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Adaptation and Growth Performance of Different Introduced Lowland Bamboo Species in Central Tigray, Ethiopia

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Abstract

Aim of study: The study was performed to evaluate the growth performance and adaptation potential of different exotic lowland bamboos, as well as identifying and providing the best-performing species.

Area of study: The study was conducted in Agbe, Tanqua Melashe district Central Tigray between June 2018 and December 2021.

Material and methods: The study focused on six different exotic lowland bamboo species, which are *Dendrocalamus hamiltonii, Dendrocalamus asper, Dendrocalamus membranaceos, Bambusa vulgaris, Bambusa bambos,* and *Guadua amplexifolia*. The experiment was designed as a randomized complete block design (RCBD) with three replications. An analysis of variance was used to analyze the collected data.

Main results: The selected bamboo species somehow had problems with survival and adaptability except for *Bambusa bambos, Bambusa vulgaris, Dendrocalamus membranaceos*, and *Dendrocalamus hamiltonii* species. Between species' parameters, such as root collar diameter, culm diameter, culm height, and number of culms, the outcome had a significant difference at ($p<0.05$). The study revealed that *Bambusa bambos* and *Bambusa vulgaris* are well adapted and showed the highest mean values in all adaptation and growth parameters followed by *Dendrocalamus membranaceos* and *Dendrocalamus hamiltonii*.

Highlights: It is important to plant well adaptated and showed high growth performance of introduced lowland bamboo species in the study area. We advocate that *Bambusa bambos* and *Bambusa vulgaris* species with the best-performed growth and adaptation, followed by *Dendrocalamus membranaceos* and *Dendrocalamus hamiltonii* for further economic and livelihood benefits.

Keywords: Adaptation, Growth Performance, Exotic Lowland Bamboo, Central Tigray, Ethiopia

Orta Tigray, Etiyopya'da Tanıtılan Farklı Ova Bambu Türlerinin Adaptasyonu ve Büyüme Performansı

Öz

Çalışmanın amacı: Çalışma, farklı egzotik ova bambularının büyüme performansını ve adaptasyon potansiyelini değerlendirmek ve en iyi performans gösteren türleri belirlemek ve sağlamak için yapılmıştır.

Çalışma alanı: Çalışma Agbe, Tanqua Melashe ilçesi orta Tigray'de Haziran 2018 ile Aralık 2021 arasında yapılmışır.

Materyal ve yöntem: Çalışma, *Dendrocalamus hamiltonii, Dendrocalamus asper, Dendrocalamus membranaceos, Bambusa vulgaris, Bambusa bambos* ve *Guadua amplexifolia* olmak üzere altı farklı egzotik ova bambu türüne odaklanmıştır. Deneme, rastgele tam blok tasarımı (RCBD) göre üç tekrarlamalı olarak tasarlanmıştır. Toplanan verileri analiz etmek için varyans analizi kullanılmıştır.

Temel sonuçlar: Bambusa bambos, Bambusa vulgaris, Dendrocalamus membranaceos ve *Dendrocalamus hamiltonii* dışında seçilen bambu türleri bir şekilde hayatta kalma ve uyum sağlama sorunlarına sahiptir. Türlerin kök yaka çapı, kulm çapı, kulm yüksekliği ve kulm sayısı gibi parametreleri arasında, sonuç değerinde ($p<0.05$) önemli bir fark bulunmuştur. Çalışma, *Bambusa bambos* ve *Bambusa vulgaris*'in iyi adapte olduğunu ve tüm adaptasyon ve büyüme parametrelerinde en yüksek ortalama değerleri gösterdiğini, ardından *Dendrocalamus membranaceos* ve *Dendrocalamus hamiltonii*'nin geldiğini ortaya koymuştur.

Araştırma vurguları: Çalışma alanında tanıtılan ova bambu türlerinin iyi adapte olanların ve yüksek büyüme performansı gösterenlerin dikilmesi önemlidir. *Bambusa bambos ve Bambusa vulgaris* türlerinin en iyi büyüme ve adaptasyon performansına sahip olduğunu, ardından *Dendrocalamus membranaceos* ve *Dendrocalamus hamiltonii'*nin çalışma alanında bu türün ekimini genişleterek farklı paydaşlar için daha fazla ekonomik ve geçim kaynağı faydaları sağladığını savunmaktayız.

