MENSURATIONAL STUDIES IN *MELOCANNA BACCIFERA*

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PATTANAIK, S., PATHAK, K. C., BHUYAN, T. C., KHOBRAGADE, N., DAS, P. & PRASAD, K. G. 2004. Mensurational studies in *Melocanna baccifera*. Mensurational attributes of *Melocanna baccifera* culms were studied from five different locations in the state of Mizoram, India. Attributes such as culm height, internode length, internode diameter, culm wall thickness and number of nodes per culm were measured. Regression models were developed for internode length, internode diameter, culm wall thickness, culm height and culm volume. Results were found to be significant.

Key words: Mensuration – regression model – volume equation – functional relationship – *M. baccifera*

PATTANAIK, S., PATHAK, K. C., BHUYAN, T. C., KHOBRAGADE, N., DAS, P. & PRASAD, K. G. 2004. Kajian sukatan *Melocanna baccifera*. *Melocanna baccifera* disukat di lima lokasi di Mizoram, India. Sifat seperti tinggi batang, panjang ruas, diameter ruas, ketebalan dinding batang serta bilangan buku bagi setiap batang ditentukan. Model regresi dibangunkan untuk panjang ruas, diameter ruas, ketebalan dinding batang, tinggi batang serta isi padu batang. Keputusan yang didapati adalah bererti.

Introduction

Melocanna baccifera, commonly known as muli bamboo, is an evergreen bamboo found in India, Bangladesh and Myanmar. In India, it is mainly distributed in the north-eastern states of Assam, Manipur, Meghalaya, Mizoram and Tripura (Biswas *et al.* 1991). It is one of the most useful bamboos growing in this region, particularly in hilly terrain. It performs better on well-drained sandy clay loam and alluvial soils. It is principally used for building houses, for making woven wares and is an important source of superior pulp. This study was undertaken to investigate the variation in internode length, internode diameter and culm wall thickness along the entire length of the culm and to develop models for culm wall thickness, culm height and culm volume. These models can facilitate plus clump selection and yield prediction, which are important for the commercial utilisation of the species.

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Materials and methods

Internode length, internode diameter, culm wall thickness and total length were measured at five locations where *M. baccifera* occurs naturally in the state of Mizoram, India, located between 21° 56' and 24° 31' N latitude and 92° 16' and 93° 26' E longitude (Figure 1). The climate of Mizoram is warm per humid with average annual rainfall ranging from 2160 to 2770 mm. During winter, temperatures vary from 11 to 24 °C and in summer from 18 to 29 °C. Soils are mostly red and lateritic in nature. The terrain is mostly undulating with altitude ranging from 500 to 800 m.

