

Research Article

Adaptation Trial of Bamboo Species in West Arsi Zone, Oromia Regional State, Ethiopia

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Abstract

Bamboo is the fastest growing perennial plant. Once the rhizome-root system is well established, new bamboo shoots attain full height and diameter within 2–3 months. Bamboo provides goods and services useful to mankind. It is a source for food, fodder, furniture, building materials, paper, particle board, energy, and medicine. Therefore the study was conducted to evaluate adaptation of six introduced bamboo species with local variety as control. Activity was conducted at Negele Arsi and Kofale districts. Among the introduced species four species namely *Dendrocalamus diannanensis*, *Dendrocalamus fuminesis*, *Dendrocalamus asper* and *Dendrocalamus yunnanis* were significantly different ($p < 0.5$) from the rest species in terms of height, DBH, RCD, Internodes length and number of nodes at Negele arsi. High survival rate was also recorded for those species. While at kofale district only four introduced bamboo species (*Dendrocalamus diannanensis*, *Dendrocalamus fuminesis*, *Dendrocalamus asper* and *Dendrocalamus yunnanis*) were survived and *Bambusa longinternode* and *Dendrocalamus barbatus* were completely damaged due to extreme low temperature. Therefore the study and observation made showed clearly that *Dendrocalamus diannanensis*, *Dendrocalamus fuminesis*, *Dendrocalamus asper* and *Dendrocalamus yunnanis* were the most adapted species to the study environment and must be popularized and scaled up in the study area for further production.

Keywords

Bamboo, Growth Performance, Survival Rate

1. Introduction

Bamboo is a woody perennial belonging to the family of grasses, Gramineae (Poaceae) with unique qualities [11]. It is a self-regenerating and renewable non-timber natural resource. Bamboo is a fast growing and self-sustaining species once established [2]. 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. Bamboos (*Poaceae – Bambusoideae*) presently native occur in every part of the world except Europe and Antarctica [10].

Bamboos are multipurpose plants of high economic and environmental value [8]. They grow fast and mature early. Once successfully planted, they keep on rhizoming, shooting and maturing every year. The annual selective cutting and sustainable utilization can be implemented without damaging ecolog-

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ical environment. Therefore, the development and exploitation of bamboo resources is considerably important. There is nearly one million hectares of bamboo forest in Ethiopia having a huge potential for economic development and environmental benefits. If this resource is managed and utilized effectively, over 12 billion Birr can be generated every year [6]. It is also commonly seen as an indication of a high ability to capture and sequester atmospheric carbon and consequently mitigate climate change, in a similar way that trees do. This report analyses the work carried out to date to explore different aspects of bamboo's growth, management and use which impact bamboo's carbon sequestration potential [5].

Despite its current and potential advantages for economic development and environmental benefits, bamboo resource of the country has been deprived of research attention so far. Up to now, only very few research activities have been done: vegetative propagation of highland bamboo [9]. Plantations of bamboo are needed to meet the increasing demand for raw material by industries, especially near Addis Ababa. There is a shortage of bamboo raw materials in some cities such as in Addis Ababa, Hawassa and Bahirdar and this raw materials from new plantations can ensure the growth of the industrial sector while providing income to local farmers [1]. *Dendrocalamus hamiltonii* and *Dendrocalamus membranaceus* are good potential bamboo species for cultivation in Ethiopia. Therefore the study focused on adaptation of six bamboo species in Nagele Arsi and Kofale district. In the study area there is a shortage of bamboo raw materials and the raw material brought from so far places. Therefore this research can address