Anahtar Kelimeler: Adaptasyon, Büyüme Performansı, Egzotik Ova Bambu, Orta Tigray, Etiyopya

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Introduction

Bamboo is a perennial plant that is a member of the Poaceae family (Terefe et al., 2016), is the fastest-growing plant in the world, and is one of the most important non-timber forest resources used as a potential alternative to wood and wood products (Oumer et al., 2020). Bamboo is a multi-purpose plant (Diriba et al., 2019), with rapid regeneration capacity, and within the possibility of harvesting between 3-5 years afterplanting, which offers significant advantages over the other forest species (Oumer et al., 2020). The resources of bamboo are spread out in many countries all over the world , mostly in Asia, Africa, and Latin America (Terefe et al., 2019a). There are more than 1,500 species of bamboo, of which 43 are found in Africa. Ethiopia is one of the world's richest countries in terms of natural bamboo forest cover, estimated at 1.47 million hectares in the western and southern parts of the country (Diriba et al., 2019; Oumer et al., 2020), representing about 7% of the world's total and 67% of Africa's bamboo forest area (Terefe et al., 2016; Diriba et al., 2019).

Bamboos are one of the few selected categories of plants that are taxonomically related and are very rich in species. Bamboo has a considerable potential for socio-economic development, ecological importance, and environmental protection (Demelash et al., 2015; Terefe et al., 2019a). As a high-yielding renewable natural resource, bamboo is essential for agro-forestry and engineered products, as well as for the regeneration of polluted land (Diriba et al., 2019). Bamboo products for domestic and export markets contribute to generating income. It can also create employment opportunities for a significant part of society and take advantage of the problems of environmental degradation (Terefe et al., 2016). Bamboo forests are essential components of ecosystems that offer certain basic environmental functions. Bamboo can be used for house construction, furniture, pulp, particle board, medicine, animal feed, and human food as an agroforestry species (Demelash et al., 2015). It reduces water erosion on slopes and regulates water flows (Terefe et al., 2019a). Due to their special root resprouting regeneration strategy, bamboo forests offer significant potential for carbon sequestration mechanisms, water conservation, and soil protection (Terefe et al., 2019a). The bamboo's potential for water recharge and the mitigation of soil erosion can provide an opportunity for watershed development and the restoration of degraded areas (Oumer et al., 2020).

Adaptation includes both planned and unplanned adjustments of natural and human systems to respond to climatic changes and their resulting impacts. Adaptation measures can be used to reduce or avoid loss of forest cover, decline in forest productivity, alteration of ecosystem processes, and reduction in the environmental benefits that forests provide to people (Chris et al., 2012). Growth integrates resource competition among trees at the stand level and the appropriateness of the local environment (Patricia et al., 2014). The growth of the tree occurs in two ways. Growth from the roots and the tips of the shoots that results in an increase in height and length is called primary growth. The growth that increases the thickness of the stems and branches is referred to as secondary growth (Franklin & David, 2017). The variations among environmental factors may affect bamboo's growth, for instance, the emergence of bamboo shoots or culms, internode length, and diameter size (Aqmal et al., 2021). The growth that began in the shoot and root meristems accounts for all the increase in length of the tree axis at both stem and root tips. In addition, it is responsible for the formation of branches, leaves, lateral roots, and root hairs that are lateral appendages (Bello & Gada, 2015).

