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Culms and Above-ground Biomass Assessment of *Gigantochloa scortechinii* in Response to Harvesting Techniques Applied

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ABSTRACT

A study on culms and above-ground biomass productivity based on three harvesting techniques of *Gigantochloa scortechinii* (buluh semantan) in natural stands had been conducted in Betau, Pahang. After 18 months of observation it was found that the harvesting techniques gave highly significant effects at 0.05% both on new culms and above-ground biomass productivity, whereas the effect of clump density was highly significant at 0.05% in new culms production only. Based on the study results, X-shape harvesting technique is recommended to be applied in the natural stands of bamboo. This method produced a higher number of new culms per clump and total above-ground biomass increment with the production of 7.6 kg and 86.7 kg, respectively, as compared with Horse-shoe shape harvesting technique. Furthermore, it is recommended that only bamboo clump density with the minimum number of 26 culms/clump were suitable for the application of this harvesting technique. The clear-felling method is not recommended for the harvesting of the natural stands of *Gigantochloa scortechinii* due to the slow recovery.

Keywords: Culms, above-ground biomass, productivity, harvesting techniques, *Gigantochloa scortechinii*

ABSTRAK

Kajian mengenai produktiviti batang dan biojisim *Gigantochloa scortechinii* (buluh semantan) berdasarkan tiga teknik penuaian dalam dirian semula jadi buluh telah dijalankan di Betau, Pahang. Selepas 18 bulan pemerhatian, didapati teknik-teknik penuaian telah memberi kesan yang sangat bererti pada 0.05% terhadap produktiviti kulma baru dan biojisim atas tanah, manakala kesan kepadatan rumpun adalah sangat bererti pada 0.05% hanya bagi pengeluaran kulma baru. Berdasarkan hasil kajian, didapati teknik penuaian bentuk-X sangat sesuai untuk digunakan di

kawasan pertumbuhan buluh semula jadi. Kaedah ini boleh menghasilkan jumlah kulma baru yang lebih banyak bagi setiap rumpun dan tambahan biojisim atas tanah dengan pengeluaran 7.6 kg dan 86.7 kg, masing-masing, berbanding teknik penuaian berbentuk Ladam-kuda. Tambahan pula, teknik ini adalah sesuai dan disyorkan hanya pada kepadatan rumpun buluh dengan bilangan minimum 26 kulma/rumpun. Kaedah tebangan habis rumpun tidak dicadangkan untuk penuaian dirian buluh semula jadi *Gigantochloa scortechinii* disebabkan oleh pertumbuhan semula yang lambat.

Kata kunci: Kulma, biojisim atas tanah, produktiviti, teknik penuaian, *Gigantochloa scortechinii*

INTRODUCTION

Gigantochloa scortechinii is one of the most commonly used bamboo species, endemic to Peninsular Malaysia. It occurs extensively in logged-over forests, particularly in the state of Kedah, Perak, Kelantan, Selangor and Pahang. The species thrives best in sites with well-drained sandy to clay loam soils with slight acidic condition (soil pH of 5.0 to 6.5).

Like other commercial species of bamboo, *Gigantochloa scortechinii* stands have been very much depleted and the supply continues to decline due to unregulated exploitation. Furthermore, these bamboos grow wild, scattered and are practically unmanaged. Many of the problems faced by the harvesters are related to the natural characteristics of the bamboo stand itself. The high quality culms that are straight and mature, are commonly located at the centre of the clumps, but are difficult to harvest. At present, there are no proper management measures being practiced to sustain the production of this raw material from natural forests. There is no information on suitable harvesting techniques that are essential to support managing bamboo stands in Malaysia. Most of the harvesting activities of the resource are unsystematic and haphazard in nature (Azmy *et al.*, 1997). Due to a lack of systematic management, this valuable resource is harvested without thought given to its intended usage.

Thus, harvesting techniques are an integral part in the management regime of natural bamboo stands for improving production and sustainability. In view of current problems, a study was conducted to determine the best harvesting techniques for natural stands of *G. scortechinii*.

