

***DF* Degree of Freedom, *SS* Sum of Squares, *MS* Mean Sum of Squares, *F* F test, *P* significant level: p < .05000**

Grand Mean 0.2917   CV 164.41

ANOVA for root formation of Tin-wa in sand+forest soil medium

Source	*DF*	*SS*	*MS*	*F*	*P*
V001	4	1.62500	0.40625	2.09	0.1100
Error	27	5.25000	0.19444		
Total	31				

***DF* Degree of Freedom, *SS* Sum of Squares, *MS* Mean Sum of Squares, *F* F test, *P* significant level: p < .05000**

Grand Mean 0.7500   CV 58.79

ANOVA for root formation of Kyathaung-wa in sand medium

Source	*DF*	*SS*	*MS*	*F*	*P*
V001	4	0.62500	0.15625	0.99	0.4284
Error	27	4.25000	0.15741		
Total	31				

***DF* Degree of Freedom, *SS* Sum of Squares, *MS* Mean Sum of Squares, *F* F test, *P* significant level: p < .05000**

Grand Mean 0.1500   CV 264.50

ANOVA for root formation of Kyathaung-wa in forest soil medium

Source	*DF*	*SS*	*MS*	*F*	*P*
V001	4	0.38542	0.09635	0.43	0.7873
Error	27	6.08333	0.22531		
Total	31				

***DF* Degree of Freedom, *SS* Sum of Squares, *MS* Mean Sum of Squares, *F* F test, *P* significant level: p < .05000**

Grand Mean 0.3167   CV 149.89

ANOVA for root formation of Kyathaung-wa in sand+forest soil medium

Source	*DF*	*SS*	*MS*	*F*	*P*
V001	4	1.37500	0.34375	1.52	0.2257
Error	27	6.12500	0.22685		
Total	31				

***DF* Degree of Freedom, *SS* Sum of Squares, *MS* Mean Sum of Squares, *F* F test, *P* significant level: p < .05000**

Grand Mean 0.3250   CV 146.55

ANOVA for root formation of Wabo-myet-sangye-wa in sand medium

Source	*DF*	*SS*	*MS*	*F*	*P*
V001	4	0.75000	0.18750	1.23	0.3226
Error	27	4.12500	0.15278		
Total	31				

***DF* Degree of Freedom, *SS* Sum of Squares, *MS* Mean Sum of Squares, *F* F test, *P* significant level: p < .05000**

Grand Mean 0.7750   CV 50.43

ANOVA for root formation of Wabo-myet-sangye-wa in forest soil medium

Source	***DF***	***SS***	***MS***	***F***	***P***
V001	4	0.51042	0.12760	0.48	0.7516
Error	27	7.20833	0.26698		
Total	31				

DF **Degree of Freedom,** ***SS*** **Sum of Squares,** ***MS*** **Mean Sum of Squares,** ***F*** **F test,** ***P*** **significant level: p < .05000**

Grand Mean 0.5917   CV 87.33

ANOVA for root formation of Wabo-myet-sangye-wa in sand+ forest soil medium

Source	***DF***	***SS***	***MS***	***F***	***P***
V001	4	0.84375	0.21094	1.01	0.4184
Error	27	5.62500	0.20833		
Total	31				

DF **Degree of Freedom,** ***SS*** **Sum of Squares,** ***MS*** **Mean Sum of Squares,** ***F*** **F test,** ***P*** **significant level: p < .05000**

Grand Mean 0.6750   CV 67.62

*Note: *SS* are marginal (type III) sums of squares