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Ripping and planing characteristics of some exotic bamboo species grown in Ghana

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Abstract: In this study, the machining characteristics of eight exotic bamboo species extracted from Daboase, Kusi near Kade and Amantia in southern Ghana were assessed. The bamboo species include *Dendrocalamus latiflorus, Bambusa bambos, Guadua angustifolia*, *Guadua chacoensis, Dendrocalamus brandisii*, *Bambusa vulgaris* var. *vittata, Bambusa vulgaris* (from plantation) and *Bambusa vulgaris* (from natural forest). These were cross-cut into the butt and top portions. All the samples for the six planing operations were planed at 20° and 30° cutting angles and at 6, 9 and14 m/min feed speeds. These were evaluated and graded in accordance with ASTM D 1666-87. The results indicate that the ease of ripping was better with the top samples than the butt and ripped surfaces were generally smooth. Ripping of *Bambusa vulgaris* from the natural was relatively difficult than the other samples. The surface planing quality was better with the butt samples from the three localities than the top portion. *Bambusa vulgaris* from the natural forest recorded the highest percentage surface quality for each planing condition. There were no statistically significant differences between 20° and 30° cutting angles ($P \geqslant 0.05$) Data on ripping and planing of the selected bamboo species that have been generated can form the basis for more comprehensive research on the machining properties of bamboo species in Ghana.

Key words: Cutting angle, feed speed, planing, ripping, surface quality

INTRODUCTION

Bamboo is a perennial and woody grass and it is the biggest member of the grass family, Gramineae belonging to the sub family Bambusoideae (Sineath *et al*., 1953; Chapman, 1996; Qisheng, 2002). It is renewable and grows abundantly in both the tropical and sub-tropical countries (Hsiung, 1991; Becher, 1996; Fu and Banik, 1996). The species have rapid growth capabilities thereby enabling it to reach maturity within three to five years (Zhou, 1995).

Its biological characteristics make it a perfect plant for preventing soil erosion and land degradation. Gaur (1987) has reported that due to its fast growth, easy propagation, soil binding properties and short rotation, bamboo is an ideal plant for use in afforestation, soil conservation and social forestry programme. The giants of this fast-growing plant sequester more carbon dioxide than just about any other plant (Zero Emissions Research Institute, undated). The report continues that bamboo forest can sequester 17 times as much carbon as a typical tree forest. Zehui (2001) has reported

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that the rapid growth of bamboo enables itself to absorb a large amount of carbon dioxide in the air, 12 tons per hectare and releases 35% more oxygen than other plants of the same size and field. The report indicates that due to bamboo's high nitrogen consumption, bamboo helps mitigate water pollution, as it takes in and transforms nutrient wastes when planted alongside manufacturing zones, intensive livestock farming, and sewage treatment facilities. It can also be used to desalinate sea water.

Bamboo is a viable alternative to tropical timbers that are used by the furniture and building/construction industries (Jayanette, 2001). Other uses of the species include paper making, rayon, handicrafts, sliced veneer, mouldings, flooring, furniture, beehives, hats, mats, walking sticks, household utensils (scoop, chopsticks, steam box, skep, etc), charcoal, liquid diesel, agricultural implements, anchors, arrows and bows, boats, broom, brushes, chicks, containers, cordages, dustbins, fishing rods, flower pots, fish traps, hedges, kit frames, ladders, lamps, mallets, musical instruments, pens, poles, pulp rafts, roofing, ropes, tobacco pipes, toys, tool handles, tub, umbrella handle, water pipes, wrappers, fodder (leaves as livestock feed), enzymes and media from shoots extracts used for culturing pathogenic bacteria, medicine and food of which its shoots are popular in Asian cuisines (Gaur, 1987; Zhu 1987; Sharma, 1987; Wu and Ma, 1987; Haryanto, 1987). Its clonally growth form, rapid growth rates and short rotation cycles, enables annual income generation, unlike the long harvest cycle for timber trees (Hogarth, 2012).

Due to its beauty, durability and flexibility, it has become an internationally traded commodity thereby making it a key resource for livelihood development. The report continues that bamboo has the potential to lift people in rural communities out of poverty, provided management techniques and trade are improved.

Other advantages of bamboo over timber, as reported by Hogarth, (2012) are that bamboo has less policy constraints and regulations, it is relatively light and can be easily harvested and transported without specialized equipment or vehicles, bamboo production does not require special tools, and there are many skills in bamboo production that are common to agricultural crop management such as soil conservation and fertilization that are easily adapted, basic processing and value-addition do not require highly skilled labour and can be undertaken by low-income rural communities with minimal capital investment. There are several methods to process bamboo from its original form and condition into finished products. According to Haryanto, (1987) bamboo is used in whole/round, split and laminated forms

Forest management in Ghana has for a long time not given due emphasis to bamboo as a resource to be exploited more systematically. This may be due to some reports that traditionally bamboo has been considered as a weed in forestry practice (Watson & Wyatt-Smith, 1961; Chin, 1979) in which attempts are made to prevent or control its growth (Salleh and Wong, 1987). In spite of this, they are mainly used for fences, scaffolding, ladders, drying platform for cocoa, musical instruments, drinking cups, baskets, traditional house construction and as vessel for tapping wine. The species has an enormous potential for alleviating both environmental and housing problems facing by Ghanaians. The most common species in Ghana from the southern and middle zone are *Bambusa vulgaris* (green type), *Bambusa vulgaris* var. *vittata* (yellow type), *Bambusa bambos, Bambusa multiplex, Bambusa pervariabilis, Dendrocalamus strictus* while *Oxythenanthera abyssinica* is found in the northern zone (Tekpetey, 2011) .

The pressures of demand due to increasing population on the dwindling supply of commonly used timbers for housing in Ghana calls for research and development efforts on the use of non-timber forest products, particularly bamboo. Unfortunately there is limited knowledge on the ripping and planing (machining) properties of bamboo species, hence hindering its use as building and construction material in Ghana. Machining is a critical property of wood species used in the wood industry. It enables wood users to know the processing techniques to be applied. Again, for manufacturers to remain competitive on both local and international markets, they must increase their productivity and improve quality. Machining operations determine the production rate, cost and product quality. As the wood industry welcomes introduction of new wood materials and cutting tools, their inter-relationship is of importance for their rapid development. There is therefore, the need to establish the properties of the bamboo species grown in Ghana for their efficient processing, promotion and utilization. The main objective of the study was to determine the ripping and planing properties of some bamboo species grown in Ghana to enhance their processing and efficient utilization for housing.

MATERIALS AND METHODS

Bamboo culms from plantation clumps were extracted from Daboase, Kusi near Kade and Amantia in Ghana to determine their ripping and planing properties. The selection of the bamboo species was based on the type of species and their availability in the plantations of the three locations. The selected bamboo species from the three sites are shown in Table 1, which include one species from the wild. A mini-chainsaw machine and a cutlass were used in extracting the bamboo culms. For each species, five bamboo culms from different clumps of the selected bamboo species were harvested and labeled accordingly as shown in Figure 1. The butt and top ends of the culms (3-3.5 meters long) were dipped into a prepared preservative to prevent fungi and insects attack. The materials were then transported to the woodworking laboratory of Forest Industry Development Division at the Forestry Research Institute of Ghana under Council for Scientific and Industrial Research (CSIR-FORIG) for further processing into various sample sizes for the ripping and planing tests.

Ripping of Bamboo culms

The extracted bamboo culms from the field were laid horizontally to minimize loss of water. This was because wood ripping machine was to be used to split them and hence was suspected to be easier in ripping at green than in a dry condition.

Each culm, depending upon the full length (3 – 3.