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Assessing the Emergence of Shoots and Growth of Culms in Response to Different Clump Managements in Ye Nwe Reserved Forest, Myanmar

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ABSTRACT

The monthly emergence of shoots and growth of new culms under different clump managements (A1, A2, Control in different months of a growing season: from May to September) was investigated using 3x4 factorial experiments in Completely Randomized Design. The number of harvested shoots, their diameter at ground level and length, gross weight and net weight per clump were recorded every 10 days. Shoots emerged in the last 10 days of a month was remained for further growth and their growth in diameter at breast height (DBH) and height (H) was measured in 40 days after their emergence.Different months were found to vary significantly in number of shoots harvested, their mean gross weight and net weight per clump. The number of shoots, harvested in July, per clump of 5.28 culms clump^{-1} was significantly higher than those harvested in May and June, August and September. The mean gross weight and net weight of shoots harvested in July was also highest with 2,127.00 g clump^{-1} and 1,230.00 g clump^{-1}, respectively. The significant effect of month on the number of new culms which were retained for further growth and their DBH was revealed. The number of new culms emerged in May and June (4.62 culms clump^{-1}), and July (5.45 culms clump^{-1}) was significantly higher than those emerged in August (3.14 culms clump^{-1}) and September (0.81 culms clump^{-1}). Similarly, culms emerged in May and June, and July showed the significant higher mean DBH (7.67 cm, 7.47 cm) than those in August (5.95 cm). Under different treatments, the significantly higher mean DBH was found under treatment A1 (7.67 cm) and A2 (7.16 cm).In terms of H of new culms, the significant interaction between treatment and month was revealed. New culms emerged in July under treatment A1 and A2 was higher than those in May and June, August and September. It was found that the unmanaged clumps produced the new culms in July, with no significant different growth in height from those produced under treatment A1, A2 and C in May and June, August and September. It was indicated that clump management was crucial to attain the better growth in height of new culms. Comparing the mean H of new culms emerged under A1 and A2 in July, the significant higher mean height of culms was investigated under A2. Therefore, it was recommend that four well distributed new culms within the clump produced in the last 10 days of July should be retained as mother culms to maintain a reasonable culm-density in the stand. Shoots emerged in the early growing season (May and June) and late growing season (August, September) should be harvested for shoot consumption due to their poor growth in H.

Keywords: monthly growth of shoots and culms, clump management, effect of month and treatment, interaction between month and treatment

ဝါးရုံစီမံအုပ်ချုပ်မှုပုံစံများ၏ မျှစ်ထွက်ရှိမှုနှင့် ဝါးပင်ကြီးထွားမှုတို့အပေါ် သက်ရောက်မှုကို ဆန်းစစ်ခြင်း

