FIBRE CHARACTERISTICS OF *GIGANTOCHLOA LEVIS* AND *DENDROCALAMUS ASPER* AS INFLUENCED BY ORGANIC FERTILIZERS

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ABASOLO, W. P., FERNANDEZ, E. C. & LIESE, W. 2005. Fiber characteristics of *Gigantochloa levis* and *Dendrocalamus asper* as influenced by organic fertilizers. The influence of chicken manure, cow dung and rice hull ash applied at different rates for a period of three years on the fibre characteristics of *Gigantochloa levis* and *Dendrocalamus asper* was evaluated. When changes in soil composition brought about by organic fertilizer treatments were correlated to the individual fibre characteristics, there was a significant relationship. Fibre wall thickness of both species was positively influenced by pH while nitrogen only affected the fibre diameter of *D. asper.* Phosphorus increased the fibre length of *G. levis* and the fibre wall thickness of *D. asper.* Potassium positively affected the fibre diameter of *G. levis* but negatively influenced the fibre wall thickness of *D. asper.* Finally, organic matter significantly increased fibre diameter of both species. In order to control the quality of bamboo fibres for a desired end-use of the material it is crucial to observe the soil composition.

Key words: Chicken manure – cow dung – rice hull ash – fibre wall thickness

ABASOLO, W. P., FERNANDEZ, E. C. & LIESE, W. 2005. Ciri gentian *Gigantochloa levis* dan *Dendrocalamus asper* di bawah pengaruh baja organik. Kesan tahi ayam, tahi lembu dan abu sekam padi yang dibubuh pada kadar berbeza selama tempoh tiga tahun dikaji terhadap ciri-ciri gentian *Gigantochloa levis* dan *Dendrocalamus asper.* Apabila perubahan komposisi tanih yang diakibatkan oleh baja organik dikorelasikan dengan ciri gentian individu, satu hubungan signifikan didapati. Ketebalan dinding gentian kedua-dua spesies dipengaruhi secara positif oleh pH sementara nitrogen hanya memberi kesan kepada diameter gentian *D. asper.* Fosforus meningkatkan panjang gentian *G. levis* dan ketebalan dinding gentian *D. asper.* Kalium mempengaruhi secara positif diameter gentian *G. levis* tetapi sebaliknya bagi ketebalan dinding gentian *D. asper.* Bahan organik meningkatkan secara signifikan diameter gentian kedua-dua spesies. Oleh itu, untuk mengawal kualiti gentian buluh mengikut kegunaan akhir yang dikehendaki, adalah penting komposisi individu tanih diawasi.

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Introduction

Bamboo is the second most important non-timber forest resource in the Southeast Asian region. Its strength to weight ratio, straightness, short rotation and easy propagation make it a versatile material suitable for a variety of purposes (Espiloy 1994). There are approximately 87 genera with about 1500 species of bamboo worldwide (Ohrnberger 1999) of which 62 species are found in the Philippines (Rojo 1996). The economically important bamboo species are kauayang tinik (*Bambusa blumeana*), kauayang killing (*B. vulgaris*), giant bamboo (*Dendrocalamus asper*), bayog (*D. merrilianus*), kayali (*Gigantochloa atter*), bolo (*G. levis*), buho (*Schizostachyum lumampao*) and anos (*S. lima*).

Due to the enormous demand for bamboo coupled with insufficient management, the supply of bamboo poles in Philippines has dwindled in recent years. From a total of 2 337 000 poles harvested in 2000, the supply was drastically reduced to only 537 000 in 2001 causing the country a loss of USD5 277000 in export earnings (Anonymous 2001). It is, therefore, crucial to improve the supply of bamboo poles to meet future demands.

The existing raw material supply can only be increased through the establishment of plantations. Studies on plantation-grown bamboos have shown that with proper silvicultural treatments, e.g. fertilizer application, bamboos from newly established plantations can be harvested after five to six years. A main drawback of plantation-grown plants is that their properties, namely, anatomical, mechanical, physical and chemical are quite unknown. Moreover, similar to trees, enhanced growth could affect the qualities of bamboo, making it inferior to naturally-grown culms. Thus, for plantation grown culms there is a need to clarify the influence of growth-boosting substances, e.g. fertilizers, especially on fibre characteristics. Therefore, a study was conducted to determine the impact of different organic fertilizers, namely, cow dung, chicken manure and rice hull ash on the fiber characteristics of culms from newly established plantations.