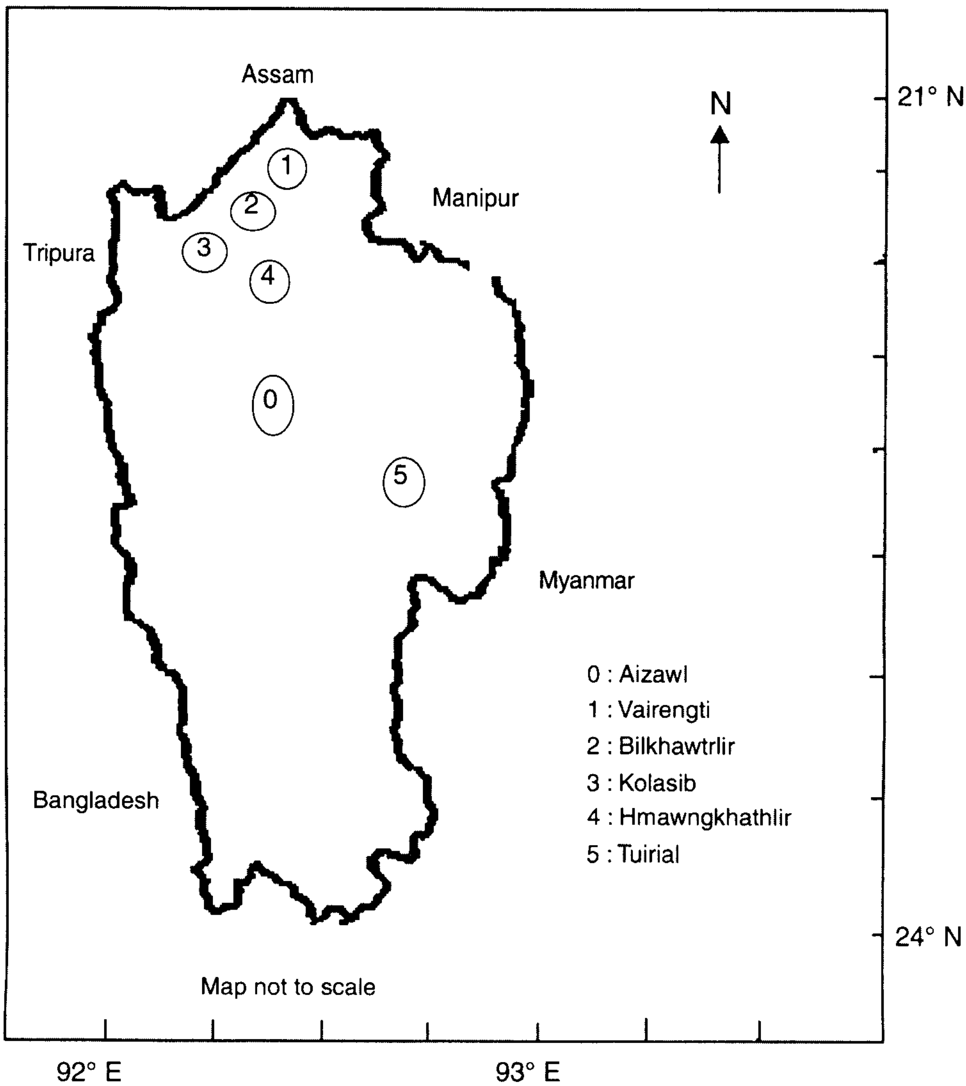

Figure 1 Map of the study area showing the five sampling locations

Multistage sampling technique was used to select the individual culms for measurement. In the first stage, five different locations were selected randomly. In the second stage, five clumps were selected randomly from each of the above five locations. In the final third stage, five culms (three-year-old and above) per clump were selected randomly and harvested flush with the ground level.

Internode length was measured for each internode starting from the base to the tip. Internode diameter was measured at the mid-point of each internode. The culms were then cut at this point to measure the diameter of the internodal cavity. Culm wall thickness was determined by using the formula $(D - d)/2$ where

D = internode diameter (cm),
d = internodal cavity diameter (cm).

The solid volume of each internode was calculated using the formula

$$V = \Pi L (D^2 - d^2)/4$$

where

V = internode volume (cm^3), and
L = internode length (cm).

Following this, individual internode volumes were summed to determine culm volume. The data were analysed using the software package STATISTICA, version 5.0 (1995). Suitable models were fitted to the data using the Quasi-Newton method of coefficient estimation for the following functional relationships.

1. Internode length = f (internode number)
2. Internode diameter = f (internode number)
3. Culm wall thickness = f (internode number)
4. Culm wall thickness = f (internode diameter)
5. Culm height = f (internode diameter)
6. Solid culm volume = f (internode length, internode diameter)

Results and discussion

The height of culms studied varied from 8.3 to 16.6 m with a mean of 11.87 m (Table 1). The number of nodes per culm varied from 27 to 54 with an average of 41.52. The mean, minimum, maximum and standard deviation of the internode length, internode diameter and culm wall thickness parameters are also given in Table 1.

Table 1 Descriptive statistics for the various parameters

Parameter	N	Mean	Min	Max	SD
Internode length (cm)	5076	29 374	2 00	62 00	11 061
Internode diameter (cm)	5076	03 179	0 15	06 70	1 706
Culm wall thickness (cm)	5076	00 528	0 04	02 70	0 334
Total culm height (m)	125	11 872	8 30	16 60	1 979
Number of nodes/culm	125	41 520	27 00	54 00	6 874

Internode length = f (internode number)

The internode length was studied as a function of internode number. It increased from the basal part of the culm until the 15th internode, then it decreased gradually until the 45th internode, after which a slight increase was again noticed. The relationship is best represented by a third order polynomial regression model (Figure 2). The model explained 71.99% of the variance in the dependent variable.

