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Study on the current status of bamboo shoots extraction from natural bamboo forests in Pyinmana Township and identification of sustainable bamboo shoot extraction method

Aung Zaw Moe, Research Officer
Phyu Phyu Hnin, Assistant Research Officer
Chan Nyein Ko Ko, Research Assistant -3
Forest Department

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Aung Zaw Moe (Research Officer),
Phyu Phyu Hnin (Assistant Research Officer),
Chan Nyein Ko Ko (Research Assistant-3)
Forest Research Institute, Forest Department

Abstract

In Nay Pyi Taw area, we observed that there are five kinds of bamboo shoot production in domestic market such as fresh shoots, dried shoots, steamed shoots, salted water-soaked shoot, fermented shoots, pickled bamboo shoot. Fermented bamboo shoot is one of the famous local products of Nay Pyi Taw. In this research, we focused on two bamboo species of *Bambusa ploymorpha* and *Dendrocalamus brandisii* which were made the famous local products as fermented bamboo shoot. In Myanmar, bamboo shoot consumption is estimated at 47,300 tons per year, with 70 percent of consumption in rural areas and 30 percent in urban markets (Myanmar survey research, 2006). Current bamboo shoot production potential around Naypyitaw is estimated that 685.83-775.64 tons per year which were harvested from natural forests during the rainy season especially in peat period of June to August. The number of new bamboo shoots emerging in one clump per growing season varies significantly based on species produced between 5 to 10+ new shoots per year. In the study area, there were mainly 3 bamboo species naturally grow in the natural forest of east of Pyinmana namely *Bambusa ploymorpha, Cephalostachyum pergracile* and *Dendrocalamus brandisii*. Assessment of the proportion of bamboo clump of these bamboo species in sample plots were found 26%, 35% and 39% and number of clumps per acre were 18, 24 and 27 respectively. In this study, A factorial experiment with four level of bamboo shoots harvesting intensity (Unit A 25%, Unit B 50%, Unit C 75% and Unit D 100%) and we assessed the successive year new bamboo shoot productivity by effect of different harvesting intensities. Among different units, bamboo shoot harvesting intensity of unit B and unit C were sustain for both shoot and culm. Young culm of one-year age can produce new shoot and sometimes two-year age in the following years should never harvested. For that reason, unit D 100% bamboo shoot harvesting level is not perfect for in sustain resource management, it may decrease the productivity of new shoot in successive year.

Keywords: *bamboo shoot, bamboo clump, bamboo culm, Bambusa polymorpha, Debdrocalamus brandisii, harvesting intensity*

ပျဉ်းမနားမြို့နယ်တွင်းရှိ သဘာဝဝါးတောများမှ မျှစ်ထုတ်ယူမှု အခြေအနေအား လေ့လာဆန်းစစ်ခြင်းနှင့် ရေရှည်တည်တံ့စေမည့် မျှစ်ထုတ်ယူမှုနည်းစနစ်အား လေ့လာဖော်ထုတ်ခြင်း

အောင်ဇော်မိုး (သုတေသနအရာရှိ)
ဖြူဖြူနွင်း (လက်ထောက်သုတေသနအရာရှိ)
ချမ်းငြိမ်းကိုကို (သုတေသနလက်ထောက်-၃)
သစ်တောသုတေသနဌာနခွဲ၊ သစ်တောဦးစီးဌာန

