Asian Journal of Plant Sciences

ISSN 1682-3974

OPEN ACCESS

Asian Journal of Plant Sciences

ISSN 1682-3974
DOI: 10.3923/ajps.2018.129.133

CrossMark

Research Article
Characteristic of Vascular Bundles and Morphology of *Gigantochloa apus* (J.A. and J.H. Schulltes) Kurz Culm

Atmawi Darwis, Ihak Sumardi, Yoyo Suhaya and Sopandi Sunarya

School of Life Sciences and Technology, Institut Teknologi Bandung (ITB), Gedung Labtek XI, Jalan Ganesha 10, 40132 Bandung, West Java, Indonesia

Abstract

Background and Objective: Bamboo culm was composed of internodes and nodes. Anatomically, bamboo culm was composed of vascular bundles (VB) and parenchymal base tissue. The purpose of this study was to determine the morphology features of culm and VB of bamboo *Gigantochloa apus*. **Materials and Methods:** The sample was taken from each internode of bamboo. The morphology of bamboo culm was determined by measuring the length, diameter and wall thickness. VB characterization was obtained through observation on each internode of bamboo culm. **Results:** The results showed that bamboo culm had internode length and inner diameter that varied from the bottom, increased at a certain height then decreased toward the top. The size of outer diameter and wall thickness of bamboo culm tended to decrease from bottom to top. VB on each internode was spread unevenly where the distance between VB looked more widened from the outer layer to the inner layer. VB distribution in the cross section had a crossing pattern (alternate). VB varied in shape and size from outer layer to inner layer of bamboo culm. The VB type on an internode of *G. apus* bamboo culm also showed variations where there was VB in type III only and some also were in type (III and IV) in each internode. **Conclusion:** The morphology of the bamboo culm was influenced by the morphology of young shoot. VB of bamboo *G. apus* spread unevenly with varying sizes, shapes and type from the outer layer to the inner layer.

Key words: Morphology, bamboo, culm, internode, distribution, vascular bundles, *Gigantochloa apus*

Citation: Atmawi Darwis, Ihak Sumardi, Yoyo Suhaya and Sopandi Sunarya, 2018. Characteristic of vascular bundles and morphology of *Gigantochloa apus* (J.A. and J.H. schulltes) kurz culm. Asian J. Plant Sci., 17: 129-133.

Corresponding Author: Atmawi Darwis, School of Life Sciences and Technology, Institut Teknologi Bandung, Jl. Ganesha No. 10, 40132 Bandung, West Java Indonesia Tel: +62-81314230918

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Bamboo is a plant belonged to the Gramineae family, Bambuseeordo and Bambusoideae subfamily. This plant is easy to grow and develop in Indonesia from coast to mountain. There are approximately 1,000 bamboo species in 80 genera and about 200 species from 20 genera are found in Southeast Asia[1]. In Indonesia, there are 118 native species and 17 are introduced species[2].

Bamboo *G. apus* is one of the common bamboo species found in Indonesia, especially in Java Island. Bamboo is growing abundantly on the island of Java, generally planted in the countryside but can also be found growing wild in national parks[3]. Bamboo *G. apus* has a close relationship with the community where this plant has many benefits to support the life of its surroundings[4]. Bamboo can be used for various purposes such as: Craft, furniture, pulp and paper and building materials[5-7]. The existence of bamboo can be categorized as economic support and cannot be separated from community life[3].

Young bamboo (Young shoot) is a new plant that arises from the rhizomes or lateral bud of the rhizomes[1]. Young shoots are generally 20-30 cm long, tapering at one end and protected by sheaths. Each shoot that emerges from the soil contains already in miniature all the nodes, segments and diaphragms. The middle part of young shoot has a large diameter cavity compared to the bottom and top[8].

Bamboo culms have a circular cross-section and are axially slightly conically tapered[9]. This fact affects the variation in diameter of culm (outer diameter), cavity (inner diameter) and bamboo wall thickness along the entire bamboo culm[10]. The variation becomes one of the considerations in the utilization of bamboo stems. The culm of bamboo is the most useful part for industrial utilization. In the industrial utilization of bamboo, particularly for making bamboo-based panels, bamboo species with large stems are selected[11].

Bamboo culm as a biological product has various properties. Vascular bundles and basic tissue parenchyma are the main constituents of bamboo culm. The characteristics of these two components have an effect on the physical and mechanical properties of bamboo[12-14]. This variation occurs in bamboo culm, age, species and environment of growing[15].