shortage of raw material of bamboo and improve household income by identifying best adapted species of bamboo to the selected area. Therefore, the objectives of the activity is to evaluate, growth and survival of bamboo species at west Arsi Zone.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted in two different agro ecologies namely Kofale and Nagele Arsi Districts. Nagele Arsi district is situated at latitude of 7°09' N to 7°41' N and 38°25' E to 38°54' E and an altitude ranges from 1500 to 2300 meter above sea level (Figure 1). The average of rain fall ranges from 800 to 1400 mm with the average minimum and maximum of temperature is 15 °C and 20 °C respectively. The rainfall is bimodal, the long rain occurs from June to September and the short rain fall is from March to April with highest usually recorded in July and August, respectively (Figure 2). Agro ecology of Kofale is tepid to high land (91%) and Midland (9%). The elevation of the area ranges between 1040 - 3574 m asl. The mean annual temperature ranges from a minimum of 15 °C to an average annual maximum of 25 °C and the annual rainfall varies between 800-1200 mm and rainfall starts in June and ends in October [3]. The district has a total area of 32835 ha of which 9534.57 ha arable land, 7721 ha grazing land, and 4405.5 ha forestland [4].

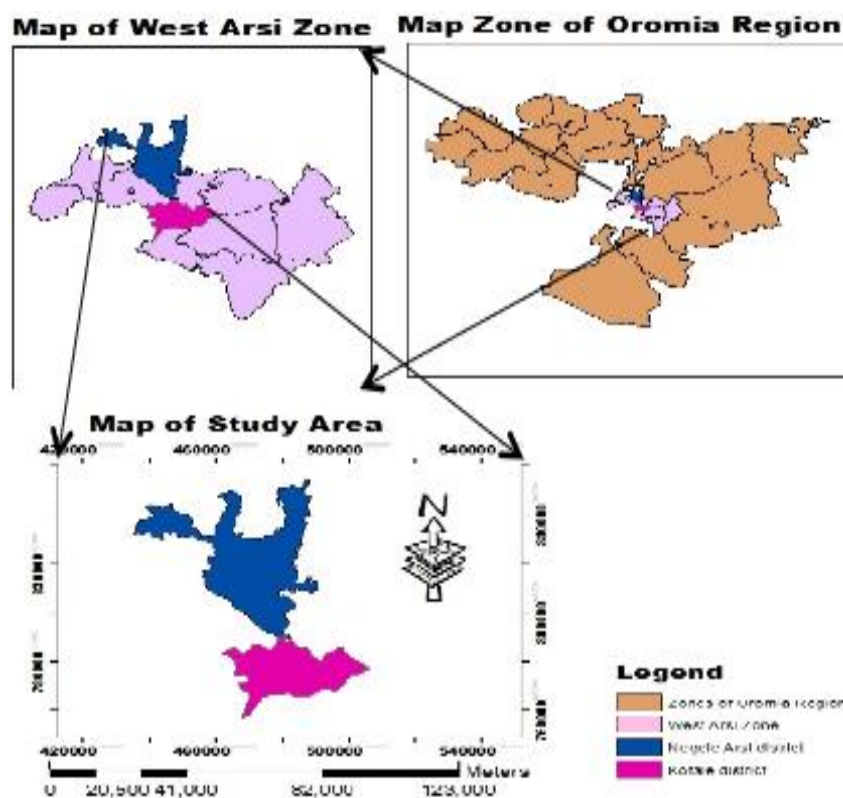


Figure 1. Map of study area.