Nowadays, there is unselective forest loss and depletion, but the unique bamboo resource will appear before its economic and environmental benefits are appreciated, unless important reversal mechanisms can be put in place (Terefe et al., 2016). Ethiopia is a developing country that is trying to move beyond the world's middle-income countries. Particularly, the forest sector will alleviate poverty, create employment opportunities, and contribute to income generation when it provides services and products for domestic and foreign markets. According to Terefe et al. (2016), The Ethiopian Green Legacy's tree planting initiatives, which annually plant millions of tree seedlings, do not include bamboo. On the other hand, bamboo research and development activities in Ethiopia are limited. Yet some of the studies are: adaptability and growth performance of introduced Bamboo species in north East Ethiopia (Getachew et al., 2021). They observed that all selected bamboo species are adapted very well except *Denderocalamus brandisii*. At the same time, both *Bambusa balcooa* and *Bambusa tulda* are best performing introduced bamboo species for scaffolding, construction, ladder, paper/pulp, handicrafts and bamboo board material. Alemayehu et al., (2015) studied on growth performance and biomass accumulation of four different introduced bamboo species in south-western Ethiopia.They discovered that among the four species *Dendrocalamus hamiltonii* showed faster growth performance followed by *Dendrocalamus membranaceus*. From the selected four bamboo species *Dendrocalamus hamiltonii* showed the highest total biomass accumulation. Diriba et al., (2019) researched the adaptation and growth performance of lowland bamboo species in west Hararghe, Mechara on station. They found, all the selected bamboo species had no problem on survival and adaptability at study area. Moreover, *Dendrocalamus hamlitonii* species were showed highest performance followed by *Dendrocalmus Membracias* with growth parameters. Incontrary *Guadua amplexofolia* revealed lowest mean values in almost all growth parameters. Tinsae et al., (2018) examined the provenance variation on early survival rate and growth performance of *Oxytenanthera abyssinica* (A. Rich.) Munro seedlings at greenhouse. They observed that, pawe provenance had slightly higher survival rate (91%) than Sherkole provenance. In addition, biomass of leaves and culms was higher in Shekole provenance, while root biomass was exceeded by the Pawe provenance. Terefe et al., (2016) investigated the adaptation and growth performance of different lowland bamboo species in Bako, west Shoa, Ethiopia. They discovered that the selected bamboo species has no problem on survival and adaptability. Besides *Dendrocalamus hamlitonii* species has showed high difference and *Guadua amplexofolia* revealed low in all growth parameters.

In recent years, there has also been a growing interest in the ecological restoration of particularly degraded areas through reforestation and afforestation programs (Tinsae et al., 2018). In general, it is important to introduce and adopt the high economic value of exotic bamboo species in order to improve the income of smallholder farmers, diversify the genetic resources of bamboo species, and protect the environment in Ethiopia. Bamboo resources in natural habitats are declining due to overexploitation, mass flowering, shifting cultivation, and extensive forest fires (Alemayehu et al., 2015). In additoin deforestation and land degradation problems are serous issues in the stady area. All of this requires introducing different potential bamboo species from other parts of the world. The study aims to evaluate the growth performance and adaptation potential of different introduced exotic lowland bamboos, besides identifying and providing the best-performing species from those introduced exotic lowland bamboos in Agbe, Tanqua Melashe District, Central Tigray, Ethiopia.

Materials and Methods

Study Area

The study was carried out in Agbe, Tanqua Melashe district of Central Tigray. The area is located at 13º 33' N latitude and 39º 03' E longitude and 837 km away from Addis Ababa and 52 km from Mekelle. The altitude is 1650 m above sea level (Figure. 1). The mean annual rainfall is about 730 mm, with a peak in July and August, and the mean annual temperature is 20 ºC. (Figure. 2). The type of soil in the study area is stony sandy and sandy loam with a pH value between 6 and 8. Cereals, pullses,oilseeds, and vegitables are cultivated in Agbe. Similarlly, *Ziziphus mucronata*, *Terminalia macroptera*, *Cordia africana*, *Acacia abyssinica*, and *Eucalyptus* trees are major trees found in the study area.