ဆုမြတ်နှင်း၊ တောအုပ်ကြီး၊ သစ်တောသုတေသနဌာန

စာတမ်းအကျဉ်း

မိုးရာသီ မျှစ်ထွက်ရှိ/ကြီးထွားသည့် ကာလအတွင်း ဝါးရုံစီမံအုပ်ချုပ်မှုအလိုက် လစဉ်မျှစ် ထွက်ရှိမှု နှင့် ၎င်းတို့၏ရင်စို့အချင်းနှင့် အမြင့်ကြီးထွားမှုတို့ကို လေ့လာခဲ့ပါသည်။ Factorial experiments (CRD) ကို အသုံးပြု၍ ဝါးရုံအုပ်ချုပ်မှုပုံစံ (၃) မျိုး (A1၊ A2၊ Control ၏ မေလမှ စက်တင်ဘာလအတွင်း လစဉ်) ၏ လအလိုက် ပထမရက် (၂၀)အတွင်း မျှစ် ထွက်ရှိမှုနှင့် လစဉ် လတစ်လ၏ နောက်ဆုံး(၁၀)ရက်အတွင်း ထွက်ရှိသည့်မျှစ်တို့၏ ရင်စို့အချင်းနှင့် အမြင့် ကြီးထွားမှုတို့ကို တိုင်းတာခဲ့ပါသည်။လအလိုက် မျှစ်ထွက်ရှိမှုအရေအတွက်၊ အခွံပါအလေးချိန်၊ အခွံမပါအလေးချိန်တို့၏ ကွဲပြား ခြားနားမှုကို တွေ့ရှိခဲ့ပါ သည်။ ဇွန်လတွင် မျှစ်ထွက်ရှိသည့် အရေအတွက်သည် အများဆုံး (ဝါးရုံတစ်ရုံ လျှင် ၅.၂၈ချောင်း)ဖြစ်ပြီး အပြင်ခွံပါ အလေး ချိန်(၂,၁၂၇ ဂရမ်)နှင့် အပြင်ခွံမပါအလေးချိန် (၁,၂၃၀ ဂရမ်)လည်း အများဆုံးဖြစ်သည်။ လအလိုက် မိခင်ပင်အဖြစ်ချန်ထားသည့် နှစ်ချင်း ဝါးပင် အရေအတွက် သည် လအလိုက် ပြောင်းလဲမှုရှိသည်ကို တွေ့ရပါသည်။ မေလနှင့်ဇွန်လ၊ ဇူလိုင်လ တို့အတွင်း ထွက်ရှိသည့် ဝါးပင် အဖြစ် ဆက်လက်ကြီးထွားရန် ချန်ထားသည့် မျှစ် (နှစ်ချင်းဝါး) အရေအတွက်သည် အများဆုံး ဖြစ်ပြီး ၎င်းတို့၏ ရင်စို့အချင်းသည်လည်း အကြီးဆုံးဖြစ်သည်။ မတူညီသော စီမံအုပ်ချုပ်မှု ပုံစံများအလိုက် နှစ်ချင်းဝါးပင်များ၏ ရင်စို့လုံးပတ်ကို နှိုင်းယှဉ်ရာတွင် A1နှင့် A2 တို့တွင် နှစ်ချင်းဝါးပင်များ၏ ရင်စို့လုံးပတ်ပိုမို ကြီးမားသည်ကို တွေ့ရပါသည်။ နှစ်ချင်းဝါးများ၏ အမြင့်ကြီးထွားမှုကို ဆန်းစစ်ရာတွင်ဝါးရုံစီမံအုပ်ချုပ်မှုပုံစံများနှင့် မိုးရာသီမျှစ်ထွက်ရှိ/ ကြီးထွား သည့် ကာလအတွင်းရှိ မတူညီသည့် လတို့အကြား ဆက်စပ်မှုကိုတွေ့ရှိခဲ့ပါသည်။ စီမံအုပ်ချုပ် ထားသည့် ဝါးရုံများ(A1၊ A2)မှ ဇူလိုင်လအတွင်းထွက်ရှိသည့် နှစ်ချင်းဝါးများ ၏ အမြင့် ကြီးထွားမှုသည် မေလနှင့်ဇွန်လ၊ ဩဂုတ်လ၊ စက်တင်ဘာလတို့ အတွင်း စီမံအုပ်ချုပ်ထားသည့် ဝါးရုံများနှင့် စီမံအုပ်ချုပ်မထား သည့်ဝါးရုံများမှထွက်ရှိသည့် နှစ်ချင်းဝါးများ၏ အမြင့်ကြီးထွား မှုထက် ပိုမိုကောင်းမွန်ပါ သည်။ စီမံအုပ်ချုပ်မှုပုံစံ A1 နှင့် A2 အောက်ရှိဝါးရုံများမှ ဇူလိုင် လအတွင်း ထွက်ရှိသည့် နှစ်ချင်းဝါး များ၏ အမြင့်ကို နှိုင်းယှဉ် ရာတွင် A2တွင်နှစ်ချင်းဝါးများ၏

ပျမ်းမျှအမြင့် ပိုမိုမြင့်မားသည်ကို တွေ့ရပါသည်။ ထို့ကြောင့် ဇူလိုင်လ၏ နောက်ဆုံး(၁၀)ရက် အတွင်း ထွက်ရှိသည့်မျှစ်များအနက် မျှစ်စို့(၄)ခုကို မိခင် ဝါးပင် အဖြစ် ဆက်လက်ကြီးထွားရန် ချန်ထား သင့်ပါသည်။ ကျန်ကာလများ (မေ၊ ဇွန်၊ ဩဂုတ်၊ စက်တင်ဘာလ)အတွင်း ထွက်ရှိသည့် မျှစ်များသည် အမြင့်ကြီးထွားနှုန်း ညံ့ဖျင်း သဖြင့် မျှစ်အဖြစ် ထုတ်ယူသုံးစွဲသင့်ပါသည်။

Assessing the Emergence of Shoots and Growth of Culms in Response to Different Clump Managements in Ye Nwe Reserved Forest, Myanmar

Introduction

Bamboo, having a significant role in Myanmar's society due to its diverse utilization, is a potential species for enhancing the livelihood of rural people through community forestry. *Dendrocalamus strictus*, *Bambusa polymorpha*, *Dendrocalamus brandisii*, *Dendrocalamus hamiltonii*, *Dendrocalamus longispathus* and *Dendrocalamus latiflorus* are consumed for their shoots in different forms: boiled fresh bamboo shoot, salted bamboo shoot and pickled bamboo shoot. The domestic bamboo shoot consumption was estimated at 13,695 ton in 2005 (ITTO, 2005). According to Food and Agricultural Organization's report in 2005, the annual bamboo removal for wood and fuel had risen from 7,752,000 metric tons in 1990 to 9,803,000 metric tons in 2005. Win *et al*. (2019) reported that the bamboo based Community Forests (CFs) provided the bamboo cutters, head of cutters and head of CFUG with the annual income of 820,000 kyats, 2,402,000 kyats and 7,295,000 Kyats. Bamboo is the major income generator for the rural poor.

Generally, the initial shoots and most of those produced in the summer are harvested, but those produced towards the end of the shooting period will be selected and retained as mother culms (Mera *et al.*, 2014). However, based on the experience of a bamboo expert, bamboo shoots emerged in the late growing season are rather small due to the shortage of nutrients in the rhizome and are susceptible to insect attack.

Virtucio and Roxas (2003) indicated that poor management practices in a plantation may contribute to a reduced production of culms and shoots. Lack of management and repeated shoot harvest likely can be attributed to a low AGB (Hnin, 2019). Although the different clump managements were tested for increasing the culm yield, not much work has been attempted on a clump management for producing both edible shoot and culm yield.