MATERIALS AND METHODS

Description of Study Sites

The study was conducted in logged-over areas in Betau, Kuala Lipis in Pahang (Figure 1). The study area has a flat and undulating topography. The mean annual rainfall, temperature and humidity of the study site are 1500 mm, 30 ^{o}C and 89%, respectively. Natural stands of *Gigantochloa scortechinii* dominated the areas with a scattered distribution. The clump density was between 204 to 250 bamboo clumps per hectare.

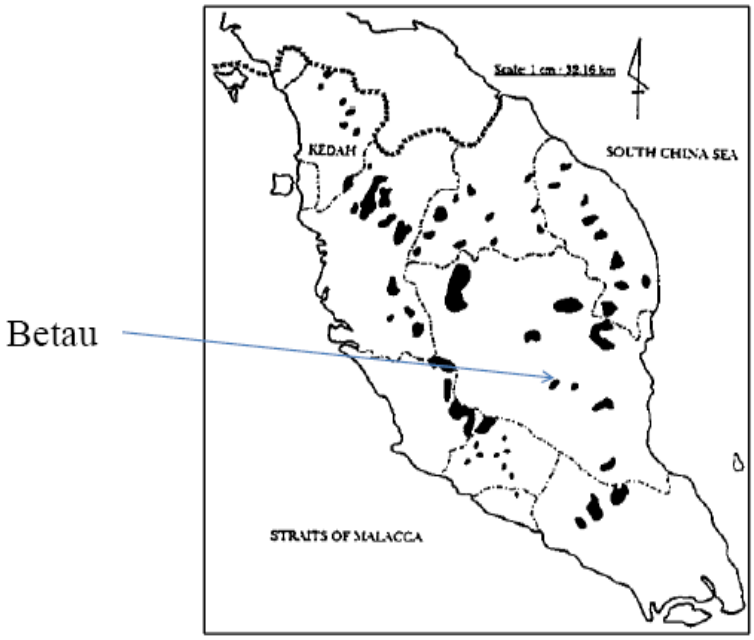

Fig. 1. Location of study sites in Betau, Pahang, Peninsular Malaysia.

Clump Density and Harvesting Techniques

Three clump densities of *Gigantochloa scortechinii* natural stands were classified; consisting of 10-25, 26-40 and more than 40 culms per clump, respectively. Three harvesting techniques were employed to extract the bamboo culms. The first technique is the Horse-shoe shape, the second technique is X-shape, and the third technique is clear-felling. The no-felling of culms was the control. The Horse-shoe

and X-shape techniques were applied by harvesting the mature culms, three year old and above, within the clump, that are mostly found in the inner zone of the clump. The distribution of the remaining culms was formed into a Horse-shoe and X-shape like clump. The third technique employed was clear-felling of all the standing culms. The harvesting techniques used in this study were based on various harvesting techniques and clump management as practiced in India (Lakshmana, 1988).

A factorial randomized design consisting of four harvesting techniques as the main-plot and three clump density as the sub-plot was used. The trial was conducted in a one hectare area. A total of 15 clumps for each harvesting technique were used, and consisted of five experimental units for each clump density in each site. A total of 60 clumps were randomly selected and observed in this trial. The parameters observed include the number of new culms produced, their height and diameter at breast height (DBH). Except for the no-felling control and clear-felling, all the culms were selectively felled for all the other techniques applied. The assessment was carried out 18 months after the harvesting techniques had been applied. All new emerged culms were marked with colored paint. Data were subjected to the Analysis of Variance (ANOVA).

The above-ground biomass consisted of newly produced culms, branch, leaf and total wet and dry weights at 18 months after treatments. This was estimated based on formulae by Abd. Razak (1994), based on earlier trials, that were carried out as follows;

$$H = -06199 + 2.2515D$$
$$W_c = 3483.82 + 5.1743D^2H$$
$$W_b = 587.047 + 1.0791D^2H$$
$$W_l = 626.463 + 0.9634D^2H$$
$$W_t = 4697.32 + 7.2169D^2H$$

Where:
D is DBH (cm)
H is Height (m)
W_c is Culm weight (g)
W_b is Branch weight (g)
W_l is Leaf weight (g)
W_t is Total dry weight (g)