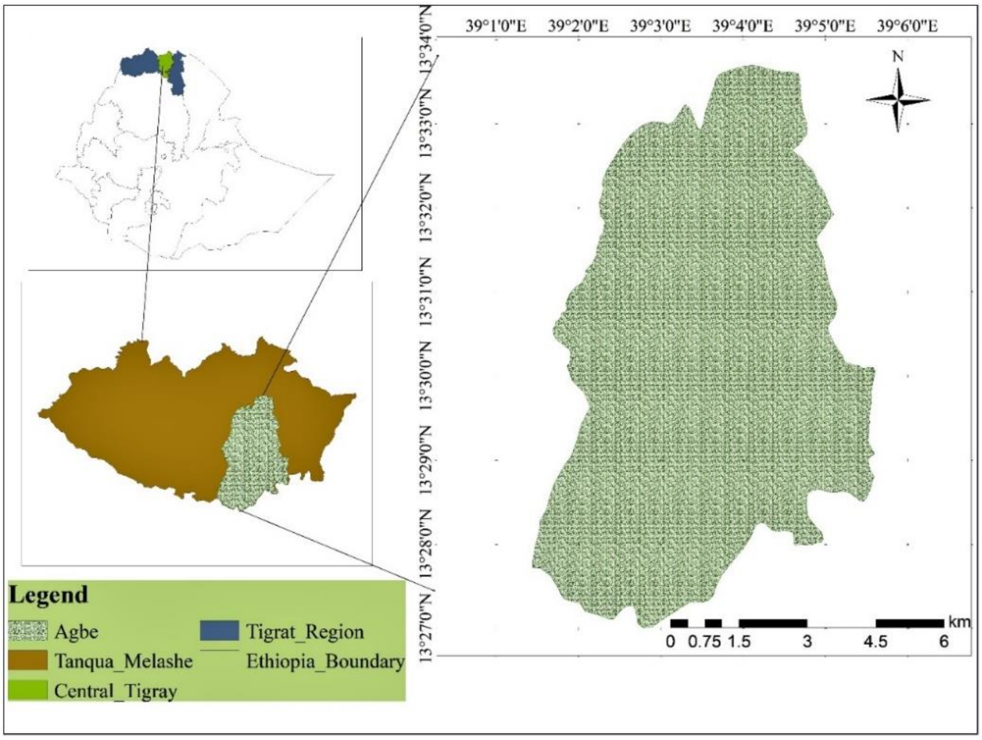

Figure 1. Location map of the study area

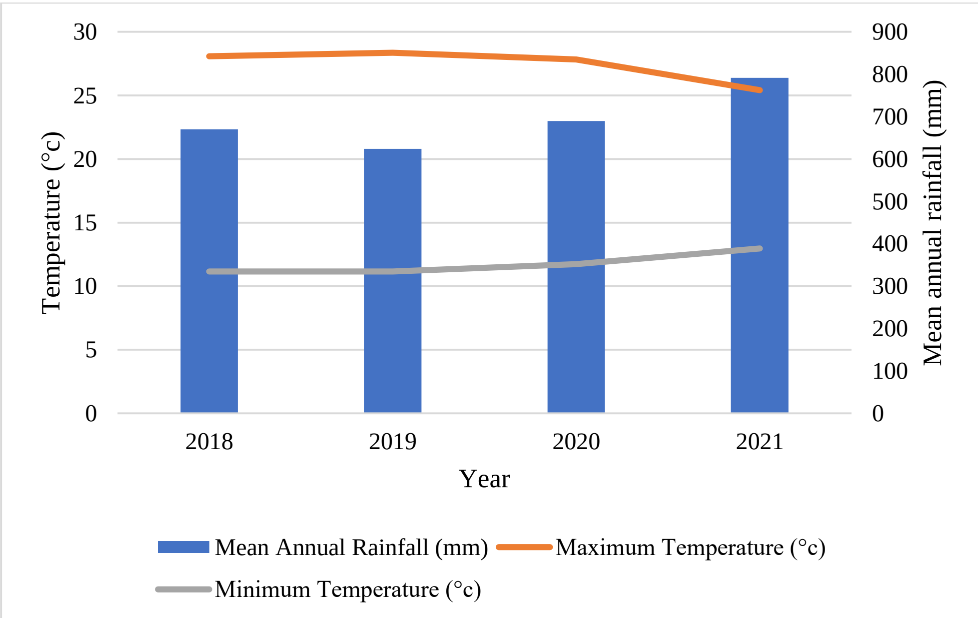

Figure 2. Mean annual rainfall (mm), maximum and minimum temperature (ºC) of the study area in between 2018-2021

Experimental Design

The experiment was designed as a randomized complete block design (RCBD) with three replications. The block was folded to accommodate the six treatments within fairly uniform soil conditions. The block size was 306 m^2. Six lowland bamboo species were used as treatments: *Dendrocalamus hamiltonii*, *Dendrocalamus asper*, *Dendrocalamus memebranaceos*, *Bambusa vulgaris*, *Bambusa bambos*, and *Guadua amplexofolia*. All treatments were assigned to all replications. The seddlings of each bamboo species were collected from Aksum nursery seddling site. The distance between the blocks and the plots was 4 m and 3 m, respectively. In addition, the plot size was 36 m^2, with a total of 4 seedlings per plot, and the distance between seedlings was 3 m.

