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Vegetative Propagation Techniques of Highland Bamboo (*Yushania alpina*) in Amhara Region, North-Western Ethiopia

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ABSTRACT

Bamboo is an important source of income for rural livelihoods in Ethiopia and somewhere else. It is increasingly recognized as potential species for environmental protection and poverty reduction in many countries including Ethiopia. The study was conducted in Amhara Regional State, Awi Zone, where Yushania alpina dominated areas of Banja district. This finding aimed at to identify advanced propagation techniques that can be pertinent for large scale plantation of Yushania alpina. randomized complete block design with three replications was used. The vegetative propagation materials (treatments) were; rhizome with two nodes, rhizome with four nodes, rhizome with six nodes, rhizome without culm and rhizome with the whole culm (offset). A total of 240 offset planting materials were planted in the experimental station. Of which, sixteen planting material were used in each plot level. New shoot sprouting, and their height, root collar diameter and mortality rate data was collected. There was no statistical significant difference in mean number of new sprouted shoots of Yushinia alpina between the five treatments. While, there was significant difference between mean shoot height of rhizome with four nodes and rhizome without Culm (137.02b ± 22.94, 67.10a ± 17.97) at ($p<0.05$) respectively. The result revealed that, rhizome with four nodes and six nodes had shown significantly higher mean shoot height and root collar diameter, as compared with the traditional one (Rhizome with the whole culm) (33.89b ± 12.17, 32.43b ± 12.68, 8.48a ± 2.53) at ($p<0.05$) respectively. The present finding confirmed that, among different Propagating techniques rhizome with four and six nodes are appropriate for large scale plantation of Yushinia alpina, as compared to the conventional propagation technique (offsets).

***Keywords*:** Culm, Node, Offset, Rhizome, Shoot, Vegetative Propagation, *Yushania alpina*

1. INTRODUCTION

Bamboo is a woody perennial belonging to the family of grasses, *Gramineae* (*Poaceae*) with unique qualities (Wang, 2006). It is a self-regenerating and renewable non-timber natural resource. Bamboo is a fast growing and self-sustaining species once established (Bystriakova *et al.* 2004). In bamboo growing countries of the world, bamboo is well known as a multipurpose plant with a myriad of application ranging from construction material, furniture, fence, handicraft, pulp and paper, edible shoots and animal fodder (CIBART, 2004; Kassahun, 2004).

According to Banik (1995), bamboos can be propagated either by sexual (reproductive) or asexual (vegetative) means. Sexual propagation is by means of seeds. However, this is not popular in the country due to the irregularity and rarity of flowering of common bamboo species plus difficulties to transport and store seeds (Azene, 2007; Lal, *et al.*, 1998; Reddy, 2006). Propagation makes use of different parts of bamboo plants as propagation material. Various methods of vegetative propagation are described by (Tesfaye *et al*., 2005). This method suit to farmers and private organizations for their low cost and ease of management (Jiménez and Guevara, 2007).

Ethiopia has two bamboo species; namely: *Yushinia alpina* and *Oxytenanthera abyssinica* which covers an area of 31,003 and 1,070,198 hectares, respectively (Kassahun, 2000; 2003 and Ensermu *et al*. 2005). The former is growing at steeper and higher altitude while the later growing lowland parts of the country. Even though, Ethiopia has huge bamboo resources, as a result of demand for fuel wood and wood products, currently suggested the resource is declined in higher rate. At present, high population growth in the country has led to increase the demand for food and natural resources and hence increase the need of additional agricultural land at steeper and higher upland areas for agricultural cultivation that leads to soil erosion which is damaging agricultural production supporting ecologies and their services.

Concerning of the above problems, Ethiopian government established a new Environment and Forest Minister, designed afforestation and reforestation program to increase the forest coverage of the country. The government promotes planting of bamboo in most regions of the country where steeper and higher uplands found. Characteristically, bamboos are well known by their fastest growth rate, high level biomass production and are environmentally friendly (Senyanzobe *et al.* 2013). The extensive rhizome-root system of bamboo and accumulation of leafy mulch, bamboo is the most effective in soil erosion controlling mechanism, conserving moisture, reinforcing embankments and stabilizing drainage channels (Zhou *et al.*, 2005).

The indigenous bamboo species of Ethiopia (*Yushania alpina)* is predominantly found in north-western, south-western, and central parts of the country. Flowering and seeding are the most necessary for reproduction and new generations (Bystriakova *et al*. 2004). Flowering and seeding time information is limited for the propagation of this species. 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: (i) excavating out offsets is cumbersome and labor intensive; (ii) offsets are also difficult to transport for long distances because of their heavy weight and long length, (iii) excavating out offsets can damage the adjoining rhizome of the neighboring culms. Establishing large scale bamboo plantations by using this technique is very expensive.

