PHYSICAL MECHANICAL CHARACTERIZATION OF PLANTATION AND NATURALLY GROWN BOLO (Gigantochloa levis)

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ABSTRACT

Bamboo is an important commodity that contributes to the economy of the country. Aside from economic benefits, bamboo served as carbon sink that lessen environmental degradation. It is important to understand the physical & mechanical properties of bamboo because it is the primary consideration for use in any project that needs bamboo materials. The study aimed at determining the physical and mechanical characteristics of plantation and naturally grown bolo. Results revealed that naturally grown bolo had higher mean diameter and thickness as compared to plantation grown bolo. However, plantation grown bolo had higher mean compression with node, compression without node, shear with node and shear without node. Plantation grown bolo is better material for any project that needs bamboo with high compression and shear properties.

Keywords: Diameter, thickness, modulus of rupture, shear, compression, moisture content, bolo

INTRODUCTION

Background of the Study

Bamboo is considered as the most versatile and fastest growing plant in the world. It is a woody perennial evergreen plant that belongs to the family *Gramineae* (Dranfield and Widjaja, 1995as cited by Camacho, et.al. 2005). The versatility of bamboo outsmarts most tree species. It is known to be natural and excellent raw material for manufacturing strong and sturdy furniture, handicrafts, and novelty items. In the Philippines, bamboo is identified both of the science and business communities as one of the products with high market potentials.

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The furniture and handicraft industries are the top local users/markets of bamboo products in the country, accounting for about 40% of the total production. Unlike other countries, however, the country has yet to fully exploit the product potentials of bamboo and improve its productivity (PCAARRD, 2013).

Bamboo has been traditionally and extensively used for house construction in the rural areas of Asia and Africa. Among the common housing components from bamboo are beams, floors, walls, partitions, roofs, ceiling, doors, windows, ladders and posts.

Species with long culms are commonly used as scaffolding for high rise buildings and for making bridges. Culm splits can serve as substitute for steel to reinforce concrete (Carandang & Fidel, 2002).

In addition, some of the general properties of bamboo that make it suitable and desirable for a lot of uses are the following: 1.) it is a highly versatile materials; 2) It can be easily and profitably grown on all types of soil, with virtually little effort and care, none or very little fertilizer, with almost no pests and diseases; 3) it has a short initial harvest cycle (3 to 5 years after planting) and a long productive life span; 4) Demand for bamboo products in the international market is increasing; 5) Bamboo is excellent for soil conservation because of its root structure; 6) Bamboo can easily worked with using simple tools; and 7) Bamboo is strong for its weight (Paculdo, 1992 as cited by Razal & Palijon, 2009).

On the other hand, the determination on the physical and mechanical properties of bamboo is important as basis for the selection of poles for different uses especially in housing construction, furniture and other important end products. According to Razal, et al. (2012), along the length of the pole, the middle portion is the densest portion, while the top and butt portions are almost similar in density for more species. Kawayan tinik is the heaviest among the erect species, followed by Kawayan kiling and bayog, while the lightest is buho. Giant bamboo and bolo have relative densities that are almost 10% lower than the specific gravity of Kawayan tinik. Critical to the utilization and service life of bamboo planks are the mechanical properties derived from bending test – namely the fiber stress at proportional limit (FSPL), modulus of rupture (MOR), and the modulus of elasticity (MOE). Most bamboo planks are used under conditions where load is applied perpendicular to the length of the plank, such as floor tile, tabletops, and as cabinet shelves. Given such condition and load, the plank will tend to sag or bend, or worse, break or fail when the maximum bending stress is exceeded.

In Capiz, Bolo (*Gigantochloa levis*) locally known as Botong is a species of bamboo commonly used in house construction, furniture making, and scaffolding for building construction. Naturally grown bolo grows vigorously in Capiz with bigger and taller culms as compared to other bamboo species. However, plantation grown bolo was observed to have smaller and shorter culms as compared to naturally grown bolo in the community. Although the plantation grown bolo has smaller and shorter culms, however, do its bending strength and modulus of rupture higher than naturally grown bolo? It is in this premise that there is a need to determine the physical and mechanical properties of plantation and naturally grown bolo, hence this study.

Objectives of the Study

The general objective of the study is to determine the physical and mechanical properties of plantation and naturally grown Bolo (*Gigantochloa levis*). The specific objectives are:

1. To characterize the physical properties of plantation and naturally grown Bolo in terms of diameter and thickness;
2. To characterize the mechanical properties of plantation and naturally grown Bolo in terms of shear, compression, modulus of rupture and moisture content;

3. To determine the significant difference between the physical and mechanical properties of plantation and naturally grown Bolo.