Data Collection Method

To achieve the objective of the study, data were collected from the field between June 2018 and December 2021. To evaluate the growth performance and adaptation potential of exotic lowland bamboos, data like root collar diameter (RCD), culm diameter, culm height, and the number of culms were collected. The number of seedlings affected by insect pests and dead plants was considered during data collection. The data were collected every six months to see the changes among the species.

Data Analysis

Data such as root collar diameter (RCD), culm diameter, culm height, and the number of culms were subjected to analysis of variance (ANOVA), and means were compared by Least Significance Difference (LSD) Fisher Tests ($P \leq 0.05$) to test the difference among

bamboo species. In this study, the collected data were transformed, coded, and analyzed using the Statistical Package for the Social Sciences 26 (SPSS Inc., Chicago, IL, USA). In addition, the survival of each species was analyzed.

Results

Survival rate: the study's findings indicate that *Bambusa bambos survived 100 % followed by Dendrocalamus memebranaceus* and *Bambusa vulgaris, which accounted for 91.7 %. In addition, Dendrocalamus hamiltonii* survived 85 %. The least-surviving species were *Guadua amplexofolia* and *Dendrocalamus asper* with a 43.5 % and 45 % survival rate respectively (Figure. 3). In addition, the specified lowland bamboo species were not affected by any diseases or pests during the trial period in all blocks. The results revealed that *Bambusa bambos, Bambusa vulgaris, Dendrocalamus memebranaceus, and Dendrocalamus hamiltonii were the best-performing bamboo species among the other species.*

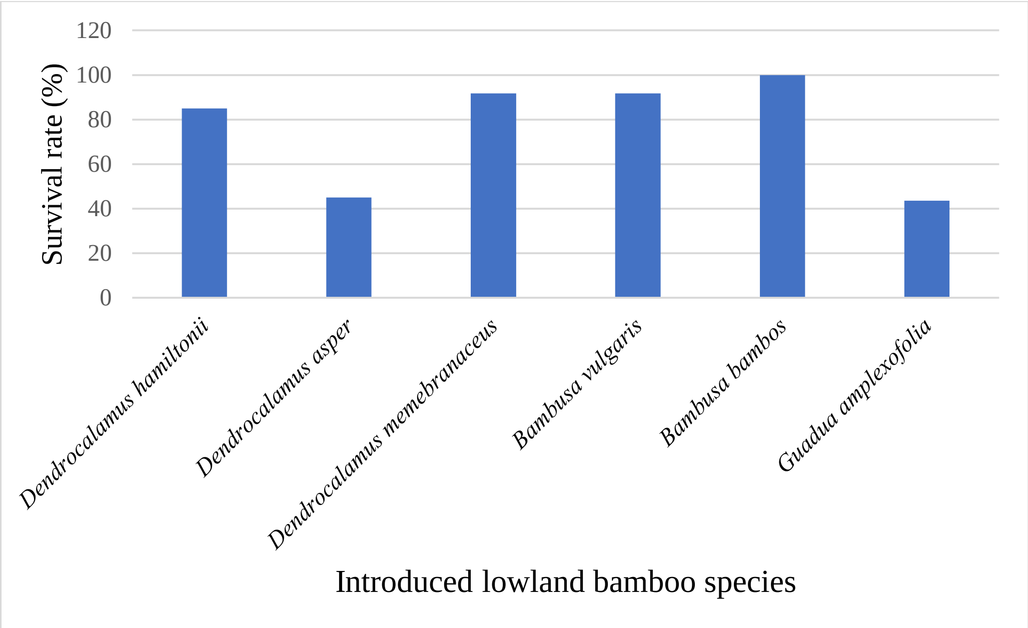

Figure 3. The survival rate of different exotic lowland bamboo species

Table 1. Mean comparisons between species based on the given parameters (Mean ± SE)

Treatments	Parameters			
	RCD (cm)	Culm diameter (cm)	Culm height (m)	No of Culms (In No.)
Dendrocalamus hamiltonii	1.02±0.42	0.83±0.07	0.64±0.07	2.49±0.35
Dendrocalamus asper	0.8±0.04	0.65±0.05	0.33±0.04	1.86±0.43
Dendrocalamus memebranaceus	1.07±0.13	0.86±0.07	0.96±0.09	4.81±0.5
Bambusa vulgaris	1.3±0.15	0.93±0.04	1.06±0.08	5.35±0.52
Bambusa bambos	2.34±0.17	0.96±0.04	1.28±0.07	5.73±0.21
Guadua amplexofolia	0.7±0.2	0.62±0.06	0.45±0.05	1.5±0.43
P value	0.007	0.001	0.001	0.001

