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Full Length Research Paper

Effect of Different Propagation Methods on three Lowland Bamboo Species, at Bako Agro-ecology, West Shoa, Oromia, Ethiopia

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ABSTRACT

Bamboo is one of the most important, fast-growing and drought-resistant species. These behaviors make the species more acceptable in making a good environment in addition to soil and water conservation and rehabilitation of degraded lands. The study was conducted on the effect of different propagation techniques using three lowland bamboo species to find out the best-preformed propagation ways. The experiment was conducted in Bako Agriculture Research Center from 2015 to 2017. A factorial arrangement of randomized complete block design (RCBD) with three replications was used. The experimental materials were; rhizome, branches, lower and middle culms cutting parts and three species (*Oxythenantera abyssinica*, *Dendrocalamus hamlitonii*, and *Dendrocalamus memebranceous*) was used. A total of 144 planting materials were planted in each experimental plot using four planting material. There was a significant difference between the species and propagation methods. The newly emerging shoots revealed a significant difference under *Dendrocalamus hamlitonii* (1.30±0.8) among other species. Under all species and treatments, *Dendrocalamus hamlitonii* showed a better performance than others regarding survival rate, root collar diameter, culm height, and internodes length. Besides this, a branch treatment under all species showed a poor performance. Therefore, this study confirmed that following rhizome part using lower and middle culm part recommended as a promising propagation technique for lowland bamboo species. Further investigation on the biological factors that hamper the initiations of new shoots and survival in using branch cutting methods is also recommended.

Keywords: bamboo; branch; culms; propagation; rhizome; shoots

INTRODUCTION

Bamboo is a fast-growing woody plant and a renewable source of fuel which has a heating value comparable to that of timber from trees. Normally, bamboo belongs to the family of grasses *Gramineae (Poaceae*) and known as the woody perennial species (Bystriakova et al., 2004; Wang. 2006). It is well known as a multipurpose plant with several of application ranging from construction material, furniture, fence, handicraft, pulp and paper, edible shoots and animal fodder (CIBART, 2004; Embaye, 2003). According to the previous study the distribution of bamboo species in Ethiopia estimated more than 1 million hectares of natural bamboo forests and this distribution of bamboo forests is the largest in Africa (LUSO, 1997; Ensermu et al., 2000). In Ethiopia, two bamboo species were found the highland bamboo (*Yushinia alpina*) and lowland bamboo (*Oxythenantera*