Though, the afforestation and reforestation program of the government constrained by lack of quality and adapted planting materials for this bamboo species. Previous research works on propagation of bamboo in Ethiopia were not successful in discovering effective techniques; hence further research to test techniques that were not tested well in previous researches is of paramount importance on both lowland and high land bamboo species.

The present finding was conducted to develop appropriate propagation techniques for effective supply of quality planting material for large scale plantation.

2. MATERIALS AND METHODS

2. 1. Description of the study area

This study was conducted in Amhara Regional State, Awi Zone, at Banja district, in the North-West parts of Ethiopia (Figure 1). It is located 447 Km far from Addis Ababa and 122 Km to the north of regional cities. The district is located within the distribution range of highland bamboo (*Yushinia alpina*) at latitude 10°52'00"-11°2'44" N and longitude 36°38'26"-37°7'8" E. The district 80% of the area is highland, 20% is middle highland. Banja district has an altitude ranges of 1900 to 2700 m a.s.l. The mean annual rain rainfall of the area is between 2,200-2400 mm and also it has unimodal rainfall distribution pattern. The rainy season starts in May and extends up to begging of November. The min-max annual temperature of the area 11-19 °C along the elevation gradients as cited in (Yenesew *et al.* 2014). The major soil groups generally identified as Acrisols (Yihenew, 2002).

2. 2. Experimental site selection

This experiment was conducted in the experimental station of Pawe agricultural research center at Sankit Lideta kebele in Banja district. The experimental site has well drained soil and gentle slope. The main access road and availability of water source was considered during site selection. Therefore, watering of the planted materials in the dry season was applied.

2. 3. Planting materials and tending operation

The planting materials were taken from one and one-half year old *Y. alpina* and prepared based on manuals for tropical bamboos (Banik, 1995; Ronald, 2005 and Njuguna and Kigomo, 2008). In this experiment, the propagating materials (treatments) were prepared by serving the whole rhizome with the presence of root system, using a sharp axe, to separate from parent rhizome. After picked up the appropriate planting materials from mother plant stocks, the rhizome attached offset planting materials were prepared by counting nodes with a slanting cut (rhizome without culm, rhizome with two nodes, Rhizome with four nodes, Rhizome with six nodes and Rhizome with whole culms/traditional methods).

The experiment was set up for a period of three and half a year started on July 24, 2011 which was the main rainy season and the soil became adequately wet and also the time farmers planting bamboo in their farm land and home gardens. Watering was done in the extreme dry season (January to March). The weeding and soil loosening was done twice a year until the end of the experiment.