* RCD: Root collar diameter in (cm)

Root Collar Diameter

The result showed that there is a significant difference between six species within root collar diameter. *Compared to the other species, Bambusa bambos had a maximum* root collar diameter *with a mean value of* 2.34±0.17 as compared to the other species. Besides *Bambusa vulgaris, Dendrocalamus memebranaceus, and Dendrocalamus hamiltonii* recorded 1.3±0.15, 1.07±0.13, and 1.02±0.42 average values respectively. While *Guadua amplexofolia* (0.7±0.2) and *Dendrocalamus asper* (0.8±0.04) showed the least mean root collar diameter (Table. 1). The present study revealed that *Bambusa bambos had a greater mean value than that of Bambusa vulgaris, Dendrocalamus memebranaceus, Dendrocalamus hamiltonii, Dendrocalamus asper,* and *Guadua amplexofolia* by 1%, 1.23%, 1.28, 1.5%, and 1.64% respectively. The mean value of root collar diameter showed a highly significant difference at the ($p<0.05$) level between a given species.

Culm Diameter

The result revealed that the highest mean value was recorded for Bambusa bambos and Bambusa vulgaris, 0.96±0.04 and 0.93±0.04 respectively, followed by Dendrocalamus memebranaceus with an average value of 0.86±0.07 and Dendrocalamus hamiltonii with a value of 0.83±0.07. The lowest average value was experienced from the other two species, *Guadua amplexofolia* and *Dendrocalamus asper,* with mean values of 0.62±0.06 and 0.65±0.05 respectively. *Bambusa bambos* mean is greater than that of *Bambusa vulgaris, Dendrocalamus memebranaceus, Dendrocalamus hamiltonii, Dendrocalamus asper,* and *Guadua amplexofolia* by 0.03%, 0.1%, 0.13%, 0.21%, and 0.34% respectively (Table. 1). This may be based on species growth performance and adaptability. The present study showed that the culm diameter results were significantly different between treatments at ($p<0.05$) level.

Culm Height

Bamboo culms are solid in the lower internodes and hollow from the upper half of the culm to the top of the culm. Based on the current study findings, the maximum culm height was attained by *Bambusa bambos (*1.28±0.07*) followed by Bambusa vulgaris (*1.06±0.08*). In addition, Dendrocalamus memebranaceus* and *Dendrocalamus hamiltonii* showed a mean value of 0.96±0.09 and 0.64±0.07 respectively. While *Dendrocalamus asper* (0.33±0.04) and *Guadua amplexofolia* (0.45±0.05) experienced the least mean value. The study found that the mean value of *Bambusa bambos was greater than that of Bambusa vulgaris, Dendrocalamus memebranaceus, Dendrocalamus hamiltonii, Guadua amplexofolia,* and *Dendrocalamus asper* by 0.22%, 0.32%, 0.64%, 0.83%, and 0.95%, respectively. The mean value of culm height showed a significant difference at ($p<0.05$) level between species (Table. 1).

Number of Culms

The mean value of the number of culms showed a significant difference at ($p<0.05$) level between treatments. Based on the study analysis result, Bambusa bambos (5.73±0.21) and Bambusa vulgaris (5.35±0.52) species revealed the highest mean value on the number of culms, followed by

Dendrocalamus memebranaceus and *Dendrocalamus hamlitonii* 4.81±0.5 and 2.49±0.35 respectively (Table. 1). The minimum mean value of the number of culms was recorded for *Guadua amplexofolia* (1.5±0.43) and *Dendrocalamus asper* (1.86±0.43). The study finding indicated that Bambusa bambos mean value was greater than that of Bambusa vulgaris, *Dendrocalamus memebranceous*, *Guadua amplexofolia, Dendrocalamus asper,* and *Dendrocalamus hamiltonii* by 0.38%, 0.92%, 2.73%, 3.17%, and 3.24% respectively.