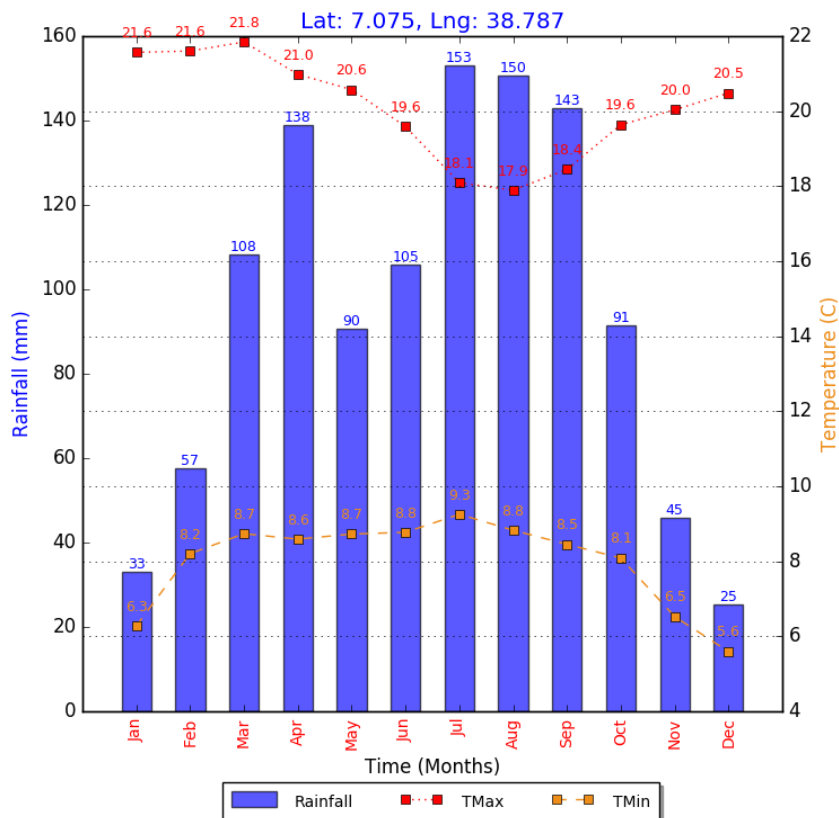


Figure 2. Mean monthly rain fall, mean maximum temperature (TMax) and mean minimum temperature (TMin) of Kofale.

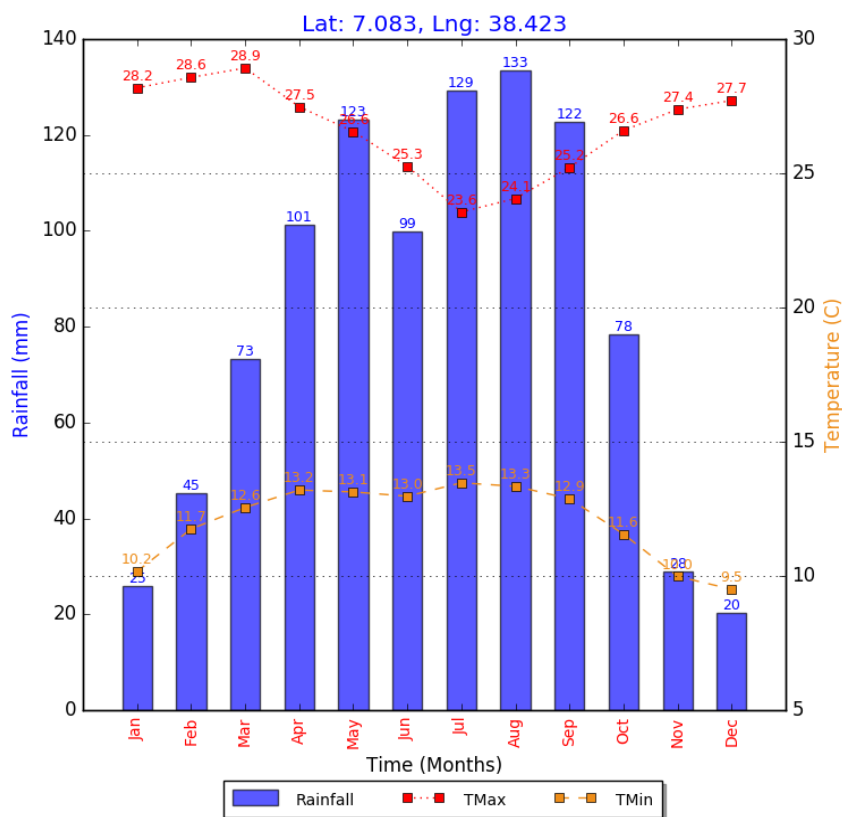


Figure 3. Mean monthly rainfall, mean maximum temperature (TMax) and mean minimum temperature (TMin) of Negele Arsi.