စာတမ်းအကျဉ်း

မြန်မာနိုင်ငံတွင် မျှစ်စားသုံးမှုမှာ တစ်နှစ်လျှင် တန်ချိန် ၄၇၃၀၀ ခန့်ရှိပြီး ကျေးလက်ဒေသစားသုံးမှု ၇၀ ရာခိုင်နှုန်းနှင့် မြို့ပြဈေးကွက်တွင်၃၀ရာခိုင်နှုန်းရှိပါသည်။ (မြန်မာ့စစ်တမ်းသုတေသန၊ ၂၀၀၆)။ သုတေသနပြုချက်အရ နေပြည်တော်အနီးတဝိုက်ဒေသများမှ တစ်နှစ်လျှင် မျှစ်ကုန်ကြမ်း ၆၈၅.၈၃ - ၇၇၅.၆၄ တန် ခုတ်သိမ်းစုဆောင်းနိုင်ကြောင်း တွေ့ရှိရပါသည်။ မျှစ်ခုတ်ယူ စုဆောင်းခြင်းကို မိုးရာသီကာလအတွင်း သဘာဝတောများမှ ရိတ်သိမ်းပြီး အထူးသဖြင့်မျှစ်လှိုင်လှိုင်ထွက်သည့်ဇွန်လမှဩဂုတ်လအထိ(၂)လခန့်စုဆောင်းလေ့ရှိပါသည်။ မျှစ်စို့ထွက်သည့် ကာလအတွင်း ဝါးမျိုးစိတ်အပေါ်မူတည်၍ တစ်နှစ်လျှင် ဝါးတစ်ရုံမှ မျှစ်နုအသစ် ၅မှ ၁၀+ ကြားထွက်လေ့ရှိကြောင်း တွေ့ရှိရပါသည်။ ပျဉ်းမနားအရှေ့ဘက် သဘာဝတောများတွင်ကျသောင်းဝါး၊ တင်းဝါးနှင့်ကျလို့ဝါးမျိုးစိတ် (၃)မျိုးသဘာဝအလျောက် ပေါက်ရောက်ကြောင်း တွေ့ရှိရပြီး၊ နမူနာကွက်များတွင် ဝါးမျိုးစိတ် (၃) မျိုး၏ ဝါးရုံပါဝင်မှု အချိုးအစားကို အကဲဖြတ်ရာတွင် ၂၆ ရာခိုင်နှုန်း၊ ၃၅ ရာခိုင်နှုန်းနှင့် ၃၉ ရာခိုင်နှုန်းအသီးသီးနှင့် တစ်ဧကပျမ်းမျှ ဝါးရုံ ပါဝင်မှု အရေအတွက်မှာ ၁၈၊ ၂၄နှင့် ၂၇အသီးသီးရှိကြောင်း တွေ့ရှိရပါသည်။ ဤသုတေသနအတွက် နေပြည်တော်ဒေသ၌ အဓိကမျှစ်ချဉ်ပြုလုပ်ရာတွင် အသုံးပြုသည့် ကျသောင်းဝါးနှင့်ကျလို့ဝါးမျိုး (၂)မျိုးကိုသာ ရွေးချယ်သုတေသနပြုခြင်းဆောင်ရွက်ခဲ့ပါသည်။ ဤလေ့လာမှုတွင် မတူညီသည့် မျှစ်ရိတ်သိမ်းမှုအချိုးအစား (၄)မျိုး(ယူနစ်A25%, Unit B 50%, Unit C 75% နှင့် Unit D 100%) တို့၏ အကျိုးသက်ရောက်မှုကြောင့် နောက်တစ်နှစ်တွင် မျှစ်နုသစ်များ၏ ထွက်ရှိမှု အခြေအနေအား အကဲဖြတ်ခဲ့ရာ ယူနစ် B နှင့် ယူနစ် C တို့သည် စဉ်ဆက်မပြတ် မျှစ်နှင့်ဝါး ဖွံ့ဖြိုးမှုကိုဖြစ်စေပြီး၊ ထွက်ရှိလာသည့် မျှစ်အရေအတွက်အားလုံး ရိတ်သိမ်းမှု ယူနစ် D 100% အဆင့်သည် နောင်နှစ်များအတွက် ဝါးနုဖြစ်ထွန်းမှု မရှိနိုင်သဖြင့် ရေရှည်တည်တံ့သော ဝါးအရင်းအမြစ်စီမံခန့်ခွဲမှု အတွက်ပြီးပြည့်စုံမှုမရှိကြောင်း တွေ့ရှိရပါ သည်။

Study on the current status of bamboo shoots extraction from natural bamboo forests in Pyinmana Township and identification of sustainable bamboo shoot extraction method

1. Introduction

Bamboos are perennial plants belonging to the subfamily *Bambusoides* of the *Poaceae* family is widely distributed in tropical, subtropical, and sometimes temperate regions. (Cheng et. Al., 2023). Current knowledge listed as many as 75 genera and 1,250 species of bamboos distributed within its natural zones (Sharma, 1979; Htun & Doo, 1984; INBAR & IPGRI, 1994a, 1994b; Aung Zaw Moe, 2002). Wong (1995) estimated 1,200 – 1,500 bamboo species existed. Tropical Asia which is considered as the center of bamboo diversity has as many as 45 genera and 750 species, out of which Myanmar is endowed with about 21 genera and 102 species (Kress et.al. 2003). Bamboo shoots and culms always share a major part of the households of the rural people for their annual expenditure.

Bamboos have been used as a building material (INBAR 2003), for bio-mass based energy (Ha-tuong and Thi, 2015), food (Nongdam and Tikendfa, 2014), furniture, pulp, particle board, forage and medicine (Kelecha, 1980; Embaye et. al., 2003).

The age of an individual culm is not related to clump age, as they sprout every year from the rhizome, which may be older in years. Culms are tender during the first year. They grow tough during the second year and are hard and mature in the third year, when they acquire full density and strength. After this age they start changing color. The age of a culm for harvesting is difficult to determine. Generally, culms that are 3 – 5 years old are considered "mature" (Liese, 1985). However, presence or absence of culm sheaths and nodal rooting, bud break and branching pattern, and color of culm are diagnostic morphological characters for determining the age of culms (Banik, 1993 b). The age of culm should be determined for various utilization and selected culm felling in management of bamboo forest.

Sustainable bamboo forest management can be influenced by the harvesting season, quantity of harvested mature culms and harvesting design (Wu, 2019; Mulatu et. al., 2016). Thinning of dead, damaged and defective culms enhances productivity and sustainable management by providing space for newly sprouted shoot (Mulatu and Masresha, 2013). Improper harvesting of culms within individual clumps, has degraded the productivity of bamboo forest. For example, harvesting young (one to two year) culms reduces the emergence of shoot and their growth to new culms in the following years (Suwannapinum, 1990). Young shoots generate on the rhizome bud of one- to two-year-old culms (Malab et. al., 2009). Only 3 year and above mature culms should be harvested if the effect of harvesting on the remaining culms is to be minimized (Banik, 2015).