Vascular bundles are distributed unevenly from the outer layer to the inner layer of the bamboo culm. The number of vascular bundles is increasingly rare from the outer layer to the inner layer of the bamboo culm[12,16]. The shape and size of vascular bundles of bamboo culm also show variations both from the bottom to the top and from the outer layer to the inner layer.

In this research, we analyze the morphological characters of *G. apus* culm and the distribution and shape of vascular bundles in the bamboo from their bottom to top. The results are very helpful to comprehend the morphological and anatomical features of *G. apus* and also to make basic records for another types of bamboo.

MATERIALS AND METHODS

Three culms of bamboo *G. apus* used in the study were obtained from Sayang Village, Jatinangor Subdistrict, Sumedang Regency, West Java, Indonesia. The bamboos used were two years old. This research was conducted from April, 2017 until February, 2018.

Each bamboo culm was measured in dimensions: Internode length, outer and inner diameter and wall thickness of culm. The measurement results were projected in the drawing sketch to determine the morphology or the shape of bamboo culm. Observation of the distribution and shape of vascular bundles on bamboo culm was conducted by cutting 2 cm length at the middle part of internode. The piece was then slashed at the cross section with a sharp knife. Samples were observed in the distribution and shape of vascular bundles using Nikon SMZ 745T stereos. The observations were displayed on the computer screen and analyzed with NIS Elements v.4.00.00 imaging software.

RESULTS AND DISCUSSION

Morphological characters of *G. apus* culm: The shape of bamboo culm was basically composed of internodes and separated by a node. Bamboo culm was composed of internodes with varying lengths as shown in Fig. 1. In a bamboo *G. apus* culm, the internode length increased from the bottom until the 10th and 11th internodes then decreased

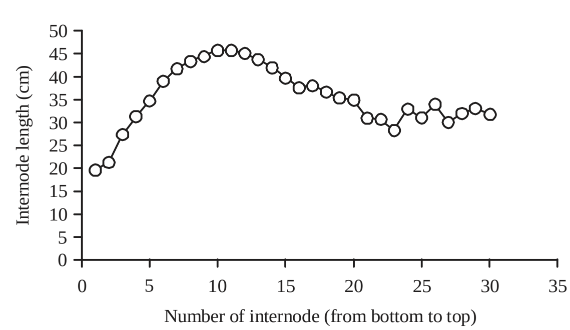

Fig. 1: Internode length on bamboo culm of *G. apus* from bottom to top

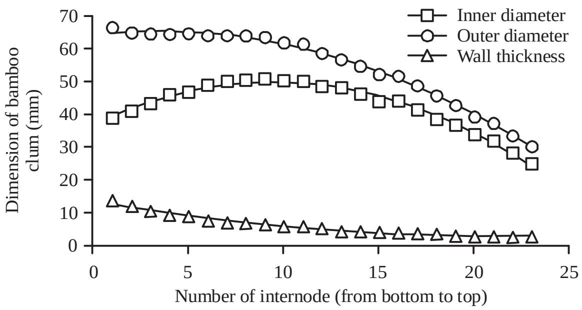

Fig. 2: Dimensions of bamboo culm of *G. apus*: Outer diameter, inner diameter and wall thickness from bottom to top

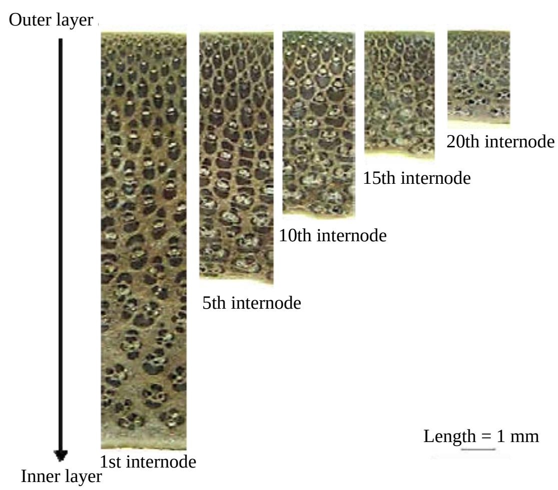

Fig. 3: Distribution of vascular bundles from the outer layer to the inner layer on the internode of the bamboo culm of *G. apus*

to the top. The increase in length started again on the 24th internode but did not exceed its maximum length. The minimum and maximum length of bamboo internodes were 19.67 and 45.67 cm, respectively. Internode length variations also occur in other bamboo species such as in *Schizostachyum*[17], *Bambusa striata*[18].

