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Table of Contents

Towards Bamboo Industry Development in Sarawak: Evaluation on Survivorship and Field Growth Attributes of Four Selected Bamboo Species

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INTRODUCTION

Bamboo is widely recognised as a highly renewable, fast-growing, and cost-effective raw material. It was traditionally used for making rafts that serve as an important medium of transportation and was used by the communities in agriculture, construction, arts and crafts, and furniture. Specifically, there are 50 species of bamboo in Peninsular Malaysia, 30 species in Sabah, and 20 species in Sarawak. Bamboo grows faster than any other plant in nature, with some species reaching 40 meters in height in just a few months while others can grow faster than one meter per day (Getachew et al., 2021). Sarawak Timber Industry Development Corporation (STIDC) was entrusted by Sarawak State Government to spearhead the development of the bamboo industry in Sarawak. By 2030, Sarawak aims to develop bamboo-based industries to produce food, charcoal, pharmaceutical, pulp and paper, cosmetics, textiles, handicrafts, and engineered bamboo products.

Economically, the bamboo industry has advanced significantly since 2015, when the country's total exports were USD 0.18 million, as opposed to USD 2.09 million in 2019. (INBAR, 2021). INBAR (2021) estimated the global bamboo and rattan sector with a trade value of USD 60 billion based on the current data available, with domestic commerce accounting for the majority of the revenue. The value of foreign exports of bamboo and rattan products in 2017 was USD 1.7 billion, according to data from the UN Comrade Database. This comprised conventional, handcrafted things, such as woven items, as well as numerous highly processed bamboo and rattan products, such as flooring, panels, and cladding. The majority of bamboo exporting countries are located in tropical and subtropical climates. The majority of bamboo-producing countries are found in Asia, including China. According to the customs data, China is the world leader in the trade of bamboo in 2018, with a value of USD 39 billion. However, a number of regions that do not produce bamboo also export a lot of bamboo goods. For example, bamboo goods are the second-largest export from the European Union (EU) worldwide. The EU imports bamboo raw materials and intermediate products from Asia, processes them, and then exports the high-value-added completed goods to other countries (Amir et al., 2020).

Since research on bamboo in Sarawak, Malaysia has received meagre attention and baseline information on the early survival rate and field growth attributes of bamboo are pivotal for the development of the Sarawak bamboo industry, there is an urgent need to evaluate the survival and field growth. Thus, a study to evaluate the survivorship and field growth attributes of a 3-year-old bamboo was conducted at the Sarawak Bamboo Pilot Project site in Sabal, Sarawak, Malaysia.

MATERIALS AND METHODS

Study area

The research was carried out at Block 8406B, Sabal Forest Reserve, Simunjan, Sarawak, Malaysia which is about 51 km Southeast of the Serian and at an elevation of more than 20 to 35 m above sea level (Figure 1). Study sites were established at bamboo plantation areas with four different Sarawak local species of bamboo, namely *Bambusa vulgaris* (Buluh minyak), *Gigantochloa levis* (Buluh beting), *Gigantochloa hasskarliana* (Buluh beti), and *Dendrocalamus asper* (Buluh betong). From 2011 to 2020, the study site received 4,134.7 mm of rain annually (Meteorological Department, 2021). The monthly mean air temperature and relative humidity were 26.9°C and 84.1%, respectively (Meteorological Department, 2021).