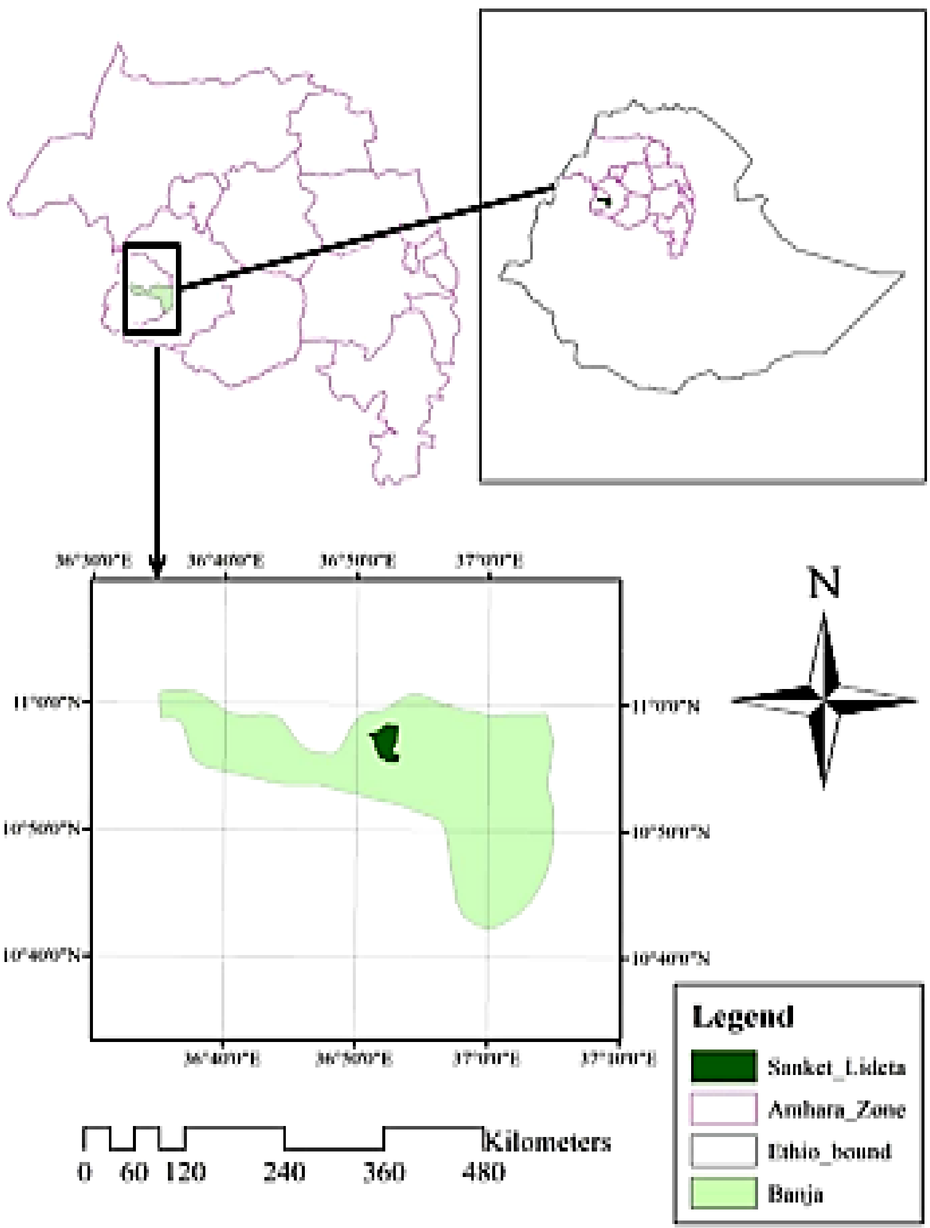

Figure 1. Location Map of the study area, Banja district, Northwestern Ethiopia.

2. 4. Experimental design and treatments

Randomized Complete Block Design (RCBD) with three replications was used. The sizes of the plots were 6 m*6 m (36 m^2) and per plot 16 propagation materials planted with 2 m spacing. The distance used between plots and bocks was 4 m. A total of 240 planting materials were planted in the experimental station. The propagation materials were used as a treatment (rhizome without culm, rhizome with two nodes, rhizome with four nodes, rhizome with six nodes and rhizome with whole culms (traditional methods).

2. 5. Data Collection

This experiment was conducted from 2011 to the year of 2014. The number of new sprouts shoot was counted, and their height, root collar diameter measured and mortality rate recorded at each six months' interval.

2. 6. Data analysis

Normality and homogeneity of variances were checked before the actual analysis. Data analysis was made using SAS 9.0 software. One-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. The different graph analysis presented by using Sigma Plot 12 and Microsoft excel 16 software.

3. RESULT AND DISCUSSION

3. 1. Shoot sprout

Table 1. Effects of propagation techniques on sprouted shoots of *Yushinia alpina*.

Propagation techniques (treatment)	No of shoots	
	Mean	SEM
Rhizome with whole culm (offset)	3.24a	1.48
Rhizome with two nodes	5.81a	1.7
Rhizome with four nodes	6.9a	1.5
Rhizome with six nodes	5.71a	1.58
Rhizome without culm	4.62a	1.39

Numbers with the same letters are not statistically significant at 5% level of significance.
Note: SEM = Standard Error of Mean

There was no significant difference in the mean number of sprouted shoots among the vegetative propagation of *Y. alpina*. In rhizome with four, two and six nodes higher number of shoot spouts were recorded as compared to the offset (traditional) propagation techniques, respectively. Whereas rhizome without culm showed less number of sprouted shoots next to offset (Table 1). Time trends indicated that there is a statistical significant difference in the mean number of new sprouted shoots between growing seasons of wet (0.5, 1.5, 2.5 and 3.5 years) and dry (1, 2 and 3 years) at ($p<0.05$) (Figure 2).

The study revealed that the sprout of new shoots between the propagation techniques was similar, but the variation of shoot emergence observed between dry and wet season. This study in line with the study of Senyanzobe (2013), the sprouting rate of shoots after planting varied significantly with different propagules depicted high number of shoots sprout during wet season. During the dry season the number of shoot reduced but increased in the wet season. According to (Yigardu and Masresha, 2014; and Sajad *et al*. 2011) the sprout of shoot challenged by strong wind, season and moisture fluctuation.