Model: $Y = a + (b_1 * X) + (b_2 * X^2) + (b_3 * X^3)$

$Y = 0.8102 + (5.3065 * X) - (0.2141 * X^2) + (0.0023 * X^3)$

where

Y = internode length (cm),

X = internode number,

a = constant, and

b_1, b_2, b_3 = regression coefficients.

Shigematsu (1958) studied the variation in internode length for 15 different bamboos of Japan and reported that internode length is species specific. Some bamboos have characteristically short internodes whereas in others, they are long. There is variation from base to top, even in the same species. The length of internodes determines the load bearing capacity of bamboo as well as its ability to peel, which in turn influences its use.

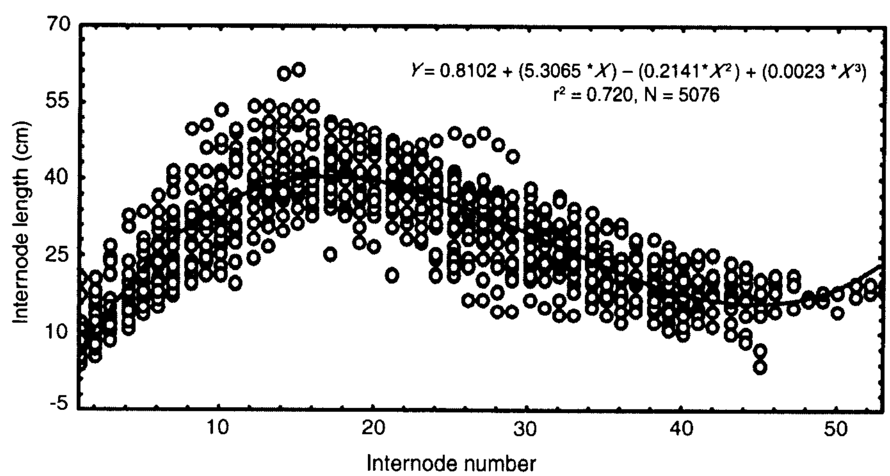

Figure 2 Scatter plot of the fitted function for internode length

Internode diameter = f (internode number)

Though a slight increase in internode diameter was noticed at the basal portion, internode diameter showed a gradual decrease towards the tip. A third order polynomial regression model as shown in Figure 3 accounted for 82.56% of the variation in the dependent variable.

Model: $Y = a + (b_1 * X) + (b_2 * X^2) + (b_3 * X^3)$

$Y = 4.3667 + (0.1525 * X) - (0.0123 * X^2) + (0.0002 * X^3)$

where

Y = internode diameter (cm),
X = internode number,
a = constant, and
b_1, b_2, b_3 = regression coefficients.

Unlike internode length, which increased until a considerable height (4.2 m) from the ground level, gradual tapering was noticed in internode diameter. Uchimura (1977) suggested that this attribute is species specific. The largest diameter in *Bambusa vulgaris* was at the middle of the culm, i.e. about 3 m from the base, while in *Schizostachyum lumampao* the largest was near the fifth internode, about 2.5 m above ground level.