Young culms of age one and two which produce new shoot in the following years should never be harvested and it may decrease the sprouting new shoots following years (Kleinhenz and Midmore, 2001). However, no study has yet been conducted to assess the effect of harvesting intensity of new shoots for sustainable shoot and culm productivity in Myanmar. Traditional bamboo shoot production is found to be six kinds of products in Naypyitaw, namely - fresh shoot, boiled bamboo shoot, saltwater-soaked shoot, pickled bamboo, fermented shoot and dried bamboo shoot. The focus of our study was bamboo shoot of *Bambusa poymorpha* (Kyathaungwa) and *Dendrocalamus brandisii* (Kyalowa). It is dominant understory bamboo species in eastern part of Pyinmana city.

In Myanmar, bamboo shoot consumption is estimated at 47,300 tons per year, with 70 percent of consumption in rural areas and 30 percent in urban markets. New sprouting bamboo shoots were harvested from natural forests during the period of June to August in Myanmar (Myanmar survey research, 2006). In the study area, there were mainly 3 bamboo species

naturally grow in the natural forest of east of Pyinmana namely *Bambusa ploymorpha* (Kyathaungwa), *Cephalostachyum pergracile* (Tinwa) and *Dendrocalamus brandisii* (Kyalowa). In this research, we focused on two bamboo species of *Bambusa ploymorpha* (Kyathaungwa) and *Dendrocalamus brandisii* (Kyalowa) which were made the famous local products as fermented bamboo shoot. Fermented bamboo shoot is one of the famous local products of Naypyitaw. In this study, we assess the proportion of bamboo clump of selected bamboo species in the constructed sample plots.

Newly bamboo shoots are connected with each other via horizontal underground rhizome (Noboru et. al., 2015). The intensity of bamboo shoot harvesting has a direct impact on the following year's shoot production, with over-harvesting typically leading to a decline in the number, size, and quality of new shoots. Optimal harvesting involves a balanced approach that maintains sufficient mother culms to support rhizome health, which is critical for future shoot regeneration. For that reason, we conducted the following year bamboo shoot productivity by experimentally manipulating the different intensities level harvesting of new shoots.

2. Objectives

The following objectives were considered for this study:

1. To study traditional harvesting methods of collecting bamboo shoot as raw materials from natural bamboo forests by the local peoples.
2. To compile annual production of bamboo shoots from natural bamboo forests.
3. To study the which intensity of bamboo shoot harvesting may assist sustainable bamboo forest management.

3. Materials and Methods

3.1. Materials

About four bamboo species naturally grow in Nancho RF and the surrounding areas, namely *Bambusa polymorpha* (Kyathaungwa), *Bambusa tulda* (Thaikwa), *Cephalostachyum pergracile* (Tinwa), *Dendrocalamus brandisii* (Kyalowa). Among them used in the production of pickled bamboo shoots were *Dendrocalamus brandisii* (Kyalowa), and *Bambusa polymorpha* (Kyathaungwa). We selected the following bamboo species to study the production of bamboo shoot:

(a) Kyathaungwa (*Bambusa polymorpha*)
(b) Kyalowa (*Dendrocalamus brandisii*)

3.2. Study site

Bamboo resource sampling plots were established in the natural forest which is near Mayantaung village (19° 39' N 96° 23' E), which is located in the south east of Pyinmana. The mean annual temperature is approximately 27.6°C and Total Annual Rainfall is approximately 1,300 mm to 1,500 mm.

3.3 Methods

3.3.1. Preparing questionnaires and conducting interviews and surveys

The questionnaires survey was prepared to assess the status and volume of bamboo shoot raw materials collected from 15 bamboo shoot collectors from 5 villages, 4 bamboo shoot brokers, 1 business man, 1 dry bamboo shoot factory and 10 private entrepreneurs who were produced fermented bamboo shoots.

Fig 1. Map of the study site

3.3.2. Bamboo culm and shoot resource data recording in sample plots

To determine the current bamboo resources in natural bamboo forests, 10 sample plots measuring 150 feet x 75 feet (0.25 acres) were measured and designated. The following data on bamboo growth in the sample plots were collected for research purposes:

(a) Identify the bamboo species
(b) Number of bamboo clump/plot
(c) Number of culms of 1 year, 2 year and 3 year and above culms/clump/ plot
(d) Number of new bamboo shoots/clump/plot

3.3.3. Establishing the sample units

In 2023, sample Unit of 10 bamboo clumps per each unit which including 5-10 culms of one-year old culms and 40 bamboo clumps for each treatment were constructed for *Bambusa polymorpha* and *Dendrocalamus brandisii* (figure 2). A factorial experiment with four level of bamboo shoots harvesting intensity (Unit A 25%, Unit B 50%, Unit C 75% and Unit D 100%) and we assessed the successive year new bamboo shoot productivity by effect of different harvesting intensities in the successive 3 year (Table 1).

Effect of shoot harvesting levels on the year of study, species and new shoot emerging were examined whether the number of bamboo shoots produced in the following year would increase or not, and analyzed the bamboo shoot extraction system that would ensure the sustainability of bamboo shoot resources.