Planting materials, preparation of growing medium and propagation methods

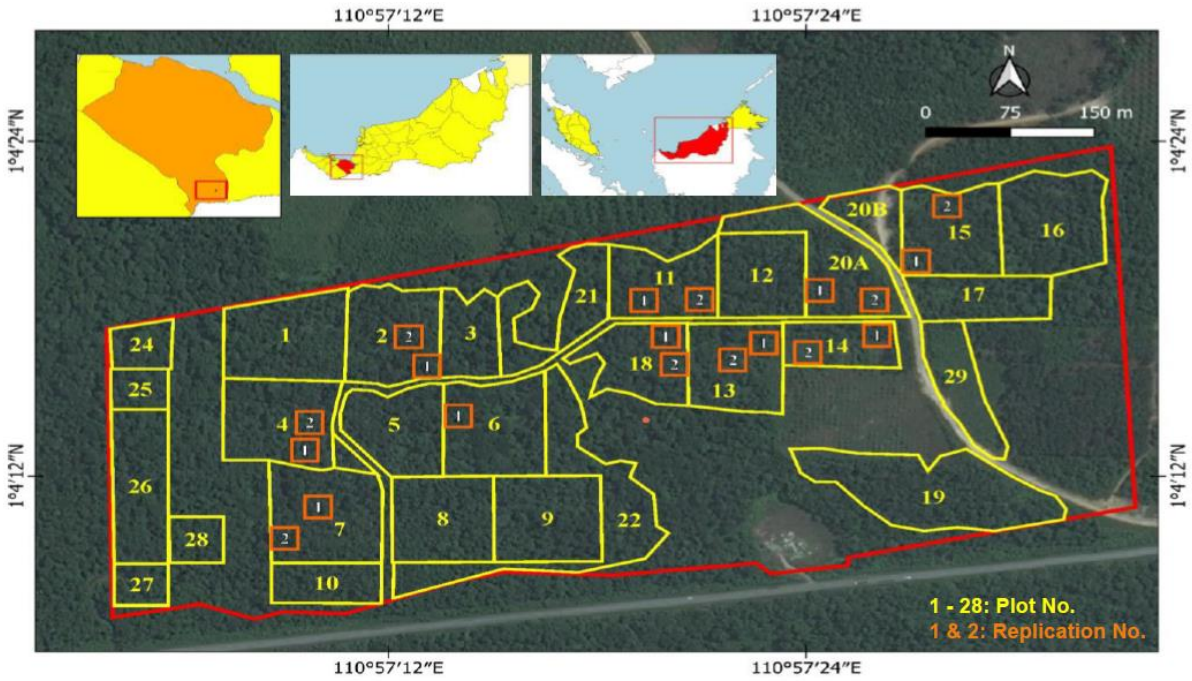
All the bamboo seedlings used in this study originated from Sarawak. The local bamboo was produced from branch cuttings of the mother plant except for *G. hasskarliana*, which was produced from the cuttings of rhizomes. For seedling production in the nursery, topsoil and river sand were mixed in a volumetric ratio of 1:1. The seedlings were transplanted in the field four months later. Fertilisation was performed three times per year at each of the plots following planting. During the early stages of planting, an inorganic fertiliser (NPK) was applied. After three months, organic fertiliser (chicken manure) was applied to the planted bamboo until it reached two years old, or until the bamboo growth conditions in the plantation area were improved. The planted bamboo species were properly maintained during the growth stage.

Survival rate and field growth assessment

Study sites with the size of 20 m x 20 m (two replications) with 5 m x 5 m planting distance for each bamboo species (Plot No. 2, 11, 13, and 14) were established. Survival rate and field growth attribute in terms of the number of culms per clump, number of new shoots, culm diameter, culm height, mean annual increments of diameter (MAID), and height (MAIH) were measured and quantified quarterly in the year of 2021. Two replications for each bamboo species involving 50 readings (25 readings for each replication) were evaluated. The culm diameter and height were measured using a digital caliper and Vertex Haglof Transponder. The MAID and MAIH were calculated based on the mean values of the seedling diameter and height of the assessed bamboo seedlings with the stand age of the experimental plot.

Data analysis

The data on the outplanted seedlings were analysed using a one-way analysis of variance (ANOVA). Scheffe's multiple comparison tests were employed to find statistically significant differences between means when the ANOVA was significant. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) (IBM, version 24.0 for Windows) (Copyright: SPSS Inc., 2016).



(Source: Mohd Hassan et al. 2022)

Figure 1. Segregation between different bamboo species at STIDC Bamboo Pilot Project area in Sabal Forest Reserve, Simunjan, Sarawak, Malaysia.