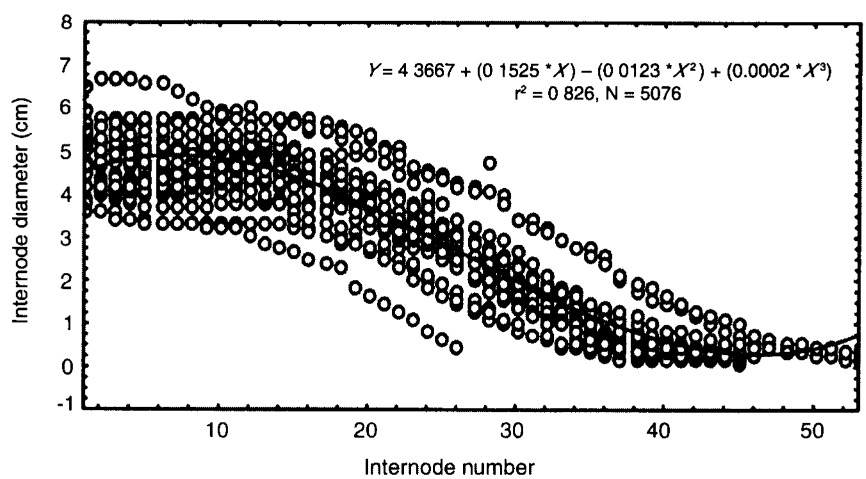

Figure 3 Scatter plot of the fitted function for internode diameter

Culm wall thickness = f (internode number)

Culm wall thickness showed a gradual decrease from base to top. A linear regression model explained 61.98% of the variation in the dependent variable (Figure 4).

Model: $Y = a + (b_1 * X)$

$Y = 0.97361 - (0.0209 * X)$

where

Y = culm wall thickness (cm),
X = internode number,
a = constant, and
b_1 = regression coefficient.

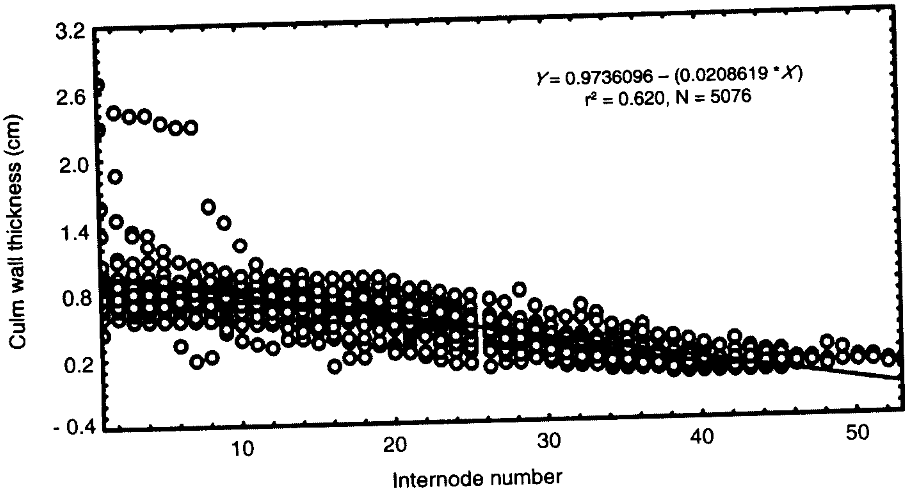

Figure 4 Scatter plot of the fitted function for culm wall thickness (as a function of internode number)

Culm wall thickness = f (internode diameter)

A high degree of correlation (r = 0.83) was noticed between culm wall thickness and internode diameter. A simple linear regression model explained 68.16% variation in the dependent variable (Figure 5).

Model: $Y = a + (b_1 * X)$

$Y = 0.01484 + (0.16159 * X)$

where

Y = culm wall thickness (cm),
X = internode diameter (cm)
a = constant, and
b_1 = regression coefficient.

The variation in culm wall thickness was found to be very interesting. On the one hand it decreased from the base upward to the tip and on the other, it had a direct relationship with the internode diameter, i.e. the greater the diameter the thicker the culm wall.