Investigating the optimal standing-density, shoot emerging behavior and growth of newly emerged culms can help arrange the shoot harvesting schedule and efficiently provide both shoot and culm yield. In this study, therefore, the monthly emergence of shoot in a growing season and culm growth under different clump managements was investigated.

Objectives

The overall objective of this study is to investigate the shoot emerging behavior for harvesting shoot and culm under different clump managements. The specific objectives are as follows:

- ❖ To compare the number of shoots harvested, their diameters, fresh weights under different treatments in different months of a growing season,
- ❖ To assess the comparative growth in diameter at breast height and height of new culms emerged under different treatments in different months of a growing season.

Materials and Methods

Materials

The present investigations were conducted in the year 2020 in Ye Nwe Reserved Forest, Compartment No. 84, Kyauktaga Township, Bago Region, Myanmar as shown in Figure 1. The experimental site is located in Bago Yoma between 18° 3' 11.25" N latitude and 96° 19' 47.18" E longitude at an altitude of 795 m above sea level. The climate of the region is broadly humid subtropical with cool winter and hot dry summer. Generally, the monsoon starts in June and lasts up to September. The mean annual precipitation is 999.9 mm. The average maximum temperature in summer may reach up to 37° C and average minimum temperature in winter may fall up to 29° C.

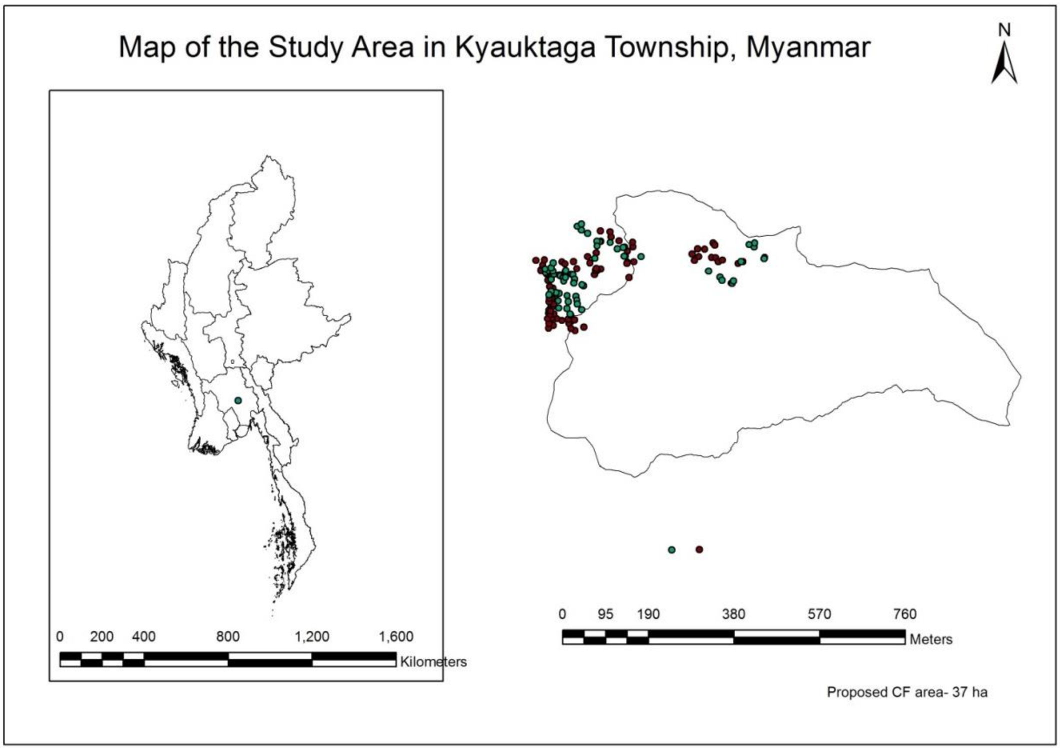


Figure 1 The map of the study area in Kyauktaga Township, Bago Region, Myanmar

Methods

Based on the criteria of, growing in the same environmental condition, having the same age of the rhizome system, 150 clumps having at least 5 culms in their 1st year and 5 culms in their 2nd year which were healthy and free from insect attack, of *Bambusa polymorpha* were randomly selected using Completely Randomized Factorial Design with 10 replications.

For the 3×5 factorial experiments with 3 levels of treatment (A1, A2, C)and 5 levels of month (B1, B2, B3, B4, B5) in a growing season, sets of clump management consist of the following 9 different combination:

A1 B1	Combination of cutting all old culms, leaving 1- and 2-year-old culms, 3 culms/age (total of 6 culms/clumps) and shoot growth in May, 10 replications