RESULTS AND DISCUSSION

Survival rate and field growth attributes

The percentage of survival rate for planted bamboo species are shown in Figure 2a. The result shows that the survival rate was at 70% and above across all the bamboo species. In November 2021, the highest mean survival rate (88%) was from *G. levis* and the lowest mean survival rate (70%) was from *G. hasskarliana*. Meanwhile, in terms of mean numbers of culms per clump, *G. hasskarliana* depicted the greatest number with 91 culms, followed by *G. levis* with 24 culms, *D. asper* with 17 culms, and *B. vulgaris* with 14 culms (Figure 2b). Based on Figure 2c, in November 2021, the mean number of new shoots for *G. hasskarliana* recorded the highest with 3 shoots as compared to other bamboo species. However, the lowest mean culm diameter was observed in *G. levis* with 2.66 cm and the highest mean culm diameter was observed in *B. vulgaris* with 4.51 cm (Figure 2d). Notwithstanding, *B. vulgaris* remained with the greatest mean culm height of 12.6 m and *G. levis* with the lowest mean culm height of 7.72 m (Figure 2e). Meanwhile, for MAID and MAIH, *B. vulgaris* was significantly higher than that of the other species with 1.69 cm year^{-1} and 4.72 m year^{-1}, respectively (Figures 2f and 2g).

The survival rate percentage is crucial in order to understand the mechanisms that affect the dynamics of the bamboo population and vital to effectively manage the population and its habitat. In general, the survival rate of different bamboo species in this study is moderately high with approximately ≥ 70%. In Kenya, a study reported by Were et al. (2017) mentioned that five bamboo species (*B. blumeana*, *B. bambos*, *B. vulgaris*, *D. asper*, and *D. membranaceus*) showed a survival rate of 100% under the prevailing conditions of the tannery soils, except for *D. birmanicus*. The quantity of culms per clump depended on a variety of internal and external conditions. The plant's origin, species, and robust system were internal variables. The type of fertiliser utilised, the slashing methods, and other maintenance schedules for the plantations were all external variables. Our findings show that generally the early growth of culms for all the