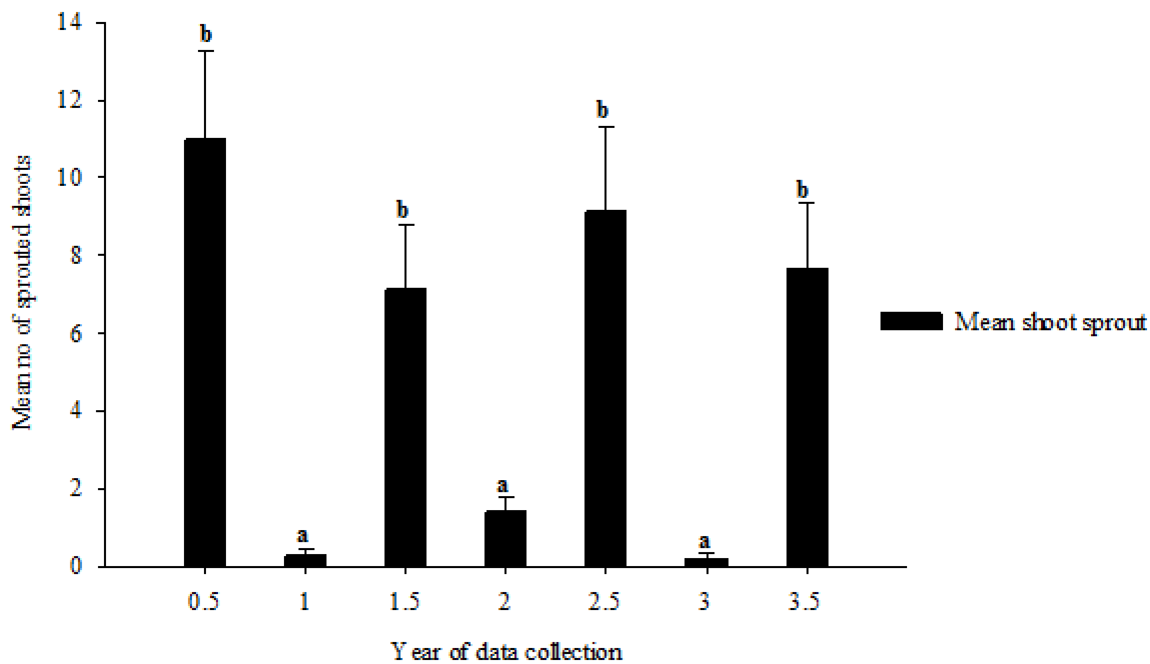

Figure 2. Mean shout sprout of *Y. alpina* at each year.

3. 2. Root collar diameter and shoot height

There is a significant difference in the mean shoot diameter increment between the traditional (offset) and rhizome with four and six nodes propagation techniques. Shoot diameter increment of four and six node propagules were higher than the remaining propagation techniques, but the lowest diameter increment was observed at rhizome with whole culm propagation technique. Comparable diameter increments were observed in rhizome with two, four, six and without culm propagation techniques (Figure 3). Similar research result was reported by the work of Yigardu and Masresha (2014) by investigating the vegetative propagation of highland bamboo. And also four and six node propagation techniques showed a better shoot root collar diameter and height (Figure 5 and 6).

There is a highly significant difference in the mean root collar diameter (RCD) of sprouted shoots at the beginning of the first six months. We observed that there was inconsistency in root collar diameter of the emerging shoots through time trends (Table 3).