Discussion

From figure 3, the survival rate of Bambusa bambos was 100 %, followed by Dendrocalamus memebranaceus and Bambusa vulgaris at 91.7 %. Similarly, Dendrocalamus hamiltonii have a survival rate of 85 %. Unfortunately, the lowest survival rate was obtained from *Guadua amplexofolia* and *Dendrocalamus asper* with a 43.5 % and 45 % survival rate respectively (Figure. 3). *In line with the study, Bambusa vulgaris grew by 86 % at* the Sabal Forest Reserve, Simunjan, Sarawak, Malaysia, between November 2019 and February 2021 *(*Hassan et al., 2022*).* The result for *Bambusa bambos is in agreement with* Kibwage et al., (2008) account for 94%. On the contrary, *Dendrocalamus memebranaceus*, *Dendrocalamus hamiltonii*, and *Guadua amplexofolia all* survived 100 % (Terefe et al., 2016). Similarly, *Dendrocalamus asper* survived 83% at the Kobo research site of the Sirinka Agricultural Research Center, Ethiopia (Getachew et al., 2021).

A three-year research study on different introduced lowland bamboo species observed a significantly higher mean in root collar diameter from *Bambusa bambos (2.3 cm) and Bambusa vulgaris (1.3 cm)* compared with the other introduced lowland bamboos. The other species, like *Dendrocalamus memebranaceus, Dendrocalamus hamiltonii, Dendrocalamus asper* and *Guadua amplexofolia,* showed 1.07, 1.02, 0.8 and 0.7 respectively (Table. 1). In line with this study, *Bambusa vulgaris with* growth regulators of honey, coconut water, and papain showed mean root collar diameters of 1.2737 cm, 1.0187 cm, and 0.892 cm, respectively; unfortunately, palm wine and control growth regulators *obtained* mean root collar diameters of 0.2397 cm and 0.15233 cm (Asinwa et al., 2021). Similarly, *Dendrocalamus memebranaceus* and *Dendrocalamus hamiltonii* has observed mean root collar diameters of 0.9 cm and 1.26 cm, respectively (Terefe et al., 2019b). On the contrary, the mean root collar diameter of *Dendrocalamus hamiltonii*, *Dendrocalamus memebranaceus*, and *Guadua amplexofolia* was recorded within 3.82 cm, 3.4 cm, and 2.93 cm, respectively (Diriba et al., 2019). According to Diriba et al. (2021), they obtained the same mean root collar diameter for *Dendrocalamus hamiltonii* with offset cut (7.3 cm), culm cut (5.3 cm), and branch cut (2.5 cm) planting as for *Dendrocalamus memebranaceus* with offset cut (8 cm), culm cut (3 cm), and branch cut (7.5 cm).

From the study findings, *Bambusa bambos (*0.96 cm*), Bambusa vulgaris (*0.93 cm*), Dendrocalamus memebranaceus* (0.86 cm), *Dendrocalamus hamiltonii* (0.83 cm), *Dendrocalamus asper* (0.65 cm) and *Guadua amplexofolia* (0.62 cm), showed statistically significant results for mean culm diameter (Table 1). In line with this study, the culm diameter of mature *Bambusa bambos has ranged between* 15 and 18 cm in diameter, that of *Bambusa vulgaris* is 5–10 cm, that of *Dendrocalamus hamiltonii is 10–18.5* cm, and that of *Dendrocalamus asper* is 20 cm (Salam & Pongen, 2008). Krishnakumar et al., (2017*)* reported that the three-year growth of *Bambusa bambos and Bambusa vulgaris has 3.91 cm and* 4.59 cm culm diameters, respectively. On the other hand, *the two* years of *Bambusa vulgaris has* 1.9 cm culm diameter (Alemayehu et al., 2015). *On the contrary, the highest mean culm diameters of* 2.178 cm, 3.44 cm, and 2.83 cm *were recorded for Dendrocalamus memebranaceus, Dendrocalamus hamiltonii,* and *Guadua amplexofolia,* respectively (Alemayehu et al., 2015). *From a three-year experiment,* Terefe et al. (2016) observed 2.53 cm, 2.01 cm, and 1.59 cm *of* mean culm diameter for *Dendrocalamus hamiltonii*, *Dendrocalamus memebranaceus*, and *Guadua amplexofolia, respectively.*

According to Getachew et al. (2021), *Dendrocalamus asper* after six years of establishment has a 2.27 cm culm diameter.