2.2. Experimental Design

Plantation was established to evaluate growth performance and adaptability of bamboo species (*Dendrocalamus diannanensis*, *Dendrocalamus fuminesis*, *Dendrocalamus asper*, *Dendrocalamus yunnanicus*, *Bambusa longinternode*, *Dendrocalamus Barbatus* and *Arundinaria alpina*) in 2020. Seedlings of this species was planted in 3 x 3 row and 9 plants were planted per plot, and the experiment was replicated 3 times. The experimental design was followed Completely Randomized Block Design (RCBD). Each plot was represented seven Bamboo species planted at distance of 3 x 3 m. Distances between plots and blocks was 3 m and 4 m respectively and the experiments was established on a total of 2106 m² land.

2.3. Data collection Methods

Data was collected every 3 months within its growth period to see its growth trend. Growth study measurements were taken from all culms and the average measurement was set for calculations. In general the following data was taken during the last four years: DBH, height, number of nodes, number of new emerging shoots, survival rate, root collar diameter and internodes length.

2.4. Data Analysis

Statistical analyses were carried out using General Linear Model (GLM) of GenStat version 15.1.0. All data was subjected to analysis of variance (ANOVA) using plot means. For means separation LSD was conducted at 5% probability level.

3. Result and Discussion

3.1. Survival Rate

Results showed that seedling survival rate was highest at Negelle arsi compared to kofale site where the two species (*Bambusa longinternode* and *Dendrocalamus Barbatus*) were showed the least survival rate which was all dead (0%) at kofale site. At Negelle site survival rate was 100% except for *Dendrocalamus diannanensis* and *Arundinaria alpina* which were 94.44% and 88.89% (Table 1) respectively. The two species *Bambusa longinternode* and *Dendrocalamus barbatus* were totally damaged due to extremely low temperature recorded during 2022.

Table 1. Mean survival percentage of the species at Negelle arsi and Kofale district.

Species name	Survival percentage (%)	
	Negelle Arsi	Kofale
<i>Dendrocalamus diannanensis</i>	94.44	94.44
<i>Dendrocalamus fuminesis</i>	100.00	100.00
<i>Dendrocalamus asper</i>	100.00	94.44
<i>Dendrocalamus yunnanis</i>	100.00	100.00
<i>Arundinaria alpina</i>	88.89	94.44
<i>Bambusa longinternode</i>	100.00	0
<i>Dendrocalamus barbatus</i>	100.00	0
Mean	97.62	96.66
CV	8.30	7.70
LCD	14.24	13.56
P value	Ns	Ns

CV = coefficient of variation,
LCD = least significant difference

3.2. Root Collar Diameter, DBH and Shoot Height at Negelle at Arsi

Growth parameters were showed statistically different

($p < 0.05$) in culm height, culm diameter at breast height, number of newly emerged culms, number of nodes, internode length and its root collar diameters among species (Table 2). There is a significant difference ($p < 0.05$) in the mean root collar diameter, DBH and Height increment between the species.

There is no significant difference between *Dendrocalamus diannanensis*, *Dendrocalamus fuminesis* and *Dendrocalamus asper* in DBH and RCD statistically. Although it is not significant statistically, *Dainasis* and *faminasis* are the more performing species and have numerical advantage compared to *Dendrocalamus asper*. *Bambusa longinternode* and *Dendrocalamus Barbatus* were the lowest performing species in both DBH and RCD. The first four species (*Dendrocalamus diannanensis*, *Dendrocalamus fuminesis*, *Dendrocalamus asper*

and *Dendrocalamus yunnanis*) were well performing species in the study area according to the result. Similar to the diameter growth the first four species were significantly ($p < 0.5$) higher than the remaining species in height. *Dendrocalamus diannanensis*, *Dendrocalamus fuminesis* and *Dendrocalamus yunnanis* were the most outstanding species in height compared to the rest species. Other studies said, different bamboo species were varies in height and has a range of 15.95-18.65 meter height in different district [7].