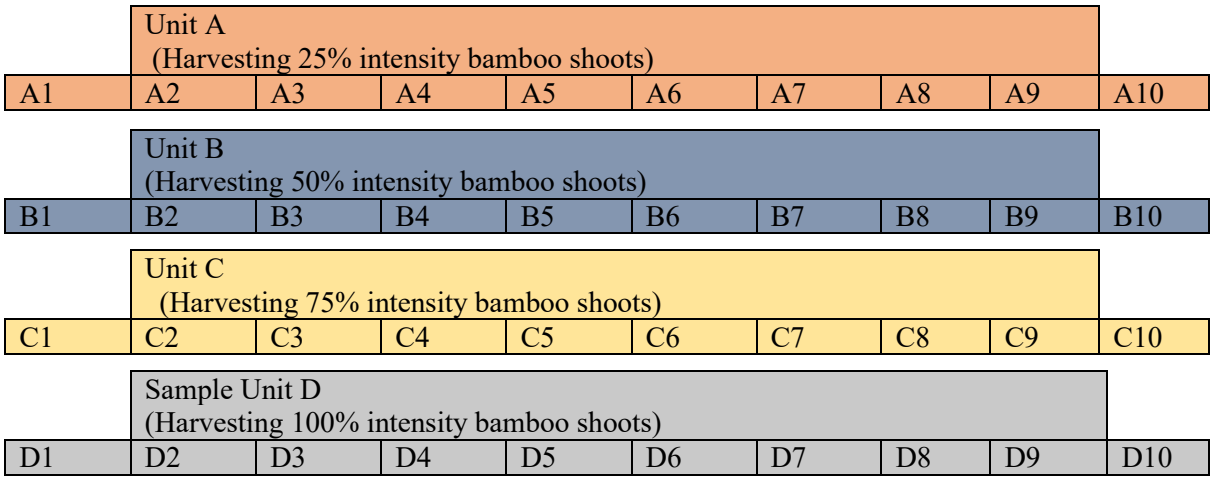

Fig 2. Four different harvesting levels

3.3.4. Data Analysis

To determine the effect of different harvesting intensities, SPSS Stat software version 15 was used to calculate the new shoot production in subsequent years based on the 1-year-old culms in the clump.

4. Results

4.1. Bamboo shoot resources of near Naypyitaw

The questionnaires survey was conducted to 15 bamboo shoot collectors from 5 villages, 4 bamboo shoot brokers, 1 business man, 1 dry bamboo shoot factory and 10 private entrepreneurs who are involved in supply chain of bamboo shoot based products. Bamboo shoot harvesting season from natural forests near Naypyitaw is during rainy season starting from late June to early September and peak season in July and August. Raw bamboo shoots are collected from natural forests around Pyinmana and Naypyitaw by bamboo shoot collectors and transported via 6 routes.

From the eastern side of Pyinmana, raw bamboo shoots of *Dendrocalamus brandisii* and *Bambusa polymorpha* were collected from the natural forest in the Paunglaung reserved forest and, carried them via the Pinlaung-Naypyitaw road and from Nancho reserved forest via the regions of Myathida, Gamone Taung, Mayantaung routes by bamboo shoots collectors, and sold them to the wholesalers. From the western side of Pyinmana, raw bamboo shoots of *Bambusa polymrpha* and *Dendrocalamus strictus* were collected from the natural forest in the Ngalaik reserved forest, Taungnyo reserved forest, Minpyin reserved forest and, are transported via the Taungdwingyi-Naypyitaw Road and Minpyin-Lewe Road etc, by bamboo shoot collectors and sold them to retailers and wholesalers.

Bamboo shoot productivity of natural forests which are near Naypyitaw is range from 685.83-775.64 tons. Only collected bamboo shoots of *Dendrocalamus brandisii* were preserved as fermented bamboo shoot products and sold in the local market and exported to others areas by 32 private entrepreneurs. Collected raw bamboo shoots of *Bambusa polymorpha* and *Dendrocalamus strictus* were made as boiled bamboo shoots products and sold in seasonal shops of roadside and send to bamboo shoots retailers and wholesalers (Table 2, in Annex 1).

4.2. Assessment of bamboo shoot species resource

In the study area, there were mainly 3 bamboo species naturally grow in the natural forest of east of Pyinmana namely *Bambusa ploymorpha, Cephalostachyum pergracile* and

Dendrocalamus brandisii. Assessment of the proportion of bamboo clump of these bamboo species in sample plots were found 26%, 35% and 39% respectively (figure 3) and mean bamboo clump of three species were found 70 clumps per acre and mean clump per acre of *Bambusa ploymorpha, Cephalostachyum pergracile* and *Dendrocalamus brandisii* were 18.4, 24.8 and 27.6 respectively (Figure 4).