The bamboo culm dimensions such as outer and inner diameter and wall thickness indicated variation from bottom to top (Fig. 2). The diameter and wall thickness of the bamboo culm on each internode showed a decrease from bottom to top. The inner diameter dimension of the bamboo increases from the bottom to the middle (9th internode) and then decreased in size to the top. The range of outer diameter, inner diameter and wall thickness of the bamboo culm were 30.08-66.21, 24.85-50.78 and 2.62-13.75 mm, respectively. Usually, the preferred bamboo was one that has a straight bamboo culm and approximately the same diameter at both ends. Based on Fig. 2 bamboo culm of *G. apus* shape was like cylinder tube starting from the bottom to 9th internode with length of 302.67 cm. If the expected bamboo culm had the same diameter at both ends, the utilized bamboo culm was only about 1/4 part of the total length. Bamboo would be more usefully effective if made into bamboo split.

The bamboo *G. apus* morphology was not different from the young shoot. When young shoot was split in longitudinal direction, largest cavity diameter was found in the middle part. The growth of bamboo culm did not only occur at the top (apical meristem) but also occurred in its constituent internodes (intercalary meristem) causing the shape of young shoot was not different from the old bamboo culm shape. The diameter of the mature culm also was already determined by the diameter of the young shoot[1]. This form was also found in *Bambusa vulgaris*[19]. The morphology of a young shoot was often very characteristic in recognizing a mature bamboo culm.

Distribution and shape of vascular bundles in *G. apus* culm: Anatomically, vascular bundles and parenchymal base tissue were the main components of bamboo culm. Both of these components played an important role in the properties of bamboo. Vascular bundles were spread unevenly from the outer layer to the inner layer (Fig. 3). The distribution of vascular bundles which expressed the number of vascular bundles per mm^2 area on each internode bamboo culm showed the same pattern. Vascular bundles on the outer layer were numerous and less frequent to the inner layer. The distance between the vascular bundles got closer with the higher internode position on the bamboo culm (Fig. 3). However, the number of vascular bundles per unit area became less and less because the shape and size was larger from the bottom to the top of bamboo culm. The pattern of distribution of vascular bundles in bamboo culms was illustrated in Fig. 4. The same pattern was found in *Bambusa rigida*[20] and in palm trees[21-23]. The distribution of vascular bundles of bamboo *G. apus* culms as shown in Fig. 4 could be modeled in a non-linear power regression equation. The arrangement of vascular bundles on the cross section of the bamboo culm appeared to form alternate patterns (Fig. 5). In the cross section of bamboo culm, there was a variation in the shape and size of the vascular bundle from the outer layer to the inner layer (Fig. 3). In the outer layer (peripheral zone) the vascular bundles were small and ellipsoid in large numbers. In the middle layer of the bamboo culm, there was a separation of the fiber cap at the top and bottom of the

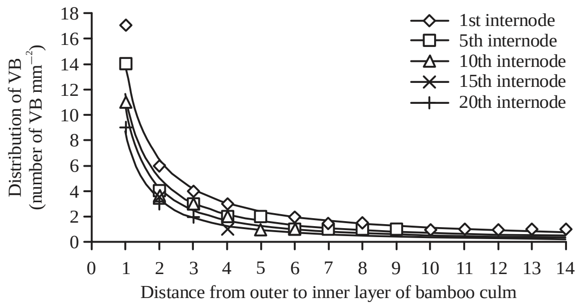

Fig. 4: Distribution of vascular bundles on bamboo culm of *G. apus*

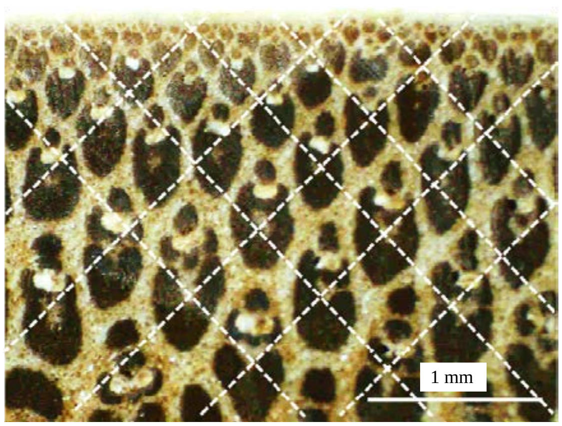

Fig. 5: Macroscopic pattern of alternate arrangement of vascular bundles on cross section of bamboo culm of *G. apus*

main vascular bundles (type IV) and vascular bundles had only one fiber cap (type III) on the inner layer. Type of vascular bundles on bamboo *G. apus* from previous studies showed types III and IV (Fig. 3). In the 1st and 5th internodes, both types could be found in the middle layer, but on the 10th, 15th and 20th internodes only found type III. Variations of vascular bundles were also found in bamboo from China[24].