Materials and methods

Materials

Culms of *G. levis* and *D. asper* grown in permanent plots at UP Laguna-Quezon Land Grant area in Real, Quezon, Philippines, were investigated. The organic fertilizers used were cow dung, chicken manure, and rice hull ash. For three years, the application of fertilizers was segregated as follows: first year—0, 0.5, 1 and 2 kg/hill once every two months; second year—0, 0.75, 1.5 and 3 kg/hill applied quarterly; and third year—0, 1.5, 3 and 6 kg/hill every six months. This means an annual application rates of 0, 3, 6 and 12 kg/hill. Every fertilizer regime was duplicated. Details are as given in Fernandez *et al.* (2003).

Soil and fertilizer characteristics

The study site is characteristically acidic (pH 4.8), low in organic matter content (5.17 to 6.64%), and clayish to slightly sandy. Nitrogen content ranged from 0.18 to 0.19%, phosphorus from 1.40 to 1.75 ppm and potassium from 0.19 to 0.14 me/100 g soil. The initial level of acidity could impair growth and should be improved for the survival of the plants. Use of commercial fertilizers could enrich the quality of soil resulting in better growth conditions but this would entail additional cost. Thus, cheap organic fertilizers were applied.

The fertilizers used were relatively neutral (pH 7 to 7.3), except for the slightly basic rice hull ash (pH 9.2). Nitrogen content ranged from 1.08 to 1.33%, phosphorus from 0.63 to 0.84% and potassium from 0.39 to 1.23%.

Sample preparation

From the four-year-old plantation, three-year-old culms were selected. Culm diameter ranged from 4.39 to 5.49 cm for *G. levis* and 5.89 to 7.50 cm for *D. asper.* Total length was from 5.27 to 7.35 m and 6.37 to 9.03 m respectively. Harvesting was performed in mid April 2002 just before the onset of the rainy season. From the fifth internode, which was approximately the middle part of the culms, sample disks were cut. From these disks, matchstick samples were randomly taken and soaked in test tubes containing 50:50 solutions of 20-volume hydrogen peroxide and glacial acetic acid. To facilitate fiber separation the tubes were heated in a hot water bath and gently stirred until most of the sticks were defibrated. The suspension was then cleaned of all traces of acid using distilled water. The fibres were then mounted onto glass slides.

Anatomical observation

The slides were observed under a Union TM Shop Measuring Microscope. A total of 30 randomly selected whole fibres were measured for their lengths and diameters at 100× magnification while lumen diameter at 400× magnification. Fibre wall thickness was derived from the average difference of fibre diameter and lumen diameter. With one replicate, a total of 60 fibre samples were evaluated.

Statistical analysis

To determine whether the individual fertilizer treatment significantly affected fibre characteristics, analysis of variance (ANOVA) at $p = 0.05$ was performed. Regression analyses were conducted for the impact of soil chemical composition.

Results and discussion

Table 1 shows the changes in soil composition before and after fertilizer treatments. The chemical constituents tested were improved after treatments. Treatments reduced soil acidity but increased nitrogen content. Chicken manure significantly raised the phosphorus as well as the potassium levels, while cow dung improved the organic matter content. Rice hull ash slightly affected the phosphorus and the potassium levels.

Fibre length of the untreated samples of *G. levis* and *D. asper* were 3.3 and 3.0 mm respectively (Figures 1a and b). These are much longer than the values reported by Liese and Grosser (1972), which were 1.80 and 1.94 mm respectively. For various treatments, increasing the fertilizers produced longer fibre in *G. levis*. In *D. asper* fiber length was more or less the same regardless of which fertilizer was applied. In