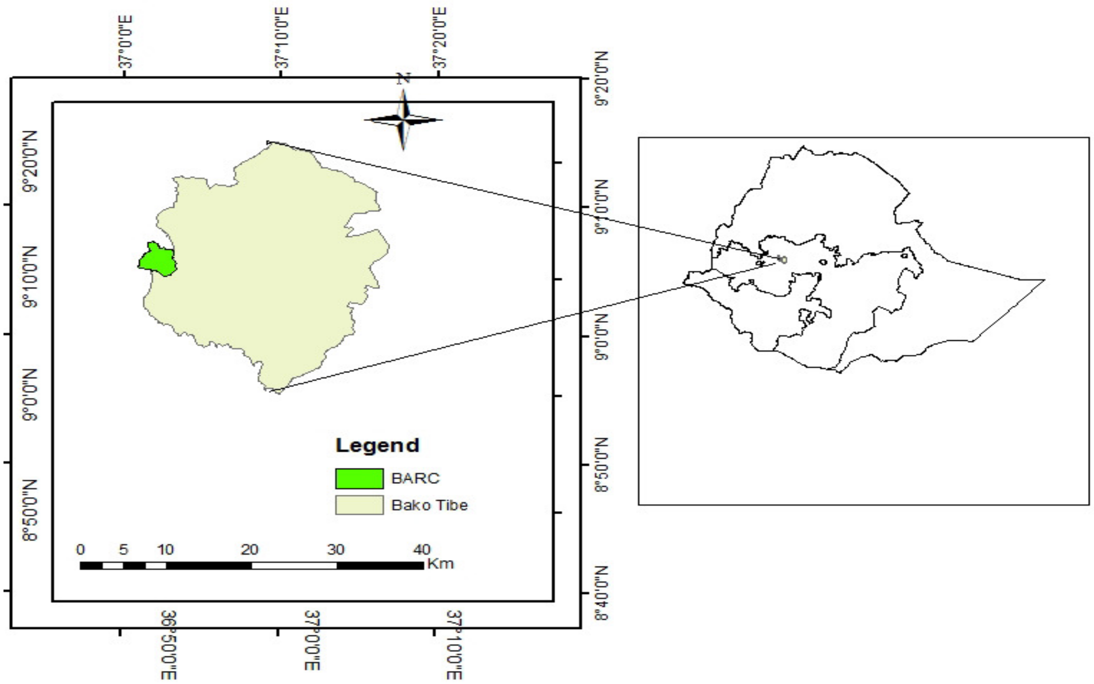

Figure 1 Location map of the study area

abyssinica). Both bamboo species are indigenous to Ethiopia and endemic to the rest of the African country (Ensermu et al., 2000). In addition this *Dendrocalamus hamlitonii,* and *Dendrocalamus memebranceous* both lowland bamboo species were exotic for Ethiopia and newly introduced by East African Bamboo Project. Therefore, the adaptation was conducted in different part of the country based upon the suitable agro ecology of the species (Regassa et al., 2016). According to Banik (1995), study bamboo species can be propagated either by sexual (reproductive) or asexual (vegetative) means of propagation. However, the seed propagation method is not popular in the country due to the irregularity and rarity of the flowering of common bamboo species plus difficulties to acquire the seeds (Lal et al., 1998; Reddy, 2006; Azene, 2007). On top of this, the nature of bamboo seeds is difficult to manage since the species give seed once in its lifetime and after giving the first seed within 30-40 years old immediately collapse so it's difficult to propagate using seeds. Various methods of vegetative propagation are described by (Tesfaye et al., 2005; Yigardu and Masresha, 2014; Yared et al., 2017). Vegetative propagation method is suitable for farmers and different stakeholders for their low cost and eases of management techniques (Jiménez and Guevara, 2007). In Ethiopia, the indigenous method of farmers in propagating bamboo is the offset method. Offset method makes the use of the rhizomes and the portion of culms (Ahlawat et al., 2002). However, the problems in using this method are huge, heavy, labor-intensive and difficult to transport the excavating out offsets can damage the adjoining rhizome of the neighboring culms (Yared et al., 2017). Establishing large scale bamboo plantations by using this technique is very expensive and difficult. Therefore, based on this problems and limitation of seed resources this research was initiated to evaluate different propagation techniques using rhizome, culm and branch cutting parts of bamboo and select the best propagation techniques based upon their performances.

MATERIALS AND METHODS

Description of the study area

This experiment was conducted at Bako Agricultural Research Center on the station. The study area is located in 9°06’ N latitude and 37°09’ E longitude as indicated below in Figure 1. The area is mid-altitude, sub-humid tropical climate with unimodal rainfall pattern, experiencing an average annual rainfall of 1270 mm and an average annual temperature of 20°C (maximum 27°C and minimum 13°C). The attitudinal range of the area is about 1650 m above sea level. The soil is dominantly reddish brown Nitosol, with a pH of 5-6, and clay dominated in texture (Legesse et al. 1987).

Material preparation and its management

Oxythenantera abyssinica (OA), *Dendrocalamus hamlitonii* (DH), and *Dendrocalamus memebranceous* (DM) were the three lowland bamboo species used as input materials. The age of the species was one and a

Table 1 Comparisons of survival rate in percent between species and cutting parts

Treatments	6 month survival in %	1 & half year age in %	3 year age in %
Lower Culm of OA	50	25	25
Middle Culm of OA	0	0	0
Rhizome of OA	100	75	75
Branch of OA	0	0	0
Lower culm of DH	75	50	25
Middle Culm of DH	25	25	25
Rhizome of DH	100	100	100
Branch of DH	25	25	25
Lower Culm of DM	0	0	0
Middle Culm of DM	50	25	25
Rhizome of DM	100	100	100
Branch of BDM	0	0	0

N.B: OA= *Oxythenantera abyssinica; DH=Dendrocalamus hamlitonii* & *DM =Dendrocalamus memebranceous*.

half to two years old were prepared based on the manuals for tropical bamboos (Banik, 1995; Ronald, 2005; Njuguna and Kigomo, 2008). Accordingly, the propagation materials (rhizomes, branches, Lower and middle Culm) cutting parts were prepared based on the procedures. Therefore, rhizomes with the presence of root were prepared using digging axes, to separate from parent rhizome. For culms and branch parts, we used a hacksaw to cut and prepared the cuttings from the selected culm parts which have nodes. After preparation, the next step was keeping the moisture of planting materials up to the planting date by applying water and mulch for three days before planting took place. The experiment was set up for a period of three years started on June 2015 which was the main rainy season and the soil became adequately wet and watering was done in the dry season (December to April).