Table 2. Mean growth performance of Bamboo species at Negele Arsi.

Species name	DBH (mm)	RCD (mm)	H (cm)	No. nod	No. Culm	internode length (cm)	Average No. New shoot
<i>D. diannanensis</i>	51.17 ^a	68.97 ^a	1233.30 ^a	29.80 ^a	11.22	35.19 ^a	5.33
<i>D. fuminesis</i>	47.73 ^{ab}	68.14 ^a	1066.70 ^{ab}	24.17 ^{ab}	12.44	35.17 ^a	4.83 ^a
<i>D. asper</i>	43.18 ^{ab}	59.31 ^{ab}	850.00 ^b	17.00 ^{bc}	9.67	28.50 ^{abc}	5.22 ^a
<i>D. yunnanis</i>	40.99 ^b	50.02 ^{bc}	916.70 ^{ab}	27.17 ^a	9.67	29.92 ^{ab}	6.33 ^a
<i>A. alpina</i>	20.69 ^c	34.46 ^{cd}	510.00 ^{cd}	17.67 ^{bc}	11.89	23.54 ^{bcd}	2.00 ^b
<i>B. longinternode</i>	13.99 ^{cd}	28.93 ^d	375.00 ^d	15.17 ^c	16.44	19.17 ^{cd}	2.00 ^b
<i>D. Barbatus</i>	10.73 ^d	25.33 ^d	348.30 ^d	15.83 ^c	15.44	17.12 ^d	2.50 ^b
Mean	32.64	47.88	757.14	22.43	12.40	29.18	4.03
CV	16.70	20.00	28.00	19.90	32.90	20.80	28.30
LCD	9.53	16.76	371.19	7.29	7.15	9.80	2.00
P value	**	**	**	**	ns	**	**

DBH = diameter at breast height, RCD = root collar diameter H = height No. nod = number of nodes IntrNL = internodes length CV = coefficient of variation LCD = least significant difference

3.3. Mean Number of Node Number per Culm and Interned Length

There is a significant difference in the mean number of node per culm, and internode length between the species. The three species namely *Dendrocalamus diannanensis*, *Dendrocalamus fuminesis* and *Dendrocalamus yunnanis* were no significantly different in number of nodes per culm and interned length while the lowest number of nodes were recorded for *Bambusa longinternode*, *Dendrocalamus Barbatus* and *Arundinaria alpina*. Internode length of *Dendrocalamus diannanensis*, *Dendrocalamus*

fuminesis, *Dendrocalamus yunnanis* and *Dendrocalamus asper* (37.19 cm, 37.18 cm, 28.50 cm, and 29.92 cm) were significantly higher than the rest three species (Table 2). *Dendrocalamus diannanensis* and *Dendrocalamus fuminesis* showed the higher internod length Whereas least mean internod length was recorded for *Dendrocalamus Barbatus* (17.12 cm) and *Bambusa longinternode* (19.17 cm). There is also significant difference ($p < 0.05$) in newly emerging shoots among species. The first three species in (Table 2) have higher number of new shoots than the rest species. *Dendrocalamus yunnanis* and *Dendrocalamus asper* were recorded 6.33 and 5.33 new shoots respectively.

Table 3. Mean growth performance of Bamboo species at Kofale site.

Species name	DBH (mm)	RCD (mm)	Height (cm)	No. node	No. Culm	internode length (cm)	Average no. new shoot
<i>D. diannanensis</i>	28.14 ^a	45.56 ^{ab}	701.70 ^a	19.83	14.17 ^{ab}	30.47 ^a	4.83