Table 1 Changes in soil properties before and after fertilizer treatments (kg/hill) on *Gigantochloa levis* (GL) and *Dendrocalamus asper* (DA) plots

	pH		N (%)		P (ppm)		K(me/100 g soil)		Organic matter (%)	
	GL	DA	GL	DA	GL	DA	GL	DA	GL	DA
Before treatment (1998)	4.80	4.80	0.18	0.19	1.40	1.75	0.19	0.14	5.17	6.64
After treatment (2001)										
Control	4.80	4.90	0.35	0.30	1.00	1.00	0.21	0.20	7.00	6.00
CM										
3	5.10	4.70	0.37	0.35	1.00	30.00	0.68	0.83	7.40	6.90
6	5.40	5.00	0.41	0.35	44.00	77.00	2.09	1.17	8.20	7.00
12	5.30	5.00	0.43	0.38	138.00	80.00	2.47	1.91	8.50	7.60
CD										
3	5.10	5.00	0.42	0.42	24.00	19.00	0.67	0.54	8.30	8.83
6	5.10	4.90	0.43	0.40	23.00	26.00	0.72	0.79	8.50	8.00
12	5.50	5.40	0.44	0.32	44.00	56.00	1.89	1.19	8.70	6.40
RHA										
3	4.60	4.80	0.39	0.46	5.00	2.00	0.54	0.48	7.70	9.10
6	4.60	4.70	0.38	0.35	2.00	4.00	0.40	0.38	7.50	6.90
12	4.80	4.90	0.38	0.35	10.00	14.00	0.65	0.60	7.60	6.90

CM : Chicken manure
CD : Cow dung
RHA : Rice hull ash

general it was deduced that the fertilizers did not significantly affect the length of the fibres. The fibres produced are also shorter than the control.

Figures 2(a) and (b) show the influence of the different organic fertilizers on fibre diameter. Fibre diameter of *G. levis* ranged from 0.020 to 0.030 mm compared with 0.018 to 0.021 mm in *D. asper*. The values reported by Liese and Grosser (1972) according to their literature survey on the same species were 0.22 and 1.12 mm respectively. In *G. levis*, thinner fibres than the control were produced regardless of the type of fertilizer used. The fibre diameter of *D. asper* was hardly affected by the treatments.

Lumen diameter of *G. levis* was two times larger than *D. asper* (Figures 3a and b). With the exception of CD (6), all fertilizer treatments in *G. levis* yielded narrow lumen diameter. For *D. asper*, most of the treatments resulted in a slightly wider lumen compared with control.

Cell wall thickness ranged from 0.006 to 0.010 mm in *G. levis* and from 0.006 to 0.023 mm in *D. asper* (Figures 4a and b). For *G. levis*, fertilizer treatments did not affect the fibre wall thickness. CM and CD at 12 kg $year^{-1}$ greatly enhanced the fibre wall thickness of *D. asper* increasing to 0.018 and 0.023 mm respectively.