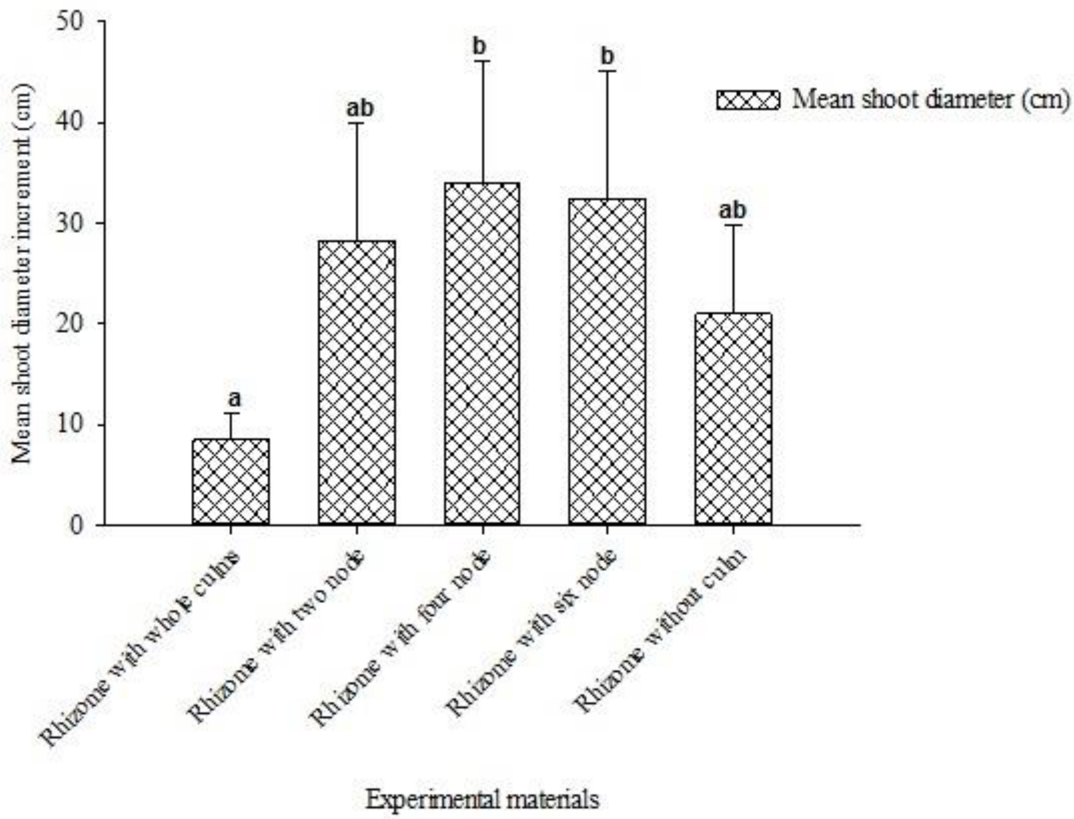

Figure 3. Root collar diameter of sprouted shoots in each propagation techniques.

Table 3. Effects of time on shoot diameter increments of propagules.

Year	Root collar diameter (mm)	
	Mean	**SEM**
0.5	118.91b	17.94
1	0.34a	0.2
1.5	12.96a	2.16

2	8.21a	1.84
2.5	14.54a	2.65
3	2.10a	1.49
3.5	16.59a	2.85

Numbers with the same letters are not statistically significant at 5% level of significance.
Note: SEM = Standard Error of Mean

There is a significant difference in the mean height growth of sprouted shoots between rhizome with four nodes and rhizome without culm. The highest mean shoots height growth was observed at rhizome with four, six and two nodes, respectively. Whereas least mean shoot height growth was recorded at rhizome without culm propagation technique (Table 4).

The time trend indicated that the highest mean shoot height growth was observed at the end of data collection period. Whereas the least mean shoot height growth was found at the first one year (Figure 4).