Significance of the Study

The results of the study will be beneficial to bamboo entrepreneurs who are looking for good sources of materials. Moreover, it will give insights to the farmers on establishing bamboo plantation to increase their income. The findings will also serve as basis for future related studies.

MATERIALS AND METHODS

Materials

The materials used in the study were approximately 3.5 to 4.0-year-old Bolo culm or pole. The Universal Testing Machine (UTM) was used in testing the mechanical properties of the bamboo samples. A calliper was used to measure the diameter and thickness of the samples.

Methods

The plantation grown bamboo samples was taken from the bamboo plantation of CAPSU Dumarao Satellite College while the naturally grown bamboo samples was taken from Barangay Jambad, Dumarao, Capiz. Five clumps were randomly selected per site and took one culm per clump. A total of 5 culms were taken from the plantation and another 5 culms from the naturally grown. Each culm was divided into 3 parts: the base/butt, middle and top portion having a length of 4 ft each cut. There was a total of 15 samples per site with a total of 30 samples for the study. The 30 samples were brought to the Forest Products Research and Development Institute (FPRDI), College of Forestry and Natural Resources, UPLB, College, Laguna. The test included the determination of the physical and mechanical properties of the samples.

Experimental Design and Treatments

2- Factorial experiment in Randomized Complete Block Design (RCBD) was used in the study.

Treatments:

Factor 1: Site/location = 2 (plantation and natural)

Factor 2: Portion of the culm = 3 (base, middle, top)

Replication: 5

2 x 3 x 5 = 30 experimental units

Statistical Tools and Analysis

The F-test at 5% and 1% levels of significance was used to analyze the significant difference between the portions of culms while t-test was used to compare the difference between the plantation grown and naturally grown bolo. Duncan's Multiple Range Test was used to determine the difference between treatments

RESULTS AND DISCUSSION

Physical characteristics of plantation grown Bolo (Botong)

Results revealed that bamboo grown in plantation does not differ in diameter between butt and middle portion, and between top and middle portion. On the other hand, thickness A which is the upper portion of the sample and thickness B the bottom portion of the sample differs between butt and the other two portions, the top and middle portion. As observed, the butt portion exhibited the highest diameter, thickness A and thickness B.

Table 1. Summary of DMRT of bamboo grown in plantation in terms of diameter and thickness.

Treatment	Diameter (mm)	Thickness A (mm)	Thickness B (mm)
Portion			
Butt	74.70 a	6.66 a	12.47 a
Middle	58.60 ba	4.44 b	5.51 b
Top	44.63 b	4.29 b	4.28 b

Physical characteristics of naturally grown Bolo (Botong)

Findings revealed that bamboo grown naturally does not differ in diameter and thickness A between butt and middle portion and between top and middle portion. Thickness B differs between butt and other two portions, top and middle. As observed, The butt portion exhibited the highest diameter, thickness A and thickness B.

Table 2. Summary of DMRT of naturally grown botong

Treatment	Diameter (mm)	Thickness A (mm)	Thickness B (mm)
Portion			
Butt	113.41 a	10.71 a	19.58 a
Middle	102.58 ba	6.60 ba	9.81 b
Top	83.45 b	5.30 b	6.56 b

Difference in diameter, thickness A and thickness B between plantation grown and naturally grown Bolo

Based on the results, diameter, thickness A and thickness B as well as the portions of poles differ between plantation and naturally grown Bolo. Comparing the two locations, the naturally grown bolo exhibited a higher mean in diameter, thickness A and thickness B than the ones grown in plantation. Likewise, comparing the two portions, the butt portion in naturally grown exhibited a higher mean in diameter, thickness A and thickness B than the ones grown in the plantation.

Table 3. Summary of DMRT on the difference in diameter, thickness A and B between plantation grown and naturally grown Bolo.

Treatment	Diameter (mm)	Thickness A (mm)	Thickness A (mm)
Location			
Plantation	66.65 b	5.47 b	8.99 b
Natural	107.99 a	8.65 a	14.69 a
Portion			
Butt	94.05 a	8.68 a	16.02 a
Middle	80.59 b	5.44 b	7.66 b
Location * Portion			
Plantation * Butt	74.70	6.66	12.47
Plantation * Middle	58.60	4.29	5.51
Natural * Butt	113.41	10.71	19.58
Natural * Middle	102.58	6.60	9.81

Mechanical Characteristics of Plantation grown Bolo

Results revealed that moisture content (MC), compression with node (CompWN) and compression without node differ between butt and the other two portions, top and middle. Bamboo grown in plantation does not differ in shear without node (ShearWON) and modulus of rupture (MOR) between butt and middle portion, and between top and middle portion. On the other hand, shear with node (ShearWN) differ among the portions. As observed, the butt portion of the bamboo had the highest mean moisture content, compression with node, compression without node, modulus of rupture, shear with node and shear without node.