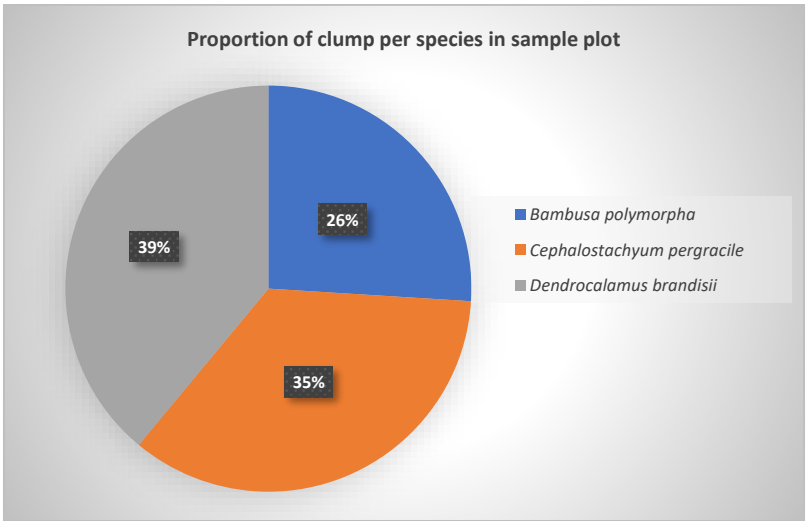

Fig 3. The proportion of clump per plot of growing bamboo species

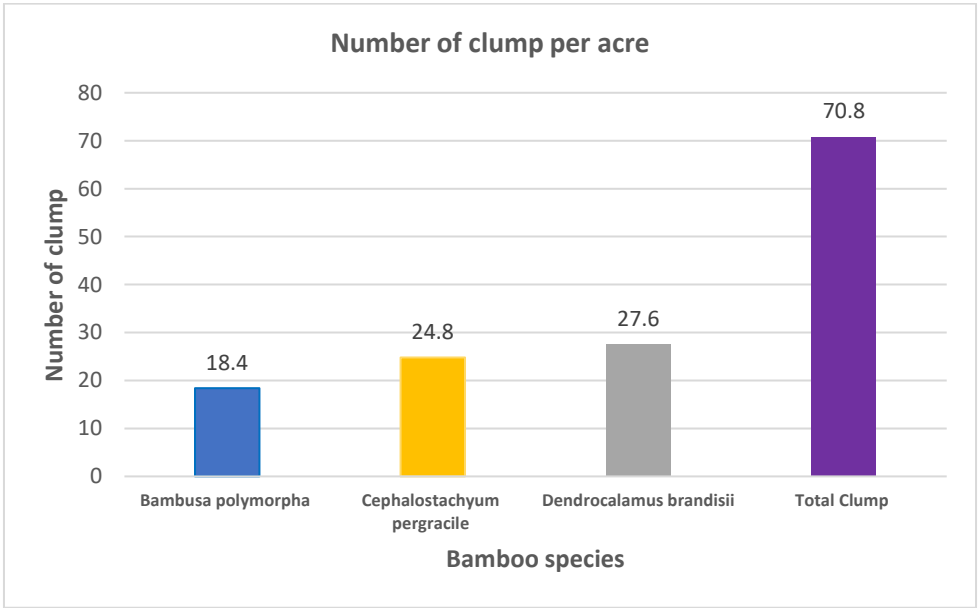

Fig 4. Mean of clump per growing bamboo species of study site

4.3. Effect of different harvesting intensity on new shoot sprouting productivity in the following years

One-way ANOVA was tested the effect of shoot harvesting levels on the year of study, species and new shoot emerging, whether the number of bamboo shoots produced in the following year would increase or not, and analyzed the bamboo shoot extraction system that would ensure the sustainability of bamboo shoot resources. A one-way analysis of variance (ANOVA) was performed to evaluate the effect of year of study (2023, 2024, and 2025) on harvesting level, shoot production, (Table 3 of Annex 2).

4.3.1. Effect of year of study on harvesting levels

A one-way analysis of variance (ANOVA) was performed to evaluate the effect of year of study on harvesting intensity (25%, 50%, 75%, and 100%) on growth and yield parameters. The results indicated that year of study had no significant effect on harvesting level (F3,44 = 0.000, p = 1.000).

Table 4. ANOVA for effect of year of study on harvesting level

Source of Variation		Sum of Squares	df	Mean Square	F	Sig.
year of study	Between Groups	.000	1	.000	.000	1.000
	Within Groups	32.000	46	.696		
	Total	32.000	47			

P<0.05, Year of study, *F* (3,44) = 0.000, *P*=1.000 (not significant differences)