Experimental layouts

A 4*3 factorial arrangement of treatments in a randomized complete block design (RCBD) with three replications was used. Based on that the total samples we used for the experiments were 36 samples. The sizes of the plots were 4m*4m (16m^2) and per plot 4 cutting materials planted with 2m spacing. The distance used between plots and blocks was 2m and 3m, respectively. A total of 144 planting materials were planted in the whole experimental plots. The experimental materials were used as treatments (rhizomes, branches, Lower and middle Culm parts). Those materials were prepared and arranged on time for the experiments accordingly since all the material is available on the station.

Data collection

The experiment was conducted from 2015 to 2017 for three consecutive years. Data like; number of new emerging shoot was counted, and their culm height, root collar diameter, culm diameter, internodes length, and survival rate in percent were measured within two months' interval.

Data analysis

The data was arranged and summarized using Excel sheet before the actual data analysis takes place. Data analysis was made using SAS v9, 2004 software. Two way ANOVA was conducted and Tukey's Honest Significance Difference (HSD) test was used throughout the comparison when statistically significant differences ($p<0.05$) were observed between factors. The different graph analysis presented using excel sheet.

RESULT AND DISCUSSION

Survival rate

In this experiment, the survival rate varied among bamboo species and the treatments used. At the early planting stage, almost all species and treatments showed a better performance in producing new shoots and survival conditions. However, the newly sprout shoots were not extended for more than two months gradually it becomes dried due to moisture stress and diseases infested the leaf part. This problem was observed on some of the treatments indicated in Table 1 above.

Obviously, the selected species has no problem in adaptability since the adaptation trial was conducted before in the same agro-ecology by Regassa T. et al. 2016, and the result of adaptability of *Oxythenantera abyssinica*, *Dendrocalamus hamlitonii*, and *Dendrocalamus memebranceous* was revealed 100% survival at Bako Agriculture Research Center. According to the three years, data *Dendrocalamus hamlitonii* showed a difference in survival rate in all treatments

Table 2. Mean ± SE of NES, RCD, CH, and IL under each bamboo species

Species	Av. NES	Av. RCD	Av. CH	Av. IL	Duration
DM	1.17±01.26[b]	0.97±1.57[b]	1.60±1.85[c]	9.49±5.50[b]	3 years Av. data
DH	1.30±0.8[a]	1.26±1.18[a]	3.49±2.28[a]	11.67±3.89[a]	3 years Av. data
OA	1.06±0.69[b]	0.88±0.71[b]	2.01±0.55[b]	6.58±5.22[c]	3 years Av. data
Overall Mean	1.18±0.45	1.04±1.12	2.37±1.55	9.26±3.87	3 years Av. data
CV in %	*10.18*	*19.32*	*9.29*	*17.58*	3 years Av. data
P-Value	*0.4305*	*0.3717*	*0.4873*	*0.2544*	3 years Av. data

NB: NES= New Emerging Shoots, RCD= Root Collar Diameter, CH= Culm Height and IL= Internodes Length, Av= Average, †Means within a column followed by the same letter are not significantly different at P = 0.05

Table 3 Means Comparisons between treatments at 0.05 significant levels (Mean ± SE)

Treatments	Av. NES	Av. RCD	Av. CH	Av. IL
Lower Culm OA	0.33±0.06[c]	0.15±0.25[c]	0.20±0.35[d]	2 ±0.67[d]
Middle Culm OA	00	00	00	00
Rhizome OA	2.00±0.72[a]	1.92±0.65[b]	2.3 ±0.9[b]	13.9±0.43[b]
Branch OA	00	00	00	00
Lower Culm DH	1.00±0.52[ba]	0.25±0.2[c]	0.73±0.21[c]	9.5±0.89[bc]
Middle Culm DH	0.33±0.53[c]	0.15±0.18[c]	0.77±0.32[c]	12.8±0.92[b]
Rhizome DH	3.00±0.78[a]	3.32±0.49[a]	4.38±1.2[a]	16.6±1.1[a]
Branch DH	0.33±0.24[c]	0.17±0.2[c]	0.53±0.45[c]	7.77±0.66[c]
Lower Culm DM	00	00	00	00
Middle Culm DM	0.67±0.42[b]	0.37±0.24[c]	0.54±0.4[c]	11 ±0.71[b]
Rhizome DM	2.00±0.87[a]	2.87±0.76[a]	4.21±0.63[a]	16 ±0.95[a]
Branch DM	00	00	00	00
Overall Mean	0.78±0.49	0.77±0.37	1.14±0.65	7.46±0.96
CV in %	*43.18*	*46.84*	*59.5*	*28.4*
P-Value	*0.125*	*0.164*	*0.129*	*0.361*

†Means within a column followed by the same letter are not significantly different at P = 0.05.