Shapes and sizes (radial and tangential diameters) vascular bundles of bamboo *G. apus* varied from the outer layer to the inner layers. The tangential diameter of the vascular bundles tended to increase from the outer layer to the inner layer, while in the radial diameter it increased from outer layer to the center and then decreased toward the inner layer. The dimensions of the vascular bundles in the bamboo *G. apus* culm also decreased from the top to the bottom (Fig. 6a, b).The structure of a young shoot was often very characteristic in recognizing a bamboo species.

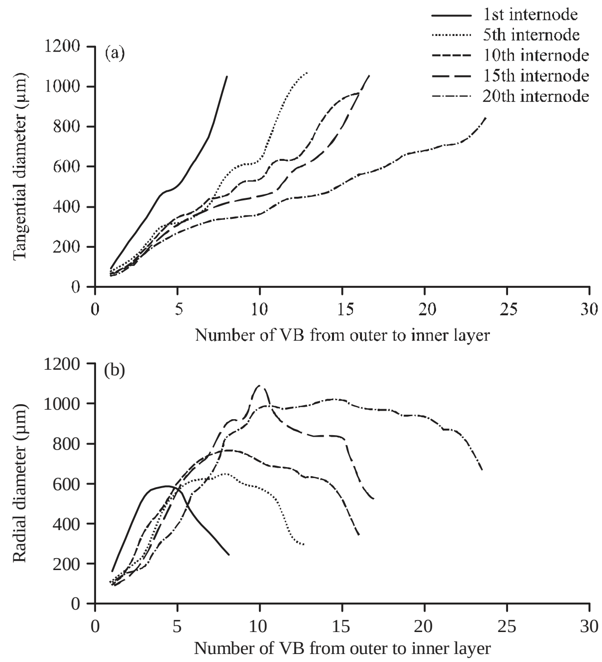

Fig. 6(a,b): Diameter of vascular bundles on the bamboo culm of *G. apus* in (a) Tangential and (b) Radial directions

CONCLUSION

The morphological characters of the mature culm of *G. apus* culm was already determined by the morphological characters of the young shoots. The size of vascular bundles towards the middle layer became larger in the bamboo culms and also more widely spread, but longer and smaller towards the outer layer. The type of vascular bundle on the bamboo culm of *G. apus* were type III and type IV. Type vascular bundles on *G. apus* depended on the height position of the culm.

SIGNIFICANCE STATEMENT

This study exposes the morphology of culms, size and type of vascular bundles of *G. apus* which can be used along with its characteristics as reference data in determining the appropriate part of the bamboo culm in accordance with its intentional purposes.

ACKNOWLEDGMENTS

We would like to thank Institut Teknologi Bandung for funding this research through the Research and Community Service and Innovation Program (P3MI) of 2017 with grant number 1257/I1.C02.2/PL/2017.