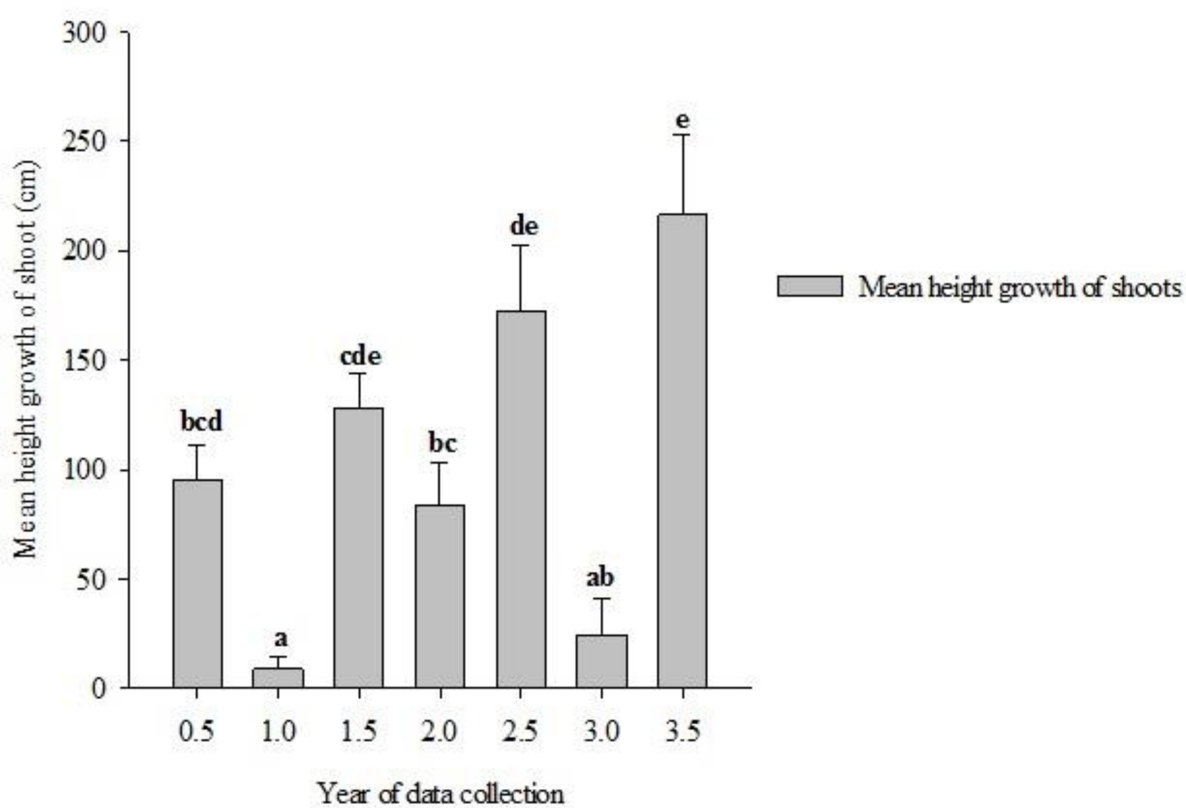

Figure 4. Mean height increment of the newly emerging shoots.

Table 4. Mean height growth of newly sprouted shoots.

Propagation techniques (treatment)	Height (cm)	
	Mean	**SEM**
Rhizome with whole culm (offset)	97.76ab	29.07
Rhizome with two nodes	99.81ab	20.39
Rhizome with four nodes	137.02b	22.94
Rhizome with six nodes	119.48ab	26.11
Rhizome without culms	67.1a	17.97

Numbers with the same letters are not statistically significant at 5% level of significance.
Note: SEM = Standard Error of Mean