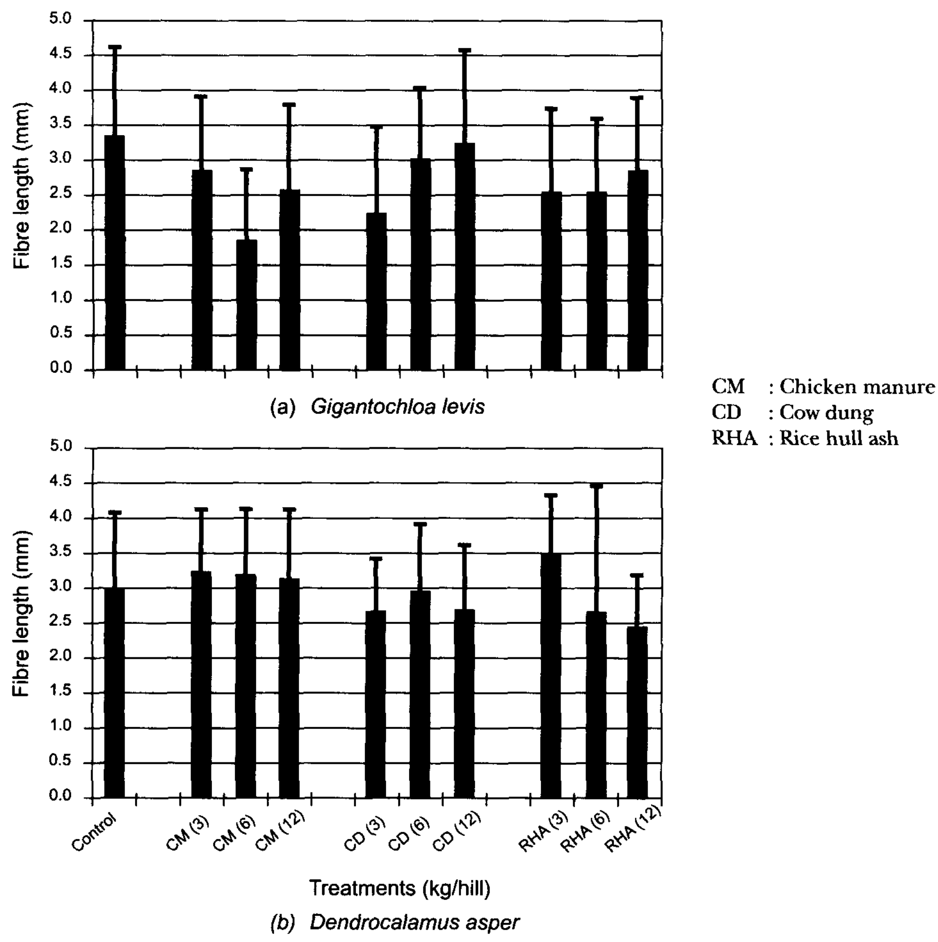


Figure 1 Influence of different organic fertilizers on fibre length (± SD)

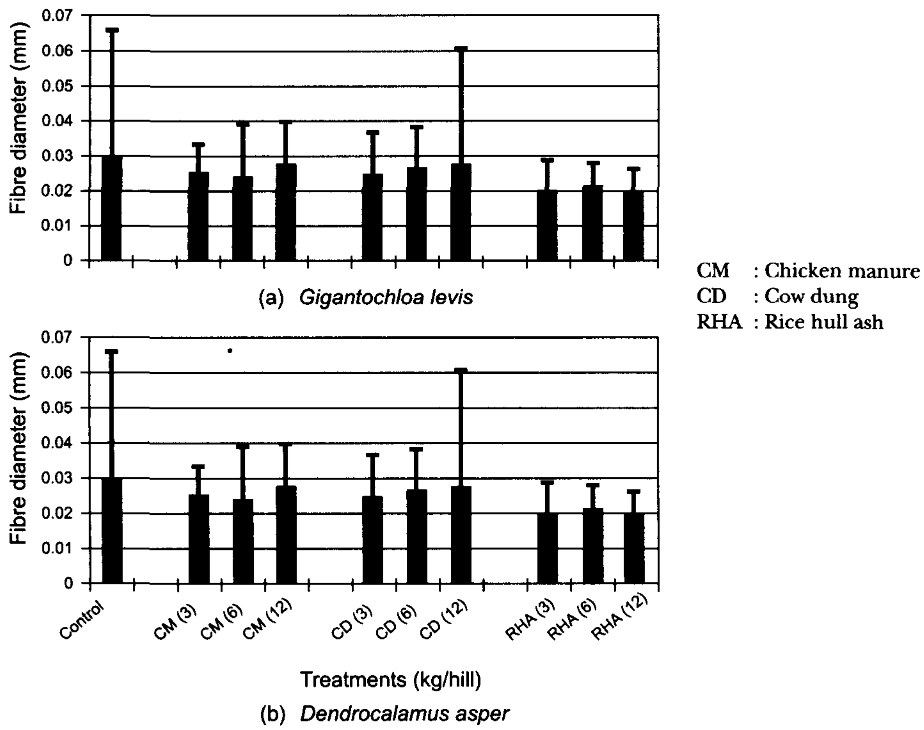
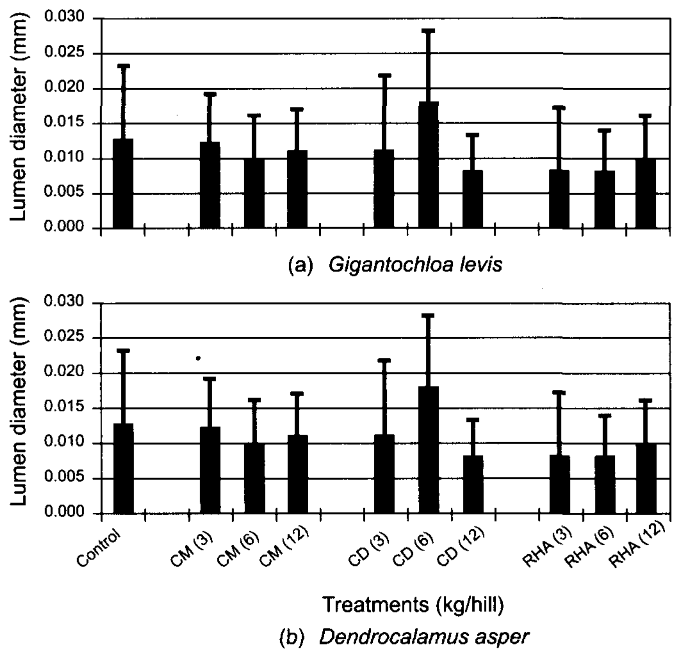