REFERENCES

1. Dransfield, S. and E.A. Widjaja, 1995. Plant Resources of South-East Asia No. 7: Bamboos. Backhuys Publishers, Leiden, Netherlands, Pages: 189.
2. Lobovikov, M., S. Paudel, M. Plazza, H. Ren and J. Wu, 2007. World Bamboo Resources: A Thematic Study Prepared in the Framework of the Global Forest Resources Assessment 2005. FAO., Rome, Italy.
3. Widjaya, E.A., 2001. Identikit Jenis-Jenis Bambu di Jawa. Puslitbang Biologi-LIPI, Bogor, Indonesia, ISBN: 979-5790-35-8.
4. Setiawati, T., A.Z. Mutaqin, B. Irawan, A. An'amillah and J. Iskandar, 2017. Species diversity and utilization of bamboo to support life's the community of Karangwangi Village, Cidaun sub-district of Cianjur, Indonesia. Biodiversitas, 18: 58-64.
5. Patel, A.B., 2005. Traditional bamboo uses by the tribes of Gujarat. Indian J. Trad. Knowl., 4: 179-184.
6. Tamang, D.K., D. Dhakal, S. Gurung, N.P. Sharma and D.G. Shrestha, 2013. Bamboo diversity, distribution pattern and its uses in Sikkim (India) Himalaya. Int. J. Scient. Res. Publ., 3: 1-6.
7. Honfo, H., F.C. Tovissode, C., Gnangle, S. Mensah and V.K. Salako *et al*., 2015. Traditional knowledge and use value of bamboo in Southeastern Benin: Implications for sustainable management. Ethnobot. Res. Applic., 14: 139-153.
8. Farrelly, D., 1984. The Book of Bamboo. Sierra Club Books, San Francisco, USA., ISBN: 0-87156-824-1.
9. Louppen, T., 2016. The influence of the natural variations on the buckling behavior of Bamboo: *Guadua angustifolia*. Master Thesis, Eindhoven University of Technology, Eindhoven.
10. Zakikhani, P., R. Zahari, M.T.B.H.H. Sultan and D.L.A.A. Majid, 2017. Morphological, mechanical and physical properties of four bamboo species. BioResources, 12: 2479-2495.
11. Anokye, R., E.S. Bakar, J. Ratnansingam and K.B. Awang, 2016. Bamboo properties and suitability as a replacement for wood. Pertanika J. Scholarly Res. Rev., 2: 64-80.
12. Liese, W., 1985. Anatomy and properties of bamboo. Proceedings of the International Bamboo Workshop on Recent Research on Bamboos. October 6-14, 1985, Hangzhou, China, pp: 196-208.
13. Wahab, R., M.T. Mustafa, S. Rahman, M.A. Salam, O. Sulaiman, M. Sudin and M.S.M. Rasat, 2012. Relationship between physical, anatomical and strength properties of 3-year-old cultivated tropical bamboo *Gigantochloa scortechinii*. ARPN J. Agric. Biol. Sci., 7: 782-791.
14. Li, X., 2004. Physical, chemical and mechanical properties of bamboo and its utilization potential for fiberboard manufacturing. MSc. Thesis, Louisiana State University and Agriculture and Mechanical College, Lusiana.
15. Razak, W., M. Tamizi, S. Othman,M. Aminuddin, H. Affendy and K. Izyan, 2010. Anatomical and physical properties of cultivated two and four-year-old *Bambusa vulgaris*. Sains Malaysiana, 39: 571-579.
16. Liese, W., 1998. The Anatomy of Bamboo Culms. Volume 18 of INBAR Technical Report, BRILL, Beijing, ISBN: 9788186247266, pp: 130-135.
17. Sharma, M., C.L. Sharma and D. Laishram, 2017. Variation in anatomical and physical properties of some *Schizostachyum* species of Manipur, India. J. Indian Acad. Wood Sci., 14: 79-90.
18. Dubey, Y.M., A.K. Khanduri and S.D. Sharma, 2017. Physical and strength properties of *Bambusa striata*. J. Indian Acad. Wood Sci., 14: 110-114.
19. Wahab, R., A. Mohamed, M.T. Mustafa and A. Hassan, 2009. Physical characteristics and anatomical properties of cultivated bamboo (*Bambusa vulgaris* schrad.) culms. J. Biol. Sci., 9: 753-759.
20. Huang, X.Y., J.Q. Qi, J.L. Xie, J.F. Hao, B.D. Qin and S.M. Chen, 2015. Variation in anatomical characteristics of bamboo, *Bambusa rigida*. Sains Malays, 44: 17-23.
21. Erwinsyah, V., 2008. Improvement of oil palm wood properties using bioresin. Ph.D. Thesis, Dresden University of Technology, Dresden.
22. Darwis, A., D.R. Nurrochmat, M.Y. Massijaya, N. Nugroho, E.M. Alamsyah, E.T. Bahtiar and R. Safe'i, 2013. Vascular bundle distribution effect on density and mechanical properties of oil palm trunk. Asian J. Plant Sci., 12: 208-213.
23. Fathi, L., 2014. Structural and mechanical properties of the wood from coconut palms, oil palms and date palms. Dissertation Report. Universitat Hamburg, Hamburg.
24. Taihui, W. and C. Weiwei, 1985. A study on the anatomy of the vascular bundles of bamboos from China. Proceedings of the International Bamboo Workshop on Recent Research on Bamboos, October 6-14, 1985, Hangzhou, China, pp: 230-243.