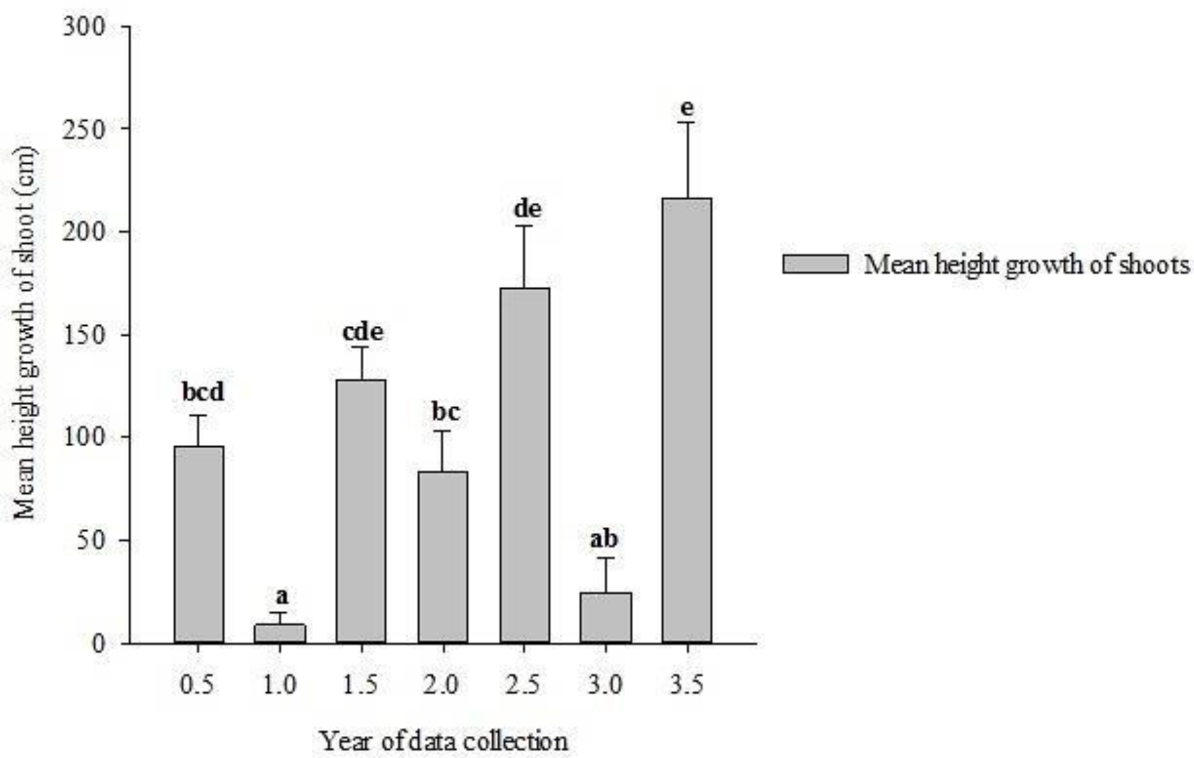

Figure 4. Mean height increment of the newly emerging shoots.

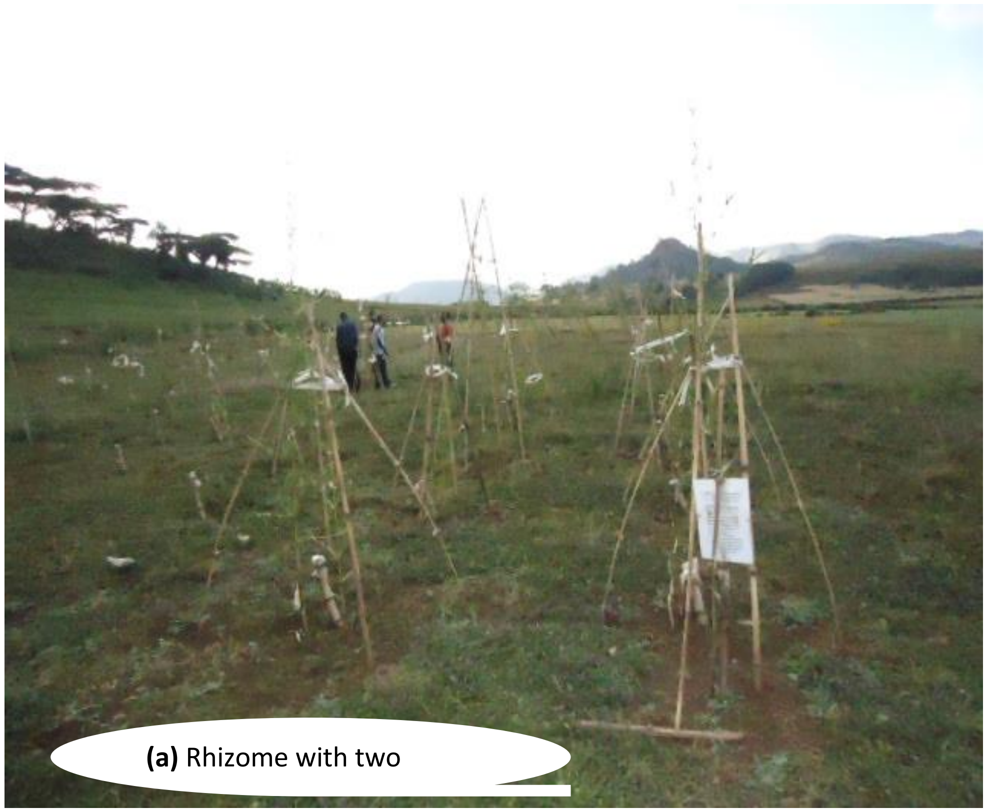

Figure 5. Planted propagation materials at the experimental station

Figure 6. Rhizome with four nodes sprouted shoots (2.5 years).

Figure 7. Rhizome with six nodes sprouted shoots (2.5 years old)

3. 3. Mortality rate of emerging shoots

There is a significant difference in the mean shoot mortality between the traditional offset and rhizome without culm propagules. The mean shoot mortality of the offset propagules is zero while the mean shoot mortality rate is higher at rhizome with six nodes. There is no significant difference in the mean shoot mortality between the other treatments (Table 6). The time trend shows that there is a significant difference in the mean shoot mortality between the offset and rhizome with two node propagules. There is no significant difference in the mean shoot mortality between other propagules (Figure 5). Temperature, moisture and other external factors affecting the survival rate of new emerging shoots (Batabyal and Tah, 2013). In addition, high shoot mortality rate at the 1st year might be related to moisture stress, termite problem and wind those hinder the survival rate of the shoot.

Table 6. The mean shoot mortality of highland bamboo propagules.