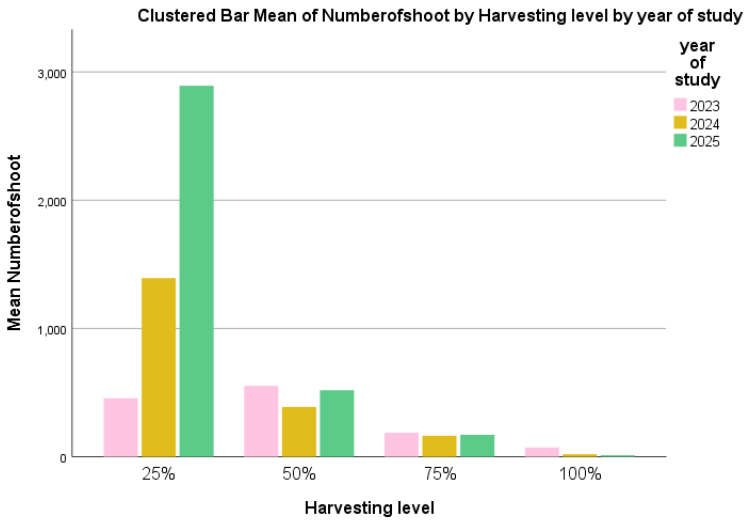

Fig 5. Number of new shoots by successive years

4.3.2. Effect of harvesting level on sprouting new shoot

A one-way analysis of variance (ANOVA) was performed to evaluate the effect of harvesting intensity (25%, 50%, 75%, and 100%) on growth and yield parameters. The analysis revealed no significant differences among harvesting levels for year of study (F (3, 44) = 0.000, p = 1.000), species (F (3, 44) = 0.000, p = 1.000), and replicate (F (3, 44) = 0.000, p = 1.000). These results indicate that harvesting intensity did not influence these variables. In contrast, harvesting intensity had a significant effect on several growth parameters. A statistically significant difference was observed for sprouting new shoot production (F (3, 44) = 5.715, p = .002), indicating that shoot emergence varied among harvesting levels.

Table 5. ANOVA for mean of new shoot sprouting under different harvesting level

Source of Variation		Sum of Squares	df	Mean Square	F	Sig.
Harvesting level	Between Groups	.000	1	.000	.000	1.000
	Within Groups	60.000	46	1.304		
	Total	60.000	47			

P<0.05, Harvesting level, *F*(3,44) = 0.000, *P*= 1.000 (not significant differences)

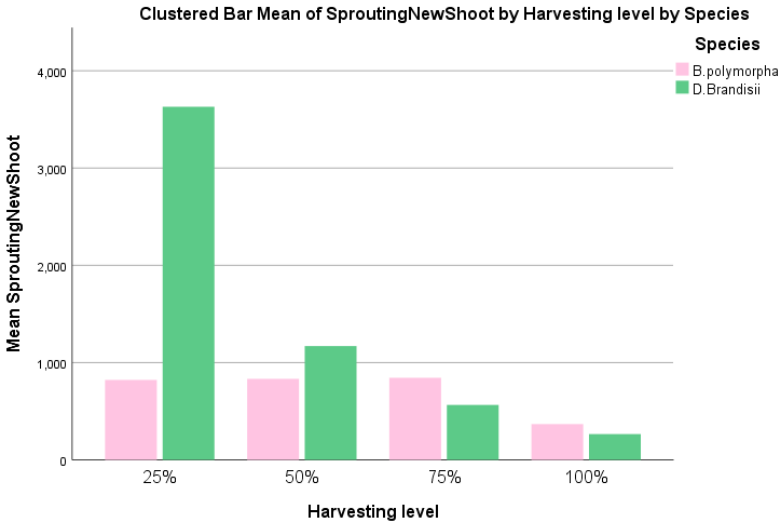

Fig 6. Number of sprouting of new shoots of species by different harvesting level by species

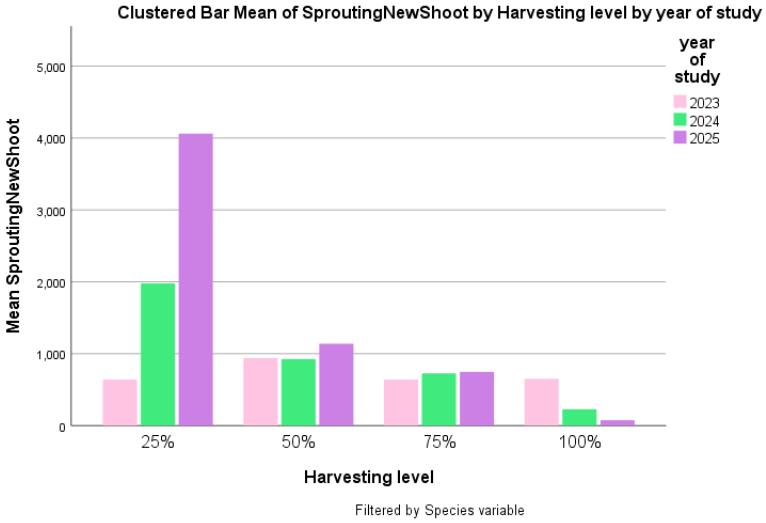

Fig 7. Number of sprouting of new shoots by different harvesting level by year of study