Plot mean were subjected to the Analysis of Variance (ANOVA) with the fix effects model as below:

$$Y_{ij} = \mu + \alpha_i + \beta_j + \delta_{(ij)} + \varepsilon_{ij},$$

Where:
Y_{ij} is the plot mean of the *i*th harvesting technique in the *j*th clump density
μ is overall mean
α_i is the effect of the *i*th harvesting technique
β_j is the effect of the *j*th clump density
$\delta_{(ij)}$ is the effect of the interaction between *i*th harvesting technique and the *j*th clump density
ε_{ij} is the error associated with the *i*th harvesting technique in the *j*th clump density

RESULTS

Total Number of Culm of the Initial Establishment Stage

The mean total number of culm recorded before and after harvesting was carried out as shown in Table 1. In this initial stage, the percentage of removable culm for the Horse-shoe shape and the X-shape harvesting techniques were 15.8% and 6.5%, respectively, and the mean number of culms per clump retained after felling were 26.3 and 30.8, respectively. These results indicated that more culms were removed in the Horse-shoe shape harvesting technique compared with the X-shape harvesting technique in the initial stage of establishment.

Table 1. The total number of culms for each harvesting technique applied during the initial establishment stage and after harvesting of *Gigantochloa scortechinii*.

Harvesting technique	Total no. of culms	Total no. of culms after harvesting	% of removable culm	Mean no. of culms/clump retained
Control	572	572	0	38.1
Horse-shoe shape	469	395	15.8	26.3
X-shape	494	462	6.5	30.8
Clear-felling	411	0	100	0

Culms Development after 18 Months of Harvesting Treatments

The results from this study showed that harvesting techniques and clump density gave an effect on the emergence of new culms 18 months after harvesting had been carried out. The statistical analysis in Table 2 reveals that harvesting techniques and clump density have high significant differences, at 0.05%, on the emergence of the new culms after the felling treatments. However, no significant difference was observed on DBH. Height was highly affected by the harvesting technique applied while no effect of clump density was observed on height. Interaction between harvesting technique and clump density was significant only on new culm production.

Table 2. Analysis of Variances on mean number of total new culms produced of *Gigantochloa scortechinii* at 18 months after felling.

Source	DF	Total no. of new culms	Height	DBH
Technique (T)	3	4674.8**	99.0**	3.2 ns
Clump density (CD)	2	4214.0**	6.4 ns	0.7 ns
T * CD	6	558.0*	3.9 ns	1.2 ns
Error	47	192.6	2.1	1.2
Corrected total	58			

Note: ns - not significant at $P > 0.05$; * - significant at $P < 0.05$,
** - highly significant at $P < 0.001$.

Comparison of these values revealed that the mean new culms yield per clump varied significantly with harvesting techniques (Table 3). Clumps subjected to control produced 10.4 culms per clump, followed by X-shape and Horse-shoe shape techniques with 7.6 and 6.1 culms, both showed higher effect on the height, respectively. However, clear-felling gave the lowest yield of 4.4 culms per clump. This showed that the harvesting techniques that were related to number of culms removed will affect the production of new culms of the bamboo clumps. These results also showed a negative relation between harvesting intensity and culm regeneration. Hence, as the harvesting intensity increased, the recovery rate is reduced and resulted in lower productivity.

Results in Table 3 also indicate that the harvesting techniques applied may also affect the culms' characteristics in terms of height and DBH.

Table 3. Effects of harvesting techniques on mean number of new culms per clump produced, height and DBH of *Gigantochloa scortechinii* at 18 months after harvesting treatments.

Harvesting technique	No. of new culms	Height (m)	DBH (cm)
Control	10.4 a	16.0 a	6.8 ab
Horse-shoe shape	6.1 b	16.8 a	7.1 ab
X-shape	7.6 b	16.8 a	7.6 ab
Clear-felling	4.4 c	11.2 b	6.5 b

Note: Values with the different letter(s) are significantly different at $P < 0.05$ based on Student-Newman-Keuls test.