(rhizome 100%, branch 25%, lower culms 25% and middle culms 25%) as we compare with other species this indicates that how the species is promising for propagation method. Furthermore, among the four experimental treatments indicated above in Table 1, rhizomes under all species showed a better performance in survival in comparing with other cutting materials this might be due to the presence of residual roots that help to enhance its root expansion and overcoming the external stresses.

New emerging shoots (NES)

The emerging of new shoots always begins during the rainy season of the year after planting this might be due to the presence of enough moisture and access of water helps to develop newly sprout shoots. On the other hand, the number of newly emerged shoots always differ among the species (Kamesh S. and Nipan D. 2007) this depends upon the potential of species in producing new shoots. The newly emerging shoots (NES) revealed a significant difference under *Dendrocalamus hamlitonii* (1.30±0.8) among others (Table 2).

were depend up on the structure In addition to this, in root collar diameter (RCD), culm height (CH) and internodes length (IL) *Dendrocalamus hamlitonii* again showed a significant difference among other species with the average values of 1.26±1.18, 3.49±2.28 and 11.67±3.89, respectively. *Oxythenantera abyssinica* and *Dendrocalamus memebranceous* are not significantly different in newly emerging shoots (NES) and root collar diameter (RCD) as indicated below in Table 2. Regarding culm height (CH) and internodes length (IL) both species showed a significant difference. Normally, the variation among the species in NES, RCD, CH, and IL might be due to structural differences and growth performances abilities of each species.

In this experiment, there is a significant difference observed in newly produced shoots between the species and the treatments as indicated in Table 3. The highest value of NES was recorded in *Dendrocalamus hamlitonii* specie with 3.00±0.78 rhizome. But the lowest result of NES was recorded under lower culm of OA, Middle culm of DH and Branch of DH 0.33±0.06, 0.33±0.53 and 0.33±0.24, respectively as indicated in Table 3. Concerning RCD, CH and IL parameters for all species rhizome treatment were showed the highest values.

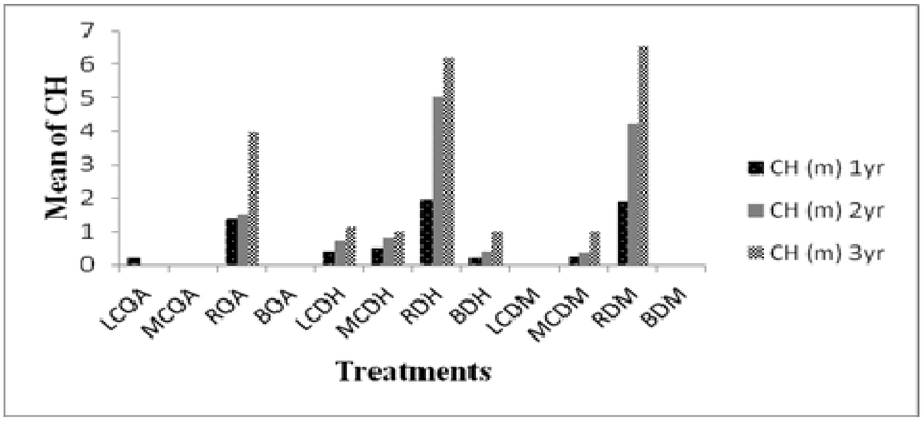

Figure 2. Mean Culm Height (CH) increment under each species and propagation method

Table 4 Mean value of internodes length under each propagation methods

Treatments	IL (cm) 1yr	IL (cm) 2yr	IL (cm) 3yr
Lower Culm OA	5	0	0
Middle Culm OA	0	0	0
Rhizome OA	12.5	13.8	15.4
Branch OA	0	0	0
Lower Culm DH	4.5	11	13
Middle Culm DH	6	14	18.4
Rhizome DH	13.8	17	19
Branch DH	3.3	8	12
Lower Culm DM	0	0	0
Middle Culm DM	8.9	11.2	13
Rhizome DM	10	18.3	21.5
Branch DM	0	0	0

Lower culm of OA revealed the least results under RCD, CH and IL. Among the experimental treatments, middle culm and braches from OA and lower culm and branches from DM at the beginning showed a good performance in survival but it doesn't extend six months that is why the recorded result illustrated zero in Tables.