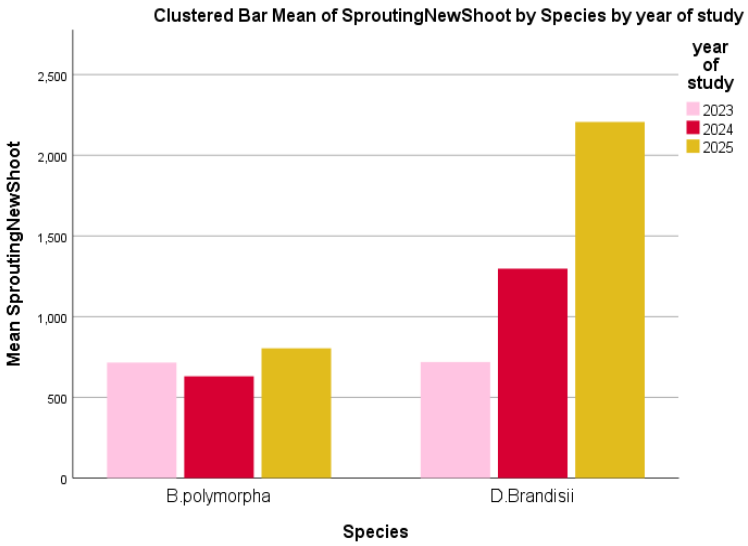

Fig 8. Number of sprouting of new shoots by species by year of study

4.3.3. Effect of the number of one-year-old culms in the clump on new shoot emerging

One-year-old culm is important in new shoot sprouting in subsequent years. For that reason, A one-way analysis of variance (ANOVA) was conducted to determine whether there were statistically significant differences among the four groups for new shoot emerging. These findings suggest that the number of one-year-old culms significantly influenced new shoot emerging. One-year-old culm production was also significantly affected by harvesting intensity (F (3, 44) = 6.553, p = .001) (Table 6).

Table 6. ANOVA for means of new shoot emerging of effect on number of one-year-old culm in clump

Source of Variation		Sum of Squares	df	Mean Square	F	Sig.
One-year old culm	Between Groups	2882130.000	3	960710.000	6.553	.001
	Within Groups	6450494.000	44	146602.136		
	Total	9332624.000	47			

P<0.05 One-year-old culm, F(3,44) =6.553, p= 0.001 (significant)

5. Discussions

5.1. Bamboo shoot resources of near Naypyitaw

In this field of survey, we found that there were 5 kinds of bamboo species namely *Bambusa polymorpha* (Kyathaungwa), *Bambusa tulda* (Thaikwa), *Cephalosta -chyum prgracile* (Tinwa), *Dendrocalmaus brandisii* (Kyalowa) and *Dendrocalamus strictus* (Hmyinwa). Among them Kyathaungwa, Kyalowa and Hmyinwa were used for bamboo shoots. we focused on two bamboo species of *Bambusa ploymorpha* and *Dendrocalamus brandisii* which were made the famous local products as fermented bamboo shoot. Fermented bamboo shoot is one of the famous local products of Nay Pyi Taw.

Current bamboo shoot production potential around Naypyitaw is estimated that 685.83-775.64 tons per year which were harvested from natural forests during the rainy season especially in peat period of June to August. Bamboo shoot collectors collected the raw bamboo shoots from natural forests around Pyinmana and Naypyitaw and transported by vehicles or motorbike via 6 routes such as Taungdwingyi-Naypyitaw Road, Minpyin-Lewe Road from western part of Pyinmana; Pinlaung-Naypyitaw Road, Myathida-Pyinmana Road, Mayantaung-Pyinman Road, Gamintaung-Pyinmana Road etc. The number of new bamboo shoots emerging in one clump per growing season varies significantly based on species produced between 5 to 10+ new shoots per year.

5.2 Assessment of bamboo species resource

In the study area, there were mainly 3 bamboo species naturally grow in the natural forest of east of Pyinmana namely *Bambusa ploymorpha, Cephalostachyum pergracile* and *Dendrocalamus brandisii*. Assessment of the proportion of bamboo clump of these bamboo species in sample plots were found 26%, 35% and 39% respectively (figure 3) and mean bamboo clump of three species were found 70 clumps per acre and mean clump per acre of *Bambusa ploymorpha, Cephalostachyum pergracile* and *Dendrocalamus brandisii* were 18.4, 24.8 and 27.6 respectively.

5.3 Effect of different harvesting intensity on new shoot sprouting productivity in the following years

In this field experiment, we observed no difference in bamboo shoot productivity between the harvesting level in the year 2023, the initial year of harvesting (Fig 6). Moreover,

the number of bamboo shoot that emerged after harvesting in that year did not differ significantly between the harvesting levels (Fig 7). The harvesting technique and intensity (harvesting level) is one of the several factors determining the number of shoots that emerge (Darabant et. al. 2016). It also affects the accessibility of one-year-old culms during harvesting (Othman et. al., 2012).

In this study, the mean number of shoots emerging per clump by the following years were differed with harvesting intensity (F (3, 44) = 5.715, p = .002), whereas the mean number of shoots per clump did not differ significantly with harvesting intensities. We observed that the number of shoots emerging per clump decreased overtime. This could be dure to the repeated cutting of mature culms in the clump. However, repeated harvesting appears to promote the productivity of edible bamboo culms (Katayama 2020). On the other hand, a reduction in the number of young culms in a low-density stand will directly lead to a reduction in the yield (Liu et. al., 2022).

Tukey HSD revealed significant differences between: 25% and 50% (p = .030), 25% and 75% (p = .011), 25% and 100% (p = .001), No significant differences were found among 50%, 75%, and 100% harvesting levels. These findings indicate that the lowest harvesting intensity (25%) differed significantly from higher intensities in one-year-old culm production. Although the difference in shoot emerging between harvesting intensities was not significant, better shoot productivity was found with 25% and 50% harvesting intensities in the years of study.