From the result, *Bambusa bambos (*1.28 m*), Bambusa vulgaris (*1.06 m), and *Dendrocalamus memebranaceus* (0.96 m) showed significantly higher culm heights than those of *Dendrocalamus hamiltonii* (0.64 m), *Guadua amplexofolia* (0.45 m), and *Dendrocalamus asper* (0.33 m) (Table. 1). A similar study states that the mean culm height varied from 0.7–2.7 m for two years of *Bambusa bambos* (Were et al., 2017). *On the contrary,* the mean culm height of *Bambusa bambos (4.16 m) and Bambusa vulgaris (6.1 m) at third-year growth performance (*Krishnakumar et al., 2017). In addition, the mean culm height varied from 2.8–6.5 m for *Bambusa vulgaris,* 1.7–5.2 m for *Dendrocalamus memebranaceus,* and 4.4–4.5 m for *Dendrocalamus asper,* respectively (Were et al., 2017). The mean culm height result is not in agreement with Terefe et al., (2016) for *Dendrocalamus hamiltonii* (2.88 m), *Dendrocalamus memebranaceus* (2.77 m), and *Guadua amplexofolia* (1.54 m) species. Other studies state that *Bambusa vulgaris, Dendrocalamus memebranaceus, Dendrocalamus hamiltonii,* and *Guadua amplexofolia has heights of* 6.77 m, 7.208 m, 10.58 m, and 3.16 m, respectively (Alemayehu et al., 2015).

*Bambusa bambos (*5.73*), Bambusa vulgaris (5.35), and Dendrocalamus memebranaceus* (4.81) showed significantly higher mean numbers of culms than *Dendrocalamus hamiltonii* (2.49), *Dendrocalamus asper* (1.86), and *Guadua amplexofolia* (1.5) (Table 1). Similarly, *Bambusa bambos exhibited a mean number of culms of* 5.93 for scenario 1, 9.86 for scenario 2, and 11.13 for scenario 3, respectively (Kumar et al., 2022). In line with this study, at the age of six years after establishment, *Dendrocalamus asper* has observed a 15.39 mean number of culms (Getachew et al., 2021). On the contrary, Krishnakumar et al. (2017) reported that the mean number of culms in the third year for *Bambusa bambos and Bambusa vulgaris was 14.7 and 19.25, respectively.* According to previous studies reported by Alemayehu et al., (2015), *Bambusa vulgaris (66) showed a higher number of culms than Dendrocalamus memebranaceus* (42), *Dendrocalamus hamiltonii* (26), and *Guadua amplexofolia* (7).

Conclusions

Bamboo is one of the fastest-growing species in the world compared to other trees and will start to produce a crop within three or four years of being planted. Bamboo responds well to drought, which can make the species more acceptable for creating an evergreen environment as well as conserving soil and water and rehabilitating degraded land (Terefe et al., 2016). Throughout this, it is important to initiate an adaptation potential and growth performance study on different introduced lowland bamboo species to meet our objective at Agbe, Tanqua Melashe District, Central Tigray, Ethiopia.

The study findings revealed that, Bambusa bambos, Bambusa vulgaris, Dendrocalamus memebranaceus, and Dendrocalamus hamiltonii are well adapted and showed the highest growth performance in root collar diameter (RCD), culm diameter, culm height, and number of culms. Unfortunately, *Guadua amplexofolia* and *Dendrocalamus asper* revealed low performance in all growth parameters. Therefore, on the basis of these results, we recommend *Bambusa bambos, Bambusa vulgaris, Dendrocalamus memebranaceus, and Dendrocalamus hamiltonii for environmental protection, water and soil conservation, and different products since they have a good quality of culms, the ability to adapt and grow easily, a large culm diameter, and a large culm height. On the contrary, the growth rates of Guadua amplexofolia* and *Dendrocalamus asper* are quite low when compared with other introduced lowland bamboo species. Watering is also important for early growth performance, at least for the first year. We advocate that *Bambusa bambos and Bambusa vulgaris* species with the best-performed growth and adaptation, followed by *Dendrocalamus memebranaceus and Dendrocalamus hamiltonii*, should be used for further economic and livelihood benefits to various stakeholders by expanding the plantation of these species in the study area.

Generally, it is better to work on the best-performing species for the intended objective as well as soil and water conservation purposes for degraded area rehabilitation.

Ethics Committee Approval

N/A

Peer-review

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Author Contributions

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Conflict of Interest

The authors declare that they have no competing interests.

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