Figure 2 Influence of different organic fertilizers on fibre diameter (± SD)

In general, it can be stated that different fertilizers applied at different rates did not significantly fluctuate from the control. This is similar to the findings of Abd. Latif and Liese (2001) on *Bambusa vulgaris* and *G. scortechinii* grown in different soil types in Peninsular Malaysia. One possible reason for this finding is that the impact of the fertilizers were evaluated as a whole without considering the changes they brought to the soil properties. Thus as a second approach, namely, the relationship between the individual soil constituents after treatment and the fiber characters, were also evaluated.

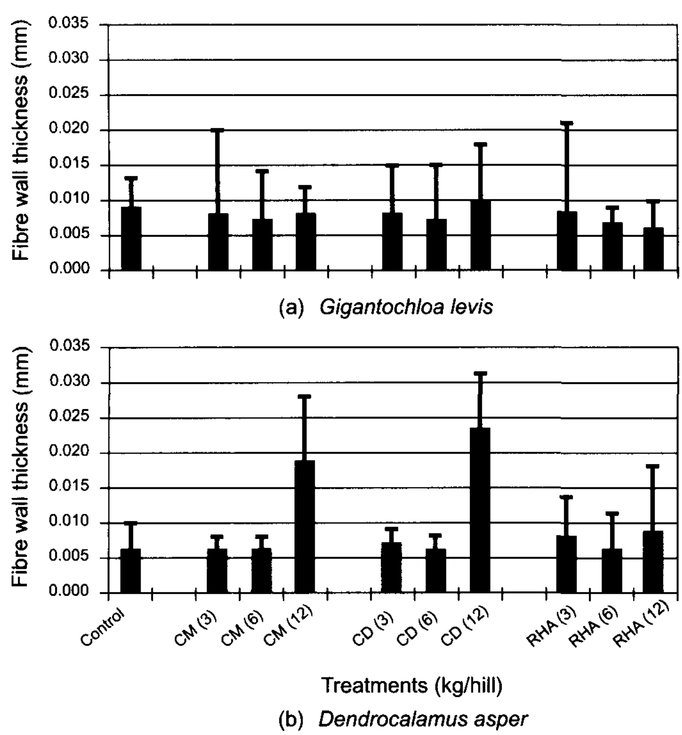
Tables 2(a) and (b) provide a summary of the regression analysis conducted. From these tables, it is obvious that the two bamboo species differ in their responses to pH changes. In *G. levis*, only fibre diameter and wall thickness were affected by pH changes while in *D. asper* all the fibre properties were influenced. Fibre wall thickness is an important property because it represents fibre strength. In both species fibre wall thickness was positively changed by an increase in pH. Thus pH level of the soil should be monitored to improve the strength properties of culms in plantations.

Nitrogen did not influence any of the fiber characteristics of *G. levis*. For *D. asper* on the other hand, fibre length and diameter were significantly affected by the nitrogen content. This means that if *D. asper* is to be used for purposes requiring longer fibres, e.g. pulp and paper and fibreboard composites, increasing the nitrogen content of the soil might be beneficial.