6. Conclusions

The natural bamboo forests need to be managed sustainably. In this study, an experiment with four level of bamboo shoots harvesting intensity (Unit A 25%, Unit B 50%, Unit C 75% and Unit D 100%) and we assessed the successive year new bamboo shoot productivity by effect of different harvesting intensities. Among different units, bamboo shoot harvesting intensity of unit B and unit C were sustain for both shoot and culm and unit D is not perfect for in sustain resource management, it may decrease the productivity of new shoot in successive year.

Harvesting too many shoots (e.g., over 75–100%) or removing all new shoots restricts the replenishment of starch in the rhizomes. This results in fewer and smaller shoots in the following year, and long-term over-harvesting can lead to a collapse in shoot productivity.
If too few shoots are harvested, the clump becomes congested with old, weak culms. While this may not immediately decrease the *number* of shoots, the shoots tend to be smaller and weaker due to intense competition for light and nutrients.

Moderate harvesting (e.g., leaving 2–3 one-year-old culms and 1–2 two-year-old culms per clump) promotes higher shoot production in the following year compared to no harvesting. This intensity prevents clump congestion, improves light access to the center of the clump, and stimulates nutrient storage in the rhizome system. Retain a balance of 1- to 2-year-old culms (e.g., 2-2 or 2-1 ratios) to ensure enough nutrients are stored in the rhizome system.

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Annex-1

Table 1. Treatment applied in experimental design

Harvesting Year	Treatment Harvesting level	Description
Harvesting intensity Initial year 2023	25%	Harvesting 25% of bamboo shoot in the clump of year
	50%	Harvesting 50% of bamboo shoot in the clump of year
	75%	Harvesting 75% of bamboo shoot in the clump of year
	100%	Harvesting 100% of bamboo shoot in the clump of year
Harvesting intensity Following year 2024	25%	Harvesting 25% of bamboo shoot in the clump of year
	50%	Harvesting 50% of bamboo shoot in the clump of year
	75%	Harvesting 75% of bamboo shoot in the clump of year
	100%	Harvesting 100% of bamboo shoot in the clump of year
Harvesting intensity Following year 2025	25%	Harvesting 25% of bamboo shoot in the clump of year
	50%	Harvesting 50% of bamboo shoot in the clump of year
	75%	Harvesting 75% of bamboo shoot in the clump of year
	100%	Harvesting 100% of bamboo shoot in the clump of year

Table 2. Raw bamboo shoots collection area, quantity, and transportation channels

Bamboo Species	Location/Routes	No. of Collectors	No. of Brokers	Collection/year (Viss)		Destination
				Minimum	Maximum	
D. brandisii	**Eastern part of Pyinmana** 8 villages near Nancho RF: Such as Myathida, Mayantaung, Ganmone-taung,	70	4-5	50,000	60,000	Narain-Dara Dry bamboo shoot factory, Bamboo preserved enterprises
D. brandisii	**Eastern part of Pyinmana** Paunglaung RF: Along the villages along Pinlaung-Naypyitaw Road	80	32	300,000	320,000	Wholesalers, Retailers, Local markets, Bamboo preserved enterprises
D. brandisii	**Eastern part of Pyinmana** Paunglaung RF: Only Tegon village	14-16	4	10,000	20,000	Local markets, Bamboo preserved enterprises
B. polymorpha *D. strictus*	**Western part of Pyinmana** Ngalaik and Taungnyo RF	9	3	15,000	20,000	Seasonal shops of roadside along the Taungdwingyi-Naypyitaw road, Wholesalers, Retailer
B. polymorpha *D. strictus*	**Western part of Pyinmana** Ngalaik and Taungnyo RF	7		20,000	25,000	Only ATM Business For making pickled bamboo shoot
B. polymorpha *D. strictus*	**Western part of Pyinmana** The villages along the Minpyin-Lewe Road	5	8	25,000	30,000	Local markets, Wholesalers, Retailer
	Total (Viss)			**420,000**	**475,000**	
	Total (Kg)			**685,830**	**775,641**	
	Total (Tonne)			**685.83**	**775.641**	

Remarks- 1 Viss = 1.63293 Kg

Annex-2

ANOVA Table for effect of study year on harvesting levels

		Sum of Squares	df	Mean Square	F	Sig.
year of study	Between Groups	.000	1	.000	.000	1.000
	Within Groups	16.000	22	.727		
	Total	16.000	23			
Harvesting level	Between Groups	.000	1	.000	.000	1.000
	Within Groups	30.000	22	1.364		
	Total	30.000	23			
Sprouting New Shoot	Between Groups	2862813.375	1	2862813.375	1.543	.227
	Within Groups	40821129.583	22	1855505.890		
	Total	43683942.958	23			
Number of shoots	Between Groups	1369948.167	1	1369948.167	1.324	.262
	Within Groups	22757981.167	22	1034453.689		
	Total	24127929.333	23			
Harvesting Shoot	Between Groups	180613.500	1	180613.500	1.516	.231
	Within Groups	2621169.000	22	119144.045		
	Total	2801782.500	23			
One-year-old culm	Between Groups	127604.167	1	127604.167	.619	.440
	Within Groups	4538707.833	22	206304.902		
	Total	4666312.000	23			