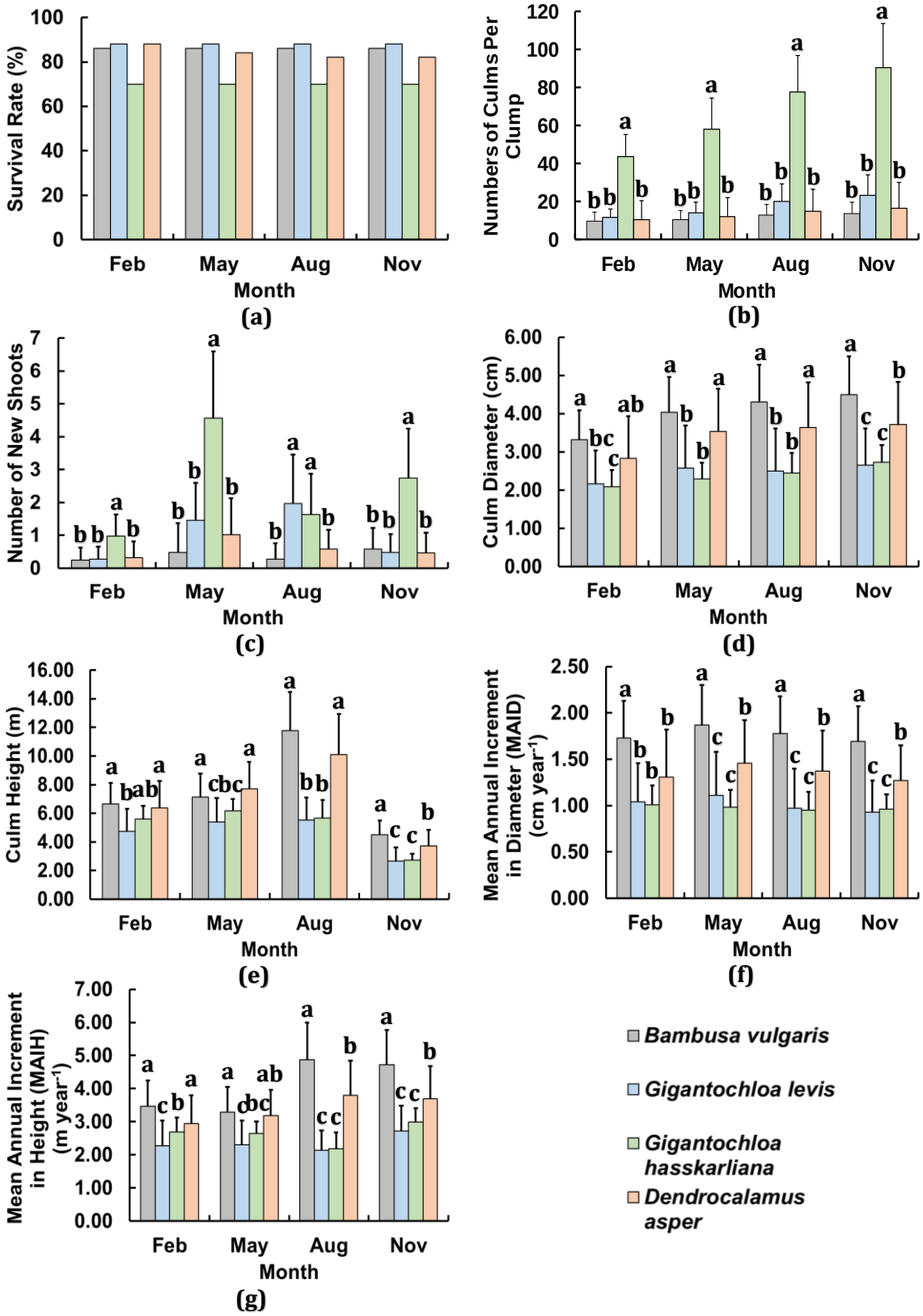


Figure 2. (a) Survival rate; (b) numbers of culms per clump; (c) number of new shoots; (d) culm diameter; (e) culm height; (f) mean annual increment in diameter (MAID); (g) mean annual increment in height (MAIH) among different bamboo species. Bars are means and error bars are standard deviations. Bars with different letters are significantly different at 5% level using Scheffe's multiple comparison test.

species were within the range of results. According to study by Krishnakumar et al. (2017), in the first year (6.46), second year (13.00), third year (19.34), fourth year (26.05), and fifth year (25.05), *B. balcooa* demonstrated its superiority over *B. vulgaris* by generating the most culms (32.37). Understanding which bamboo species are the most active in terms of bamboo growth requires careful observation of the bamboo shoots' production. The first bamboo products that can be sold to the food industry are young bamboo shoots. When the shoots are not picked, they mature into bamboo culms, which alters how bamboo is used in other industries like furniture and charcoal production. In this study, *G. hasskarliana* revealed an active shoot growth in comparison to other bamboo species. On the other hand, field growth attributes in terms of the MAID and MAIH, *B. vulgaris* portrayed the highest increment in growth. It can be deduced that this potential species could be recommended to be planted for larger scale operations towards the development of bamboo industry in Sarawak, Malaysia. According to a previous study by Mohd Hassan et al. (2022) at Sabal Forest Reserve, *B. balcooa* depicted the highest growth increment in diameter and height with 1.84 cm year^{-1} and 4.35 m year^{-1}, respectively.

CONCLUSION

Different bamboo species have different growth pattern in terms of survival rate and field growth attributes. *B. vulgaris* clearly showed the fastest MAID and MAIH growth as compared to other Sarawak bamboo species in this study. The scientific information and findings from this study would be beneficial as guidelines for bamboo industry players, managers, nursery practitioners, and policymakers to initiate and undertake the development of the bamboo industry, mainly in Sarawak. It is recommended that, particularly in Sarawak, a long-term monitoring period is required to build a commercial bamboo industry plantation project. However, more thorough research is needed to identify the edaphic elements that can affect the survival and growth performance of planted bamboo in Sarawak using the line planting approach.

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