Table 4. Summary of DMRT on **plantation grown** bolo in terms of moisture content, compression with node, compression with node, modulus of rupture, shear with node and shear without node.

Treatment	MC (%)	Comp WN, (MPa)	Comp WON (MPa)	MOR (MPa)	Shear WN (MPa)	Shear WON (MPa)
Portion						
Butt	26.78	126.97 a	131.88 a	68.14 a	16.93 a	9.39 a

Middle Top	a 17.10 b 15.29 b	81.41 b 54.10 b	83.28 b 54.60 b	32.91 ba 24.01 b	10.53 b 6.44 c	6.93 ba 4.21 b

Mechanical Characteristics of Naturally grown Bolo

Results showed that moisture content and shear without node differ in butt and the other two portions, the top and middle. Meanwhile, shear with node and modulus of rupture do not differ among the portions. Compression with node and compression without node differ among the portions. The butt portion had the highest mean in moisture content, compression with node, compression without node, modulus of rupture, shear with node and shear without node.

Table 5. Summary of DMRT on **naturally grown** bolo in terms of moisture content, compression with node, compression with node, modulus of rupture, shear with node and shear without node.

Treatment	MC (%)	Comp WN (MPa)	Comp WON (MPa)	MOR (MPa)	Shear WN (MPa)	Shear WON (MPa)
Portion						
Butt	32.86 a	101.87 a	103.46 a	45.09 a	8.06 a	7.06 a
Middle	19.67 b	78.15 b	78.33 b	43.16 a	6.74 a	3.91 b
Top	17.86 b	51.63 c	48.66 a	41.80 a	5.54 a	3.27 b

Difference in moisture content, compression with node, compression without node, modulus of rupture, shear with node and shear without node between plantation grown and naturally grown bolo.

Results showed that shear with node, shear without node and modulus of rupture differ between plantation and naturally grown bolo. Likewise, moisture content, shear with node, compression with node and compression without node differ between butt and middle portion of the culm. Naturally grown bamboo had the highest mean modulus of rupture while plantation grown had the highest mean shear with node and shear without node. The butt portion of the culm had the highest mean moisture content, while the middle portion had the highest mean shear with node, compression with node and compression without node.

Table 6. Summary of DMRT on the difference between plantation grown and naturally grown bolo in terms of mechanical properties.

Treatment	MC (%)	Comp WN (MPa)	Comp WON (MPa)	MOR (MPa)	Shear WN (MPa)	Shear WON (MPa)
Location						
Plantation	21.94	67.75	68.94	28.46 b	8.49 a	5.57 a
Natural	26.27	64.89	63.49	43.44 a	6.14 b	3.59 b
Portion						
Butt	29.82 a	52.86 b	51.63 b	37.36	5.99 b	3.74
Middle	18.39 b	79.78 a	80.81 a	34.55	8.63 a	5.42
Location * Portion						
Plantation * Butt	26.78	54.10	54.60	32.91	6.44	4.21
Plantation * Middle	17.10	81.41	83.28	24.01	10.53	6.92
Natural * Butt	32.86	51.63	48.66	41.80	5.53	3.27
Natural * Middle	19.67	76.16	78.33	45.09	6.74	3.91

Conclusions

Based on the findings of the study, the following conclusions were drawn:

1. The butt portion of the plantation grown and naturally grown bolo exhibited the highest diameter and thickness in upper and lower portion of the sample.
2. Diameter between butt and middle portion of the culm from plantation and naturally grown bolo did not significantly differ.
3. Moisture content, compression with node and compression without node significantly differ between butt and the other two portions in the plantation grown and in the naturally grown bolo.

4. Although plantation grown bolo is smaller in diameter and thickness, however it had higher mean compression with node, compression without node, shear with node and shear without node than the naturally grown bolo.

Recommendations

Based on the findings of the study, the following recommendations are forwarded:

1. Plantation grown bolo is good source of materials for any project that needs bamboo materials which requires better mechanical properties as compression and shear.
2. Conduct study on the factors (e.g. soil analysis, microclimate condition, etc.) that affect physical and mechanical properties of bamboo.
3. Conduct future researchers related to this study.

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