CM : Chicken manure
CD : Cow dung
RHA : Rice hull ash

Figure 3 Influence of the different organic fertilizers on lumen diameter (± SD)



CM : Chicken manure
CD : Cow dung
RHA : Rice hull ash

Figure 4 Influence of the different organic fertilizers on fibre wall thickness (± SD)

Table 2(a) Summary of the influence of soil composition on fibre characteristics of *Gigantochloa levis*

	pH	N	P	K	Organic matter
Fibre length (mm)	y = 3.35 - 0.14x r = 0.10	y = 3.72 - 2.25x r = 0.17	y = 2.87 - 0.005x r = 0.59	y = 2.72 - 0.08x r = 0.16	y = 1.96 + 0.08x r = 0.10
Fibre diameter	y = .002 + .005x r = 0.72*	y = 0.02 - 0.004x r = 0.004	y = 0.02 - 2E-5x r = 0.28	y = 0.02 + .002x r = 0.68*	y = -0.01 + .004x r = 0.72*
Lumen diameter (mm)	y = 3.35 - 0.14x r = 0.10	y = 3.35 - 0.14x r = 0.10	y = 3.35 - 0.14x r = 0.10	y = 3.35 - 0.14x r = 0.10	y = 3.35 - 0.14x r = 0.10
Cell wall thickness (mm)	y = .006 + .001x r = 0.48*	y = .006 + .005x r = 0.14	y = .008 - 8E-7x r = 0.04	y = 007 + .0005x r = 0.37	y = -.003 + .001x r = 0.61*

* : Significant at 5%

Table 2(b) Summary of the influence of soil composition on fibre characteristics of *Dendrocalamus asper*

	pH	N	P	K	Organic matter
Fibre length (mm)	y = 5.9 - 0.59x r = 0.56*	y = 2.14 + 2.16x r = 0.48*	y = 2.89 + 0.02x r = 0.19	y = 2.84 + .13x r = 0.21	y = 2.19 + .11x r = 0.43
Fibre diameter (mm)	y = .03 - .002x r = 0.51*	y = 0.01 - .018x r = 0.91*	y = 0.02 - 1E-5x r = 0.38	y = 0.12 + .0004x r = 0.19	y = 0.02 + .001x r = 0.90*
Lumen diameter (mm)	y = -.004 + .002x r = 0.56*	y = .008 - .004x r = 0.24	y = .01 - 1E-5x r = 0.36	y = .007 - .001x r = 0.30	y = .01 - .0002x r = 0.13
Cell wall thickness (mm)	y = - 0.12 + .03x r = 0.95*	y = .0.02 - .04x r = 0.35	y = 0.01 + .0001x r = 0.59*	y = 002 - .009x r = 0.69	y = -.02 - .002x r = 0.22

* : Significant at 5%

For *G. levis*, only fibre length was significantly influenced by phosphorus levels in the soil. As the level increased, shorter fibres occurred. For *D. asper*, fibre wall thickness was moderately affected by phosphorus content.

Potassium only affected fibre diameter of *G. levis* and fibre wall thickness of *D. asper*. However, potassium inversely affected fibre wall thickness of *D. asper*. Thus for this species, minimal changes in potassium content are recommended. Nevertheless, if the material is to be used for pulp and paper, increasing potassium content would be advantageous.

For both species, enhancing the organic matter content of the soil led to the production of broader fibres. However, in *G. levis,* it also increased fibre wall thickness and this will make beating more difficult.

Conclusions

Fibre characteristics of the two bamboo species responded differently to the organic fertilizers applied. The response was not obvious when the fertilizers were taken as a whole. Only when actual changes in soil characteristics after organic fertilizer treatments were considered, a significant correlation was observed. pH and phosphorus affected the fibre wall thickness while nitrogen, potassium and organic matter influenced the fibre diameter. Therefore, to improve the characteristics of the fibres for a desired end-use of the bamboo material, it is important to monitor the level of pH, nitrogen, phosphorus, potassium and organic matter content of the soil.

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