Moreover, mean yield revealed that felling of culm density of more than 40 culms/clump of bamboo resulted in higher culm production (Table 4). Felling of culms gave a significantly higher number of culm productions with an average of 10.5, 7.2 and 3.8 new culms per clump; for categories of above 40, 26-40 and 10-25 culms/clump groups, respectively. However, the culm height and DBH were not affected by clump density.

Table 4. Effects of clump density on number of new culms per clump produced, height and DBH of *Gigantochloa scortechinii* 18 months after harvesting treatments.

Clump density (no. of culms/clump)	No. of new culms	Height (m)	DBH (cm)
10 –25	3.8 c	14.8 b	6.9 a
26–40	7.2 b	16.0 ab	6.8 a
> 40	10.5 a	15.1 ab	7.2 a

Note: Values with the different letter(s) are significantly different at $P < 0.05$.

To sustain the yield and productivity of this bamboo, a culm selection system of harvesting should be adopted. This study indicated that harvesting techniques are closely related to culm removable percentage and density of a clump. The clump size also gave significant effect on culm production and clump condition. This study shows that the X-shape harvesting method is preferred,

and bamboo clumps which have more than 26 culms per clump can use this harvesting technique. Bamboo clumps having less than 26 culms per clump should be harvested selectively to attain better culm production. Thus, harvesting should be done selectively initially on the smaller clumps until they reach a limit of more than 26 culms per clump. It is important to have a systematic management of bamboo resources to ensure adequate and continuous supply of bamboo culms over a long period of time. This study also indicated that clear-felling is not recommended for harvesting *Gigantochloa scortechinii* due to low recovery. Similar results on *Dendrocalamus strictus* bamboo were reported by Varmah and Bahadur (1980).

It has been reported that good quality culm production also depended on the age of culm to be harvested and the harvesting cycle (Azmy *et al.*, 1997). In Indonesia, Yudodibroto (1985) reported that bamboo stands are harvested selectively to maintain good culm quality. Experiments conducted recommend the cutting of 3-4 year old culms; 5 culms per clump cut during the first year and 10 to 20 culms per clump with an increase in age or 15% of clump density. Some people cut their bamboo culms every three years rather than annually. In China, three year-old culms are retained while those over four-years old are felled, except for those necessary for maintaining the required canopy density (Guoging, 1985).

Effects of Harvesting Technique and Clump Density on the Above-ground Biomass of *Gigantochloa scortechinii*

The results from this study indicated that harvesting techniques and clump density gave effects on above-ground biomass increment on the emergence of new culms for the duration of 18 months after harvesting was carried out. The analysis in Table 5 shows that harvesting techniques and clump density had high significant and significant influence on the production of above-ground biomass respectively. However, no significant difference was observed in the interaction between harvesting technique and clump density.

Further examinations revealed that control treatment produced the highest above-ground biomass compared with the harvesting techniques applied. However, clumps subjected to the X-shape harvesting technique produced 86.7 kg followed by the Horse-shoe shape technique (81.5 kg). The clear-felling technique was the lowest (Table 6). This study indicated that the harvesting techniques applied and clump density will give an effect to the above-ground biomass production of the bamboo clumps. The results also showed that as the harvesting intensity increased, the recovery rate was reduced and resulted in lower productivity.

Similar results were observed on the effects of clump density (Table 7). The clump density of more than 40 culms per clump produced the highest above-ground biomass of new culms for all characteristics, while clump density between 10 to 25 culms per clump gave the lowest.

Table 5. Analysis of variances on the above-ground biomass increment produced by *Gigantochloa scortechinii* at 18 months after felling.

Source	DF	New Culms	Branch	Leaf	Total
Technique (T)	3	21971.1**	829.8**	743.2**	41725.3**
Clump density(CD)	2	10374.1*	392.0*	351.1*	19709.9*
T*CD	6	5523.7	210.2	186.8 ns	10505.6 ns
Error	47	3378.8	124.9	113.8	6395.7
Corrected total	58				

Note: ns – not significant at $P > 0.05$; * significant at $P < 0.05$;
** significant at $P < 0.01$.

Table 6. Effects of harvesting techniques on above-ground biomass increment of *Gigantochloa scortechinii* at 18 months after harvesting treatments.