A1 B2	Combination of cutting all old culms, leaving 1- and 2-year-old culms, 3 culms/age (total of 6 culms/clumps) shoot growth in June, 10 replications
A1 B3	Combination of cutting all old culms, leaving 1- and 2-year-old culms, 3 culms/age (total of 6 culms/clumps) shoot growth in July, 10 replications
A1 B4	Combination of cutting all old culms, leaving 1- and 2-year-old culms, 3 culms/age (total of 6 culms/clumps) shoot growth in August, 10 replications
A1 B5	Combination of cutting all old culms, leaving 1- and 2-year-old culms, 3 culms/age (total of 6 culms/clumps) shoot growth in September, 10 replications
A2 B1	Combination of cutting all old culms, leaving 1- and 2-year-old culms, 4 culms/age (total of 8 culms/clumps) shoot growth in May, 10 replications
A2 B2	Combination of cutting all old culms, leaving 1- and 2-year-old culms, 4 culms/age (total of 8 culms/clumps) shoot growth in June, 10 replications
A2 B3	Combination of cutting all old culms, leaving 1- and 2-year-old culms, 4 culms/age (total of 8 culms/clumps) shoot growth in July, 10 replications
A2 B4	Combination of cutting all old culms, leaving 1- and 2-year-old culms, 4 culms/age (total of 8 culms/clumps) shoot growth in August, 10 replications
A2 B5	Combination of cutting all old culms, leaving 1- and 2-year-old culms, 4 culms/age (total of 8 culms/clumps) shoot growth in September, 10 replications
Control	50 replications

Pandey and Ojha (2013) reported that the optimum harvesting age for *Dendrocalamus asper, Dendrocalamus strictus* and *Bambusa tulda* was on 10−14 days, 6−10 days and 10−16 days (after emergence from the ground) respectively, when their shoots had richer nutritional composition and lesser concentration of cyanides. Therefore, the following data of the shoots, emerged in the first 20 days of a month during the growing season, with the height from the ground ranged from 45 cm and below was collected in every 10 days during the data collection period from June, 2020 to September, 2020:

- number of new shoots emerged,
- diameter at ground level, length, gross weight and net weight.

However, due to the lock down measures taken place in April, 2020, the data on shoots emerged in May and early June could not be measured. In June when the lock down measure was temporarily lifted, the data collection was started and the local villagers were trained to record the number of shoots emerged in the first 20 days of a month, their diameter at ground level, length, gross weight and net weight for further data collection. Therefore, shoot emergence in May and June could not be recorded, separately.

Shoots emerged in the last 10 days of a month, being healthy, well-distributed in a clump and having larger diameter, were remained for further growth. Their growth in diameter at breast height (DBH) and height (H) was measured in 40 days after their emergence (Yen, 2016).

Data analysis

Statistical analysis, analysis of variance (ANOVA) and post-hoc analysis (Tukey's HSD), was done in use of 3×4 factorial experiment in completely randomized design to analyse the difference in number of shoots emerged, their gross weight and net weight, and DBH and H of new culms resulted from different treatments and months. Statistical analysis was carried out with the RStudio software package using two factors, i.e, treatment and month.

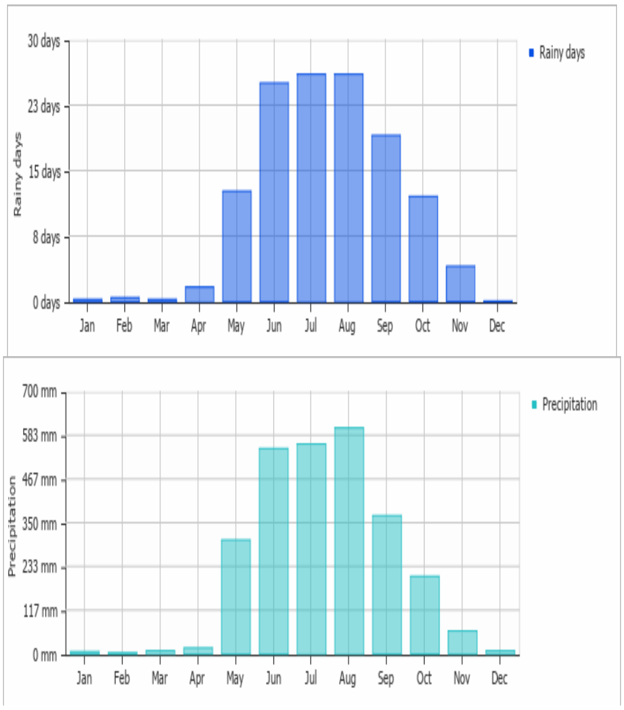
Results and Discussion

Shoot emerging behaviour of *B. polymorpha*

More than 50 percentages of shoots was produced in July which was followed by August, May and June, and September under 3 treatments. Despite having high number of rainy days (Figure 2) and rainfall in September, the lowest percentage of shoots was shared to the total number of shoots emerged in the growing season as shown in Table 1 and Figure 3. It could be assumed that rainfall is not the only factor which influenced the emergence of shoots.

Table 1 Percentage of shoot emergences under different treatments in different months

Clump management	Shooting % per clump in May and June		Shooting % per clump in July		Shooting % per clump in August		Shooting % per clump in September	
	Number	Net weight	Number	Net weight	Number	Net weight	Number	Net weight
A1	17.24	9.39	51.72	50.66	26.44	33.26	4.60	6.68
A2	9.68	3.98	54.84	52.11	32.26	41.58	3.23	2.33
C	3.57	2.57	64.29	40.77	26.79	47.92	5.36	8.74



Source: https://weather-and-climate.com/average-monthly-Rainy-days,bago-mm,Myanmar-Burma