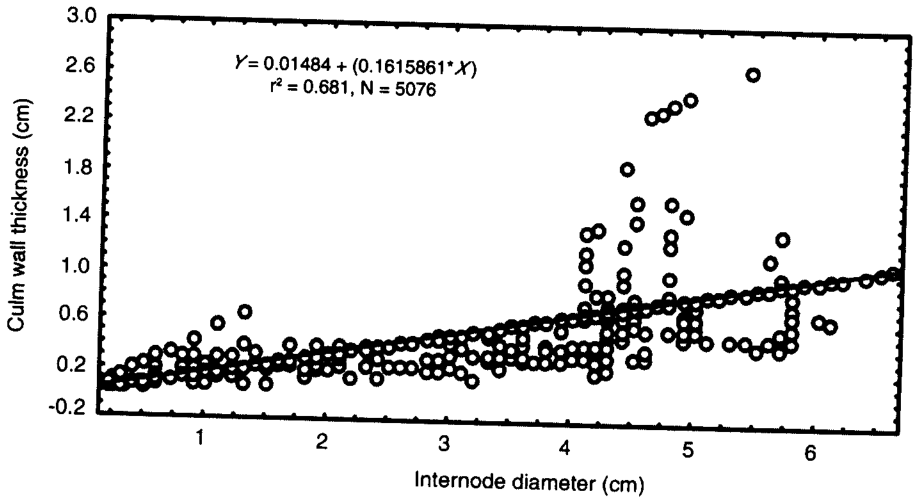

Figure 5 Scatter plot of the fitted function for culm wall thickness (as a function of internode diameter)

Culm height = f (internode diameter)

Out of the several models which were tried for fit to the data for culm height, polynomial regression of the third order showed the best fit with a correlation coefficient r = 0.69. The model explained 48.58% of variability in the dependent variable.

Model: $Y = a + (b_1 * X) + (b_2 * X^2) + (b_3 * X^3)$

$Y = 110.7046 - (70.1110 * X) + (15.75205 * X^2) - (1.12822 * X^3)$

where

Y = culm height (m),
X = culm diameter at eighth internode (cm),
a = constant, and
b_1, b_2, b_3 = regression coefficients.

Watanabe and Ueda (1976) developed an exponential type model for Japanese bamboo *Phyllostachys bambusoides* ($Y = a * X^b$). However, in this study a third order polynomial regression model fitted the data better. The point of diameter at breast height measurement in bamboos needs some further investigation. Sometimes the points fell on nodes where it was not possible to get correct diameter measurements due to the presence of branches.

In this study, the internode length and internode diameter at the eighth internode were used for culm height and culm volume models. The correlation coefficient value improved from the base till the eighth internode. Beyond this internode, logistical problems were encountered when taking measurements since the eighth internode of *M. baccifera* was 1.37 m above the ground.

Culm volume = f (internode length, internode diameter)

Internode length and internode diameter at the eighth internode were highly correlated (r = 0.91) to solid culm volume (excluding the cavity volume). A linear multiple regression model best fitted the data and was found to be highly significant (1% level). The model accounted for 83.31% of the variation in the dependent variable.

$$\text{Model: } V = a + (b_1 * L) + (b_2 * D)$$
$$V = -0.008178 + (0.000004 * L) + (0.003165 * D)$$

where

V = culm volume (m^3),
L = internode length at eighth internode (cm),
D = internode diameter at 8th internode (cm),
a = constants, and
b_1, b_2 = regression coefficients.

Volume equations are species specific as some bamboos like *Dendrocalamus strictus* have thick walls with minimal internodal cavity space while others (e.g. *Schizostachyum dullooa*) have thin walls. Hence, a model developed for one species may not work for other species.

Conclusions

Bamboos are most important in the pulping industry. The output of bamboos is conventionally measured in terms of tonnage. The volume equation developed in this study can be used to determine clump volume or stand volume, which will help in yield prediction for a particular area. The models presented here will enable resource managers to plan their cutting cycles on a sustainable basis. The equations will also be useful for researchers involved in bamboo improvement programmes. During the selection procedure, individual culm volumes can be easily determined, thereby, facilitating selection procedures of plus clump.

It is hoped that this study will serve as an impetus for other detailed studies to be conducted for *M. baccifera* from different locations.

Acknowledgement

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References

BISWAS, S., NAITHANI, H. B. & CHANDRA, S. 1991. Occurrence of *Melocanna baccifera* in Sikkim. *Indian Forester* 117: 583–586

SHIGEMATSU, Y. 1958. Analytical investigation of the stem form of important species of bamboo. *Bulletin of Faculty of Agriculture* 3: 124–135

UCHIMURA, E. 1977. *Ecological Studies on the Cultivation of Bamboo Forest in Philippines.* Forest Research Institute Library, College Laguna.

WATANABE, M. & UEDA, K. 1976. On the structure of Madake (*Phyllostachys bambusoides*). *Reports of the Fuji Bamboo Garden* 21: 9–26.