Species name	DBH (mm)	RCD (mm)	Height (cm)	No. node	No. Culm	internode length (cm)	Average no. new shoot
<i>D. fuminesis</i>	22.89 ^{ab}	39.07 ^{ab}	613.74 ^{ab}	17.83	14.83 ^{ab}	29.50 ^a	4.67
<i>D. s asper</i>	20.48 ^{ab}	39.73 ^{ab}	558.27 ^{ab}	15.00	12.17 ^{ab}	30.53 ^a	2.83
<i>D. yunnanis</i>	21.96 ^{ab}	47.77 ^a	588.30 ^{ab}	19.67	8.33 ^b	27.00 ^{ab}	3.53
<i>A. alpina</i>	15.62 ^b	30.43 ^b	500.00 ^b	15.83	21.00 ^a	21.57 ^b	3.00
Mean	21.82	40.51	592.40	17.63	14.10	27.81	3.77
CV	20.50	21.80	18.40	18.90	22.70	7.40	39
LCD	8.14	16.04	198.47	6.07	5.82	3.77	2.67
P value	*	*	*	Ns	**	**	ns

DBH = diameter at breast height RCD = root collar diameter H = height No. nod = number of nodes IntrNL = internodes length
CV = coefficient of variation LCD = least significant difference

3.4. Root Collar Diameter, DBH and Shoot Height at Kofale Site

Similar to Negelle Arsi there was a significant difference ($p < 0.05$) in the mean root collar diameter, DBH and Height increment between the species at kofale site. Among the introduced species four bamboo species were significantly different from the local species in DBH, root collar diameters and height. Statistically significant difference among the introduced species were obtained (Table 3). However, statistically it is not significant difference between the two species i.e *Dendrocalamus diannanensis* and *Dendrocalamus fuminesis* were numerically greater than the rest three species. This indicates that the two species were more adapted at both sites and perform better than the other species. Introduced species were not only significantly different in DBH, but also showed higher root collar diameter and height. The highest value was opted from *Dendrocalamus diannanensis* and *Dendrocalamus fuminesis* in height (701.70 cm and 613.74) respectively.

3.5. Mean Number of Node, Number of Culm and Internodlength at Kofale Site

There was significant difference between the species in number of culm and internod length. Higher number of culm was recorded for local species and followed by *Dendrocalamus diannanensis* and *Dendrocalamus fuminesis* whereas number of nodes did not show significant difference. Introduced species were significantly ($P \leq 0.5$) different in internodlength from the *Arundinaria alpina* and *Dendrocalamus diannanensis*, *Dendrocalamus fuminesis* and *Dendrocalamus asper* had the longest internod length. At kofale site there is no significant difference in newly emerged shoots among species. However it is not significant statistically the higher num-

ber of new shoot was recorded for *Dendrocalamus diannanensis*, and *Dendrocalamus fuminesis*.

4. Conclusion

Among the species, *Dendrocalamus diannanensis*, *Dendrocalamus fuminesis*, *Dendrocalamus asper* and *Dendrocalamus yunnanis* were showed best performance with average DBH, root collar diameter, height, number of node, number of culm and internod length at both site. *Arundinaria alpina* had the greatest number of culms and showed lower performances in diameter of culms and height at both site. *Dendrocalamus diannanensis*, *Dendrocalamus fuminesis*, *Dendrocalamus asper* and *Dendrocalamus yunnanis* were the most performed species at nagele arsi and kofale site. Even though it is less performed at kofale district the species were better than the rest three species relatively at kofale site and the two species *Dendrocalamus Barbatus* and *Bambusa longinternode* were not tolerate low temperature and totally damaged during cool season at kofale site and survived at mid land environment of Nagelle Arsi according to the current findings, hence The study and observation made showed clearly that *Dendrocalamus diannanensis*, *Dendrocalamus fuminesis*, *Dendrocalamus asper* and *Dendrocalamus yunnanis* were the most adapted species to the study environment.

5. Recommendation

From the current findings *Dendrocalamus diannanensis*, *Dendrocalamus fuminesis*, *Dendrocalamus asper* and *Dendrocalamus yunnanis* must be popularized and scaled up in the study area for further production. Furthermore, research on adaptation of this species to similar agroecology is also recommended. It is also recommendable that strengthen research on utilization of this species for different purpose.

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Author Contributions

Desta Negeyo: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Conflicts of Interest

No conflict of interest.

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