Propagation techniques (treatment)	Shoot mortality	
	Mean	**SEM**
Offset/Traditional (control)	0.00a	0.00
Rhizome with two nodes	1.19ab	0.48
Rhizome with four nodes	1.00ab	0.49
Rhizome with six nodes	0.14ab	0.10
Rhizome without culm	1.43b	0.82

Numbers with the same letters are not statistically significant at 5% level of significance.
Note: SEM = Standard Error of Mean

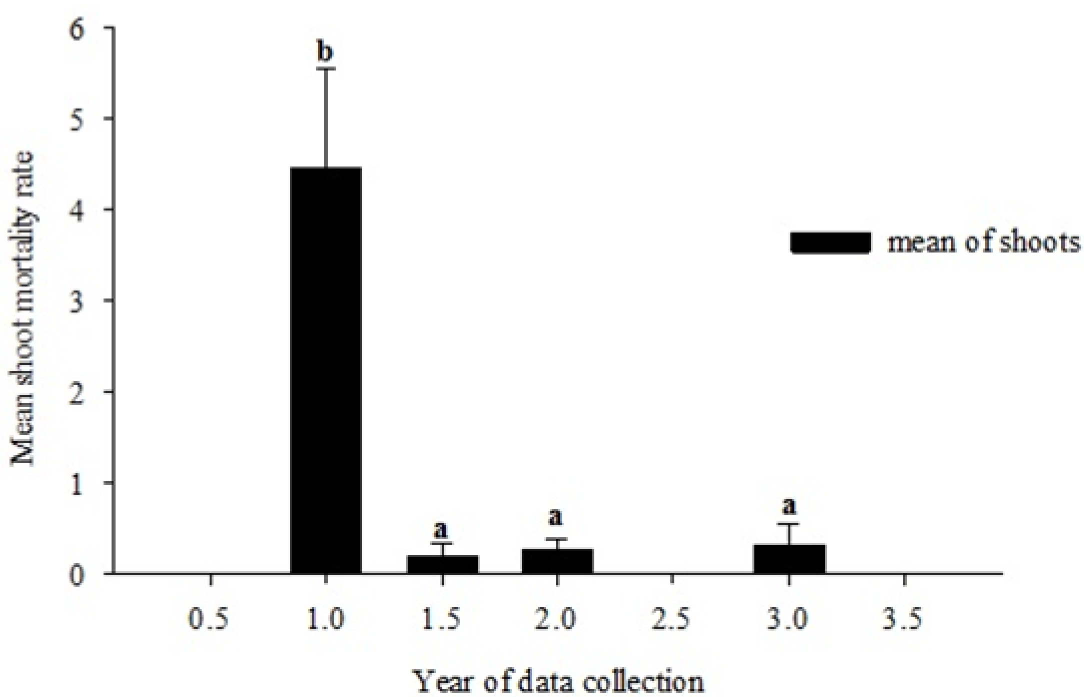

Figure 5. The effects of time on shoot mortality rate of emerging shoots.

4. CONCLUSION AND RECOMANDATIONS

Propagating by means of rhizome with whole culm is traditionally known old age methods for bamboo propagation. But it is mainly inappropriate for large scale plantation, due to labor intensiveness, time consuming, transportation and other logistical cost. The present finding showed that there is no difference among shoot sprout rate of each propagation material (treatment) whereas, season (dry and wet seasons) have been effects on the shoot sprout rate of each planting materials. On the other hand, the highest and the least shoot mortality was observed on rhizome without culm and off-set (rhizome with whole culm) respectively. In this result, planting materials of rhizome with four, six and two nodes foremost height growth were recorded, respectively.

The study revealed that rhizome with six nodes, rhizome with four nodes are best and better alternative means of Ethiopian highland bamboo (*Yushania alpina*) propagation for large scale as well as small scale plantation.

Bamboo is one of the most valuable plants nature has given to mankind. But to use its full potential, more fundamental research is needed, to lay foundations for the future bamboo expansion and existence in Ethiopia.

- One of the major challenges observed for shoot mortality in this experiment was termite infestation. So, further research has to be done with chemical treatment application together with, adding of different vegetative propagation techniques (branch and culm cutting, and layering).
- In Ethiopia bamboo spreading out by means of vegetative propagation (cutting) for huge scale industrial bamboo plantation expansion it is not sufficient methods. So, to enhance in large scale, better to further research has to be need on tissue culture protocol development.
- In this finding due to in sufficient watering, high shoot mortality rate was recorded in the first year of the experimental season. Therefore, better to be conduct additional research, by applying fully watering and tending operation at least in the first two planting years.

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