As presented in Table 3, the interaction between cutting materials and species is significantly different at $p < 0.05$. According to the results, *Dendrocalamus hamlitonii* revealed a good performance under all experimental treatments, while the performance of *Dendrocalamus memebranceous* and *Oxythenantera abyssinica* under all experimental treatments was nearly comparable. Regarding the experimental treatments, rhizome showed better performance under all species this might be due to the presence of residual roots which highly facilitate the growth of new shoots through providing water and nutrients.

Root collar diameter and culm height

The root collar diameter is indicated by the thickness of the lower parts of the culms which are directly or indirectly related to the quality of bamboo production (Kamesh S. and Nipan D. 2007). In this study, there is a significant difference in the mean root collar diameter increment under all propagation method and species used. Accordingly, the root collar diameter of *Dendrocalamus hamlitonii* and *Dendrocalamus memebranceous* was showed higher under rhizome than other propagation methods, while the lowest root collar diameter was observed at the lower and middle culms of *Oxythenantera abyssinica* and *Dendrocalamus hamlitonii* as indicated in Table 3 above. Culms are solid in the lower internodes and are hollow from the upper half up to the top of the culm. The culms of *Oxythenantera abyssinica* are semi-solid when young but solid in older culms. Whereas, *Dendrocalamus hamlitonii* and *Dendrocalamus memebranceous* relatively semi-solid and hollow at the upper part of the culms when compare to *Oxythenantera abyssinica*. The full length of the culm may vary among the species as reported by Fu Maoyi., 2005. The increments of culms height across the species and the treatments were significantly different as indicated below in Figure 2. According to the result obtained from the analysis showed that rhizome propagation method under each species was highly significant in comparing with others propagation methods, while others methods showed similar culm height increment throughout the experiment period (Table 3 and Figure 2).

Internodes length (IL)

Bamboo culms structure is cylindrical and is divided into sections by diaphragms or nodes. The section between two nodes is called internodes. In most of the species, internodes are hollow but solid in some others. It indicates the quality of bamboo production which used for different purposes (Ronald, 2005). In the current study; there is a significant difference in the mean values of internodes length between the experimental treatments and species as presented in Table 2, 3 and 4. Following the rhizomes, vegetative treatment for each species lower and middle culms of *Dendrocalamus hamlitonii* and *Dendrocalamus memebranceous* showed a good performance in internodes length. Whereas, branch treatment of all species showed poor performance in internodes length as indicated in Table 3. The reason that internodes length showed better performances under rhizomes, lower and middle culm these parts has a high potential of storing foods, water, and nutrients that used for culm building, biomasses comparing with branches.

CONCLUSION AND RECOMMENDATIONS

Vegetative propagating using the offset method, (rhizome with the whole culms) is a traditional and common method for bamboo propagation elsewhere. However, due to a shortage of seeds, using different vegetative propagation method is becoming an alternative method for the propagation and expansion of bamboo resources at small and large scales. The present finding showed that there is a significant difference between the species and treatments used. According to the current results, rhizome treatment for all species revealed a better performance when compared with others. Among the species *Dendrocalamus hamlitonii* (DH) was the one showed the best performance under all treatments except some variation observed in survival rate, culm height, and root collar diameter. Therefore, based on the finding *Dendrocalamus hamlitonii* species is the one which is the suitable and best option for all treatments used for vegetative propagation methods. In another way, both *Dendrocalamus memebranceous* and *Oxythenantera abyssinica* species showed relatively a poor performance under all treatments by comparing *Dendrocalamus hamlitoni*. In general, the current results of bamboo propagation using different cutting parts is easy and appropriate techniques next to rhizome for further expansion of bamboo resources. Besides, using different parts of culms is promising propagation techniques, since the seed limitation is one of the biggest challenges for bamboo species. Finally, to use bamboo's full potential, we recommend that more fundamental research is needed, for the future bamboo expansion in particular to the western Oromia and general to Ethiopia

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Conflict of interest: The authors declare no conflict of interest.

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