Harvesting Technique	New Culms (kg)	Branch (kg)	Leaf (kg)	Total (kg)
Control	89.3 a	17.1 a	16.4 a	122.8 a
Horse-shoe shape	59.1 ab	11.5 ab	10.9 ab	81.5 ab
X-shape	62.9 ab	12.3 ab	11.6 ab	86.7 ab
Clear-felling	25.6 c	4.8 c	4.7 c	34.9 c

Note: Values with different letter(s) are significantly different at $P < 0.05$.

Table 7. Effects of clump density on above-ground biomass increment of *Gigantochloa scortechinii* at 18 months after harvesting treatments.

Clump Density (no. of culms/clump)	New Culms (kg)	Branch (kg)	Leaf (kg)	Total (kg)
10–25	30.2 b	5.8 b	5.6 b	41.6 b
26–40	54.9 ab	10.5 b	10.1 ab	75.4 ab
> 40	93.6 a	18.1 a	17.2 a	128.9 a

Note: Values with the different letter(s) are significantly different at $P < 0.05$.

DISCUSSION AND CONCLUSIONS

In order to ensure maximum culm and biomass productivity, it is essential to enforce a correct felling practice (Azmy *et al.,* 1977). Thus, the harvesting system does play an important role in determining the yield and to overcome the difficulty of space during harvesting in the natural bamboo stands. Systematic harvesting also increases the production of bamboo stock (Fateh Mohamad, 1931; Numata, 1979).

Based on the results of the study conducted, the *Gigantochloa scortechinii* natural stands should be managed systematically. The results indicated that the harvesting techniques and clump density gave highly significant effects on the emergence of the new culms, culm quality and above-ground biomass at 18 months after felling. The X-shape harvesting technique was recommended for natural stands because this method produced a higher number of new culms and greater total biomass as compared with the Horse-shoe shape harvesting technique. Furthermore, it is recommended that only bamboo clumps with a density of 26 culms/clump and above were suitable for this harvesting technique. Smaller clumps should not be harvested until they reach the limit of more than 26 culms/clump of bamboo. The clear-felling method was not recommended for harvesting of natural stands of *Gigantochloa scortechinii* due to slow recovery and low above-ground biomass production. With proper clump size selection and harvesting techniques used, natural bamboo stands can be managed sustainably.

REFERENCES

Abd. Razak Othman. 1994. Culm composition and above-ground biomass of *Gigantochloa scortechinii* in natural stand and a three-year-old plantation. *Journal of Tropical Forest Science* **7(2):** 280-285.

Azmy Hj. Mohamed, Norini Haron & Wan Razali Wan Mohd 1997. *Management Guidelines and Economics of Natural Bamboo Stands.* FRIM Technical Information Handbook No. 15. 40 pp.

Fateh Mohammad, M. 1931. The bamboo forest of Hoshiarpur District, Punjab, India. In *Bamboo Research in Asia.* G. Lessard and A. Chouinard (eds.). *Forester* **LVII:** 491-510.

Guoging, Li. 1985. Improved cultivation techniques of bamboo in North China. In *Proceedings of the International Bamboo Workshop: Recent Research on Bamboo.* 6-14 October 1985. Hangzhou, People Republic of China. p. 71-78.

Lakshmana, A. C. 1988. A new approach of the management of bamboo stands. In *Proceedings of the International Bamboo Workshop.* I.V. Ramanuja Rao, R. Ganaharan and C. B. Sastry (eds.) 14-18 November 1988. Cochin, India. p. 128-132.

Numata, M. 1979. The structure and succession of bamboo vegetation. In *Ecology of Grasslands and Bamboo Lands in the World.* Numata, M. (ed.). The Hague. p. 222-236.

Varmah, N. C. & Bahadur, K. N. 1980. Country report and status of research on bamboo in India. In *Proceedings of the International Bamboo Workshop: Bamboo Research in Asia.* 30 May 1980. Singapore. p. 19-46.

Yudodibroto, H. 1985. Bamboo research in Indonesia. In *Proceedings of the International Bamboo Workshop: Recent Research on Bamboo.* 6-14 October 1985. Hangzhou, People's Republic of China. p. 91-96.