Figure 2 Number of rainy days and rainfall per month

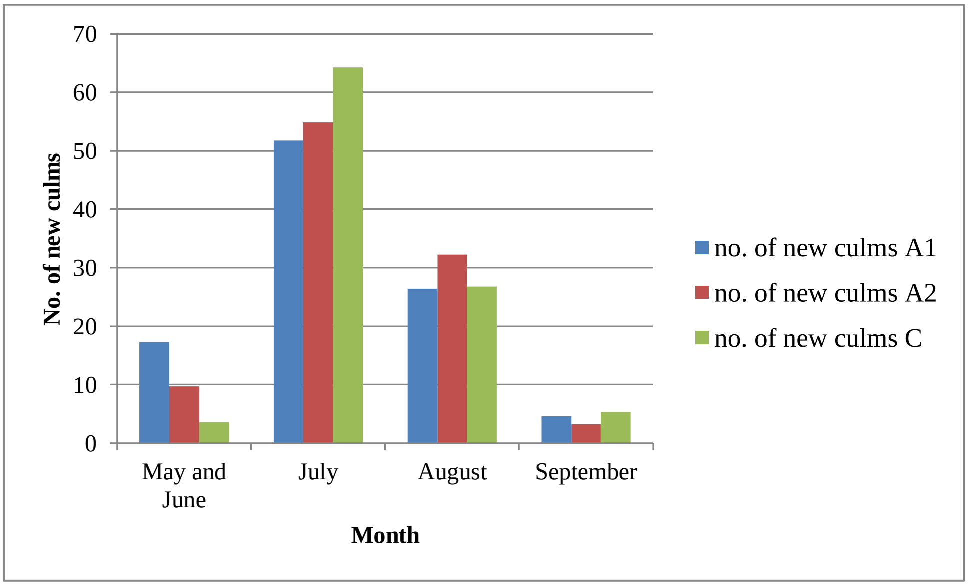


Figure 3 Percentage of shoot emergence by month

Effect of treatments and months on the emergence of shoots/ shoot yield

No variation in the number of shoots harvested, and length of harvested shoots, their mean gross weight and net weight of shoots in a clump was revealed due to the effect of treatment at p=0.05, as presented in Table 2 and Table 3. However, mean diameter at ground level of harvested shoots differed significantly at $F_{0.05(df\ 2,59)}$=5.962, p<0.0001. Shoots emerged under treatment A1 and C showed significantly higher mean diameter of 7.01 cm and 6.75 cm, respectively.

Different months were also found to vary significantly in the number of shoots harvested, their mean length, mean gross and net weight per clump at $F_{0.05(df\ 3,59)}=20.773$, $p<0.0001$; $F_{0.05(df\ 3,59)}=5.859$, $p<0.0001$;$F_{0.05(df\ 3,59)}=11.831$, $p<0.0001$;$F_{0.05(df\ 3,59)}=9.012$, $p<0.0001$, shown in Table 4 and Figure 4. The significant highest number of shoots per clump of 5.28 culms clump^{-1} was harvested in the first 20 days of July than those harvested in May and June (1.85 culms clump^{-1}), August (2.62 culms clump^{-1}) and September (1.42 culms clump^{-1}). The highest number of shoots in July resulted in the highest mean gross and net weight of shoots per clump. The mean gross weight and net weight of shoots per clump harvested in July was significantly highest with 2,127.00 g and 1,230.00 g, respectively, which were not significantly different from the mean gross weight of 1,591.00 g and mean net weight of 973.60 g of shoots harvested in August.

In contrast, the mean gross weight and net weight of shoots per clump harvested in May and June was lowest with 388.60 g and 255.90 g, respectively, which were not significantly differed from those in September with 756.00 g and 500.40 g, respectively. No interaction between treatment and month was revealed at $p=0.05$.

Table 2 Analysis of variance for shoot emerging behaviour from different treatments in different months

Source of variation	d.f.	Sum of squares				
		Number of shoots	Diameter of shoots at ground level	Length of shoots	Mean gross weight per clump	Mean net weight per clump
Treatment	2	0.69	11.86*	430.00	54669	46816
Month	3	181.56*	22.09*	7783.00*	33653083*	10564315*
Treatment × Month	6	13.42	5.59	928.00	55943751	1757905
Error	59	171.89	58.66	26122	55943751	23053571

Remark: * represents Significant at the 0.05 level.

Table 3 Variation in number of harvested number of shoots in a clump, their mean diameter, mean gross weight and net weight due to the effect of treatment

Month	Number of harvested shoots in a clump	Mean diameter of harvested shoots at ground level (cm)	Mean length of harvested shoots (cm)	Mean gross weight of harvested shoots in a clump (g)	Mean net weight of harvested shoots in a clump (g)
A1	3.22^{a}	7.07^{a}	28.17^{a}	$1{,}447.23^{a}$	869.10^{a}
A2	3.44^{a}	6.27^{b}	23.21^{a}	$1{,}506.53^{a}$	881.50^{a}
C	3.11^{a}	6.76^{a}	26.85^{a}	$1{,}500.57^{a}$	934.10^{a}

Remark: Letters a and b represent post-hoc comparison of means. Figures followed by the same letters in a column are not significantly different from each other according to Tukey's HSD test.

Table 4 Variation in number of harvested shoots in a clump, their mean diameter, mean gross weight and net weight due to the effect of month

Month	Number of harvested shoots in a clump	Mean diameter of harvested shoots at ground level (cm)	Mean length of harvested shoots (cm)	Mean gross weight of harvested shoots in a clump (g)	Mean net weight of harvested shoots in a clump (g)
May and June	1.85^{b}	6.01^{b}	9.61^{c}	388.60^{c}	255.90^{c}
July	5.28^{a}	7.15^{a}	21.41^{c}	$2{,}127.00^{a}$	$1{,}230.00^{a}$
August	2.62^{b}	6.80^{b}	37.55^{ab}	$1{,}591.00^{ab}$	973.60^{ab}
September	1.42^{b}	6.05^{b}	32.06^{bc}	756.00^{bc}	500.40^{bc}

Remark: Letters a and b represent post-hoc comparison of means. Figures followed by the same letters in a column are not significantly different from each other according to Tukey's HSD test.

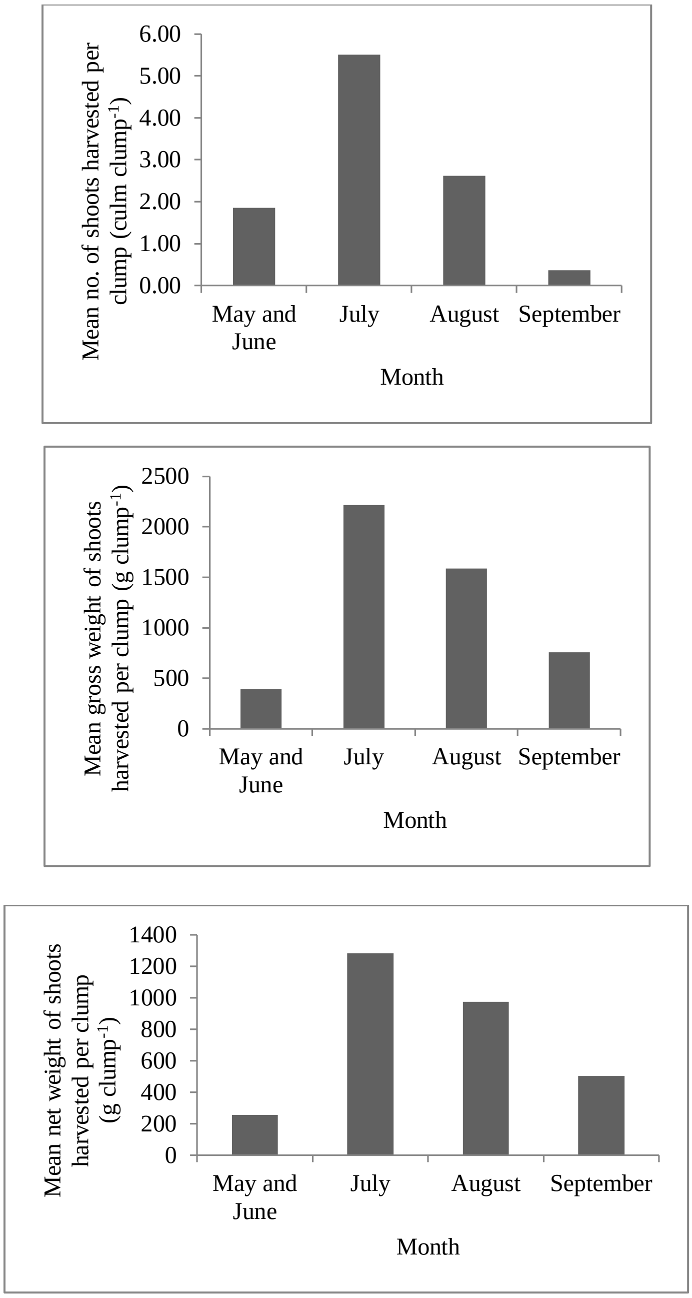


Figure 4 Number of shoots harvested, their mean gross weight and net weight per clump by months

Analysis of variance for growth of new culms from different treatments in different months

A two way ANOVA was conducted to examine the effect of treatment and month on the growth of new culms, and the interaction between treatment and month (Table 5).

Table 5 Analysis of variance for the growth of new culms from different treatments in different months

Source of variation	d.f.	Sum of Squares		
		No. of new culms	Mean DBH of new culms (cm)	Mean H of new culms (m)
Treatment	2	11.13	24.50*	73.96*
Month	3	115.16*	47.49*	205.43*
Treatment × Month	5	28.08	10.11	82.09*
Error	77	219.71	79.90	150.23

Remark: * represents Significant at the 0.05 level.

No significant effect of treatment on the number of new culms emerged in every last 10 days of the tested months was revealed, as presented in Table 5 and Table 6. However, mean DBH of new shoots among different treatments varied at $F_{0.05(2,77)}=11.803$, $p<0.0001$. Mean DBH of new culms under treatment C (6.36 cm) were significantly lower than those under treatment A1 (7.67 cm) and A2 (7.16 cm).

A significant difference in the number of new culms and their DBH among different months was also revealed at $F_{0.05(3,77)}=13.452$, $p<0.0001$; $F_{0.05(3,77)}=15.256$, $p<.0.0001$. The number of new culms emerged in the last 10 days of July (5.45 culms clump^{-1}) and, May and June (4.62 culms clump^{-1}) was significantly higher than those emerged in August (3.14 culms clump^{-1}) and September (0.81 culms clump^{-1}). Similarly, culms emerged in May and June (7.67 cm), and July (7.47 cm) showed the significantly higher mean DBH than those in August (5.95 cm), as shown in Table 7.

Table 6 Variation in the number of new culms and their mean DBH by treatment

Treatment	No. of new culms	Mean DBH (cm)
A1	4.00^{a}	7.67^{a}
A2	4.81^{a}	7.16^{a}
C	4.19^{a}	6.36^{b}

Remark: Letters a and b represent post-hoc comparison of means. Figures followed by the same letters in a column are not significantly different from each other according to Tukey's HSD test.

Table 7 Variation in the number of new culms and their mean DBH by month

Month	No. of new culms	Mean DBH (cm)
May and June	4.62^{a}	7.67^{ab}
July	5.45^{a}	7.47^{ab}
August	3.14^{b}	5.95^{c}
September	0.81^{b}	6.79^{bc}

Remark: Letters a and b represent post-hoc comparison of means. Figures followed by the same letters in a column are not significantly different from each other according to Tukey's HSD test.

Variation in the growth of new culms by the interaction effect between treatment and month

A statistically significant interaction effect between the treatment and month on the height of new culms was revealed at $F_{0.05(5,77)}= 8.415$, $p<0.0001$, shown in Table 5. Tukey's post hoc test was applied for pairwise comparisons. The mean height of new culms emerged in July under treatment A1 (3.56 m) was significantly higher from those under C (0.90 m) in May and June, A1 (1.25 m) in May and June, A2 in May and June (0.91 m), C in August (0.30 m). Similarly, significantly higher mean height of new culms emerged in July under treatment A2 (7.41 m) was investigated than those under treatment C in May and June (0.90 m), A1 in May and June (1.25 m), A2 in May and June (0.91 m), A1 in August (2.47 m), A2 in August (2.75 m), C in August (0.30 m), A1 in September (0.76 m) and A2 in September (0.91 m).

The height of new culms emerged under A1 in July and A1 in August was not significantly differed. Considering the significant higher number of new culms and their DBH in July (5.45, 7.47 cm), however, culms newly emerged in July under A1 should be retained for further growth.

New culms emerged under treatment A1 and A2 in July showed significantly better growth in height. Comparing the new culms emerged under in July A1 and A2, the significant higher mean height of culms was revealed under A2. However, the mean height of new culms under treatment C (2.33 m) emerged in July was non-significantly different from those under treatment A1 in May and June (1.25 m), A2 in May and June (0.91 m), C in May and June (0.90 m), A1 in August (2.47 m), A2 in August (2.75 m), A1 in September (0.76 m) and A2 in September (0.91 m). It was found that the unmanaged clumps produced the new culms in July, with no significant different growth in height from those produced under treatment A1, A2 and C in May and June, August and September. It was indicated that the clump management was crucial to attain a better growth in height of new culms.

Mera *et al.* (2014) reported that the initial shoots and most of those produced in the summer are harvested, but those produced towards the end of the shooting period are selected and retained as mother culms. However, in this research, it was revealed that new culms emerged in the early growing season (May and June) and late growing season (August, September) were lower in their number, mean DBH and H. Therefore, it is recommend that three or four well distributed new culms within the clump produced in July should be retained as mother culms to maintain a reasonable culm-density in the stand.

It was also found that the number of new culms which were retained for further growth in May and June and their mean diameter were higher. However, their growth in height was significantly lower due to the relatively fewer rainy days and lower rainfall, and moisture content in soil. On the other hand, despite having the higher rainfall in September, the lowest number of new culms was recruited. It could be assumed that the emergence of shoots and their growth were influenced not only by rainfall but the nutrient in the rhizome of one- and two-year-old culms. Since treatment A2 showed the best growth in height in July, treatment A2 is recommended for clump management and shoots emerged in July should be remained to let them grow to their full growth. Shoots emerged during the rest of the growing season should be harvested within 10 days after their emergence for shoot consumption.

Table 8 Height growth of new culms in response to different treatment and month

Treatment	Mean Height (m)			
	May and June	July	August	September
A1	1.25 (±1.03)	3.56 (±1.49)	2.47 (±1.71)	0.76
A2	0.91 (±0.63)	7.41 (±2.73)	2.75 (±1.39)	0.91 (±0.57)
C	0.90 (±0.43)	2.33 (±1.06)	0.30 (±0.17)	-

Annual harvestable shoot and culm yield

For shoot consumption, the annual harvestable number of shoots was in the order of A1 (12.07 culms clump^{-1} yr^{-1})> A2 (11.23 culms clump^{-1} yr^{-1})> C (10.64 culms clump^{-1} yr^{-1}), as presented in Table 9. The annual harvestable net weight of shoots of 3.4 kg clump^{-1} under A1, 3.1 kg clump^{-1} under C and 2.7 kg clump^{-1} under A2 was yielded, shown in Table 10.

Based on the preliminary data collected in January, 2019 prior to clump management, 54 clumps, in average, of *Bambusa polymorpha* and *Cephalostachyum pergracile* were recorded in a 30 x 30 m wide sample plot. Of 54 clumps, 21 clumps of *B. polymorpah* and 33 clumps of *C. pergracile* were mixed in a plot. Mean annual harvestable number of shoots and their mean net weight per hectare, and harvestable number of 3-year-old culms was computed by multiplying with 23,333 clumps per ha of *B. polymorpha*. Clumps under treatment A1 yielded the highest annual net weight of shoots of 78.5 ton ha^{-1} yr^{-1} which was followed by C (71.5 ton ha^{-1} yr^{-1}) and treatment A2 (63.3 ton ha^{-1} yr^{-1}), as shown in Table 10. ITTO (2001) reported that a sympodial bamboo plantation with the culm density of 4,000 culms ha^{-1} (500 clump ha^{-1} x 8 culms clump^{-1}) could yield the annual per hectare yields of 10 to 30 ton of edible shoots. It was also reported that a well-managed multipurpose stand with the culm density of 2,225 culms per hectare can yield 3 tones of edible shoots and 9 tones of timber per hectare annually (ITTO, 2001). However, the annual harvestable shoot yield investigated in this research was higher due to the higher culm density of 139,998 - 186,664 culms ha^{-1} (23,333 clumps ha^{-1} x 6-8 culms clump^{-1}) in natural stand.

In terms of culm yield, 3-4 culms aged three year per clump could be harvested for culm yield under treatment A1 and A2. Annually, 69,999 culms ha^{-1} yr^{-1} (23,333 clumps ha^{-1} x 3 culms clump^{-1}) under A1 and 93,332 culms ha^{-1} yr^{-1} under A2 (23,333 clumps ha^{-1} x 4 culms clump^{-1}) could be harvested.

Table 9 Average annual harvestable number of shoots by treatment and month

Treatment	Number of harvestable shoots per clump (culms clump^{-1})				No. of annual harvestable shoots per clump (culms clump^{-1} yr^{-1})	No. of annual harvestable shoots per hectare (culms ha^{-1} yr^{-1})
	May and June	July	August	September		
A1	2.14	5.63	2.30	2.00	12.07	281,629
A2	1.80	5.10	3.33	1.00	11.23	262,030
C	1.00	6.00	2.14	1.50	10.64	248,263

Table 10 Average annual harvestable net weight of shoots by treatment and month

Treatment	Harvestable mean net weight of shoots per clump (g clump^{-1})				Annual harvestable net weight of shoots per clump (kg clump^{-1} yr^{-1})	Annual harvestable net weight of shoots per ha (ton ha^{-1} yr^{-1})
	May and June	July	August	September		
A1	314.9	1486.0	780.5	783.8	3.4	78.5
A2	189.4	1240.2	1099.5	185.1	2.7	63.3
C	204.1	1079.0	1087.1	694.0	3.1	71.5

CONCLUSION

This study was conducted in order to provide the information on the shoot emerging behavior and growth of new culms to an interested farmer and community user group, and to provide them with the clump management in which the shoot harvesting schedule was arranged so that both shoot and culm yield could efficiently be harvested. The number of shoots harvested, their mean height, mean gross and net weight of shoots per clump varied with different months during the growing season. The number of shoots harvested was highest in July. The mean net weight of harvested shoots per clump was in the order of July> August> September> May and June.

In terms of the growth of new culms, the number of new culms and their DBH emerged in the last 10 days of July and, May and June was significantly higher than those emerged in August and September. For the height of new culms, however, the significant higher mean height of culms was revealed under A2 in July. The adoption of a clump management in which 3-3 culms of 1-2 year of age per clump maintained is recommended to obtain good performance in DBH and height growth of new culms. New culms emerged in the last 10 days of July should be kept as mother culms. Culms which emerged in the rest of the growing season should be harvested every 10 days after their emergence for edible shoots.

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Literature Cited

Hnin, S. M. 2019. **Allometric equations for estimating the aboveground biomass of 14-year-old bamboo plantation at Moeswe Research Station, Myanmar**. Kasetsart University, Bangkok, Thailand.

ITTO. 2001. **Review of bamboo management**. International Tropical Organization, Yokohama, Japan.

ITTO. 2005. **Promoting sustainable utilization of Bamboo through community participation in Sustainable Forest Management: Current Market Situation of Bamboo Shoot in Myanmar and Market Expansion Potential**. Project document. PD 146/02 Rev. 1(1). Forest Department, Myanmar; International Tropical Timber Organization, Yokohama, Japan.

Mera, F. A. T., & Xu, C. 2014. Plantation management and bamboo resource economics in China. Revista Ciencia Y Tecnología, 7(1), 1-12.

Pandey, A. K. and V. Ojha. 2013. Standardization of harvesting age of bamboo shoots with respect to nutritional and anti-nutritional components. Journal of forestry research, 24(1), 83-90.

Virtucio, F. D. and C. A. Roxas 2003. **Bamboo production in the Philippines**. Ecosystem research and Development Bureau, Department of Environment and Natural Resources, College, Laguna, Philippines.

Win Z. C., S. M. Hnin, K. Y. M. Hlaing, A. Z. Moe, S. Moe, M. T. Aung, K. Thet and K. L. Cho. 2019. Survey on Sustainable Management of Bamboo through Pilot Bamboo Community Forestry in Tharyarwady District, Myanmar. *In* Proceedings of the workshop on **Forestry and Rural Livelihood Development**. Yunnan, China.

Yen, T. M. 2016. Culm height development, biomass accumulation and carbon storage in an initial growth stage for a fast-growing moso bamboo (Phyllostachy pubescens). **Botanical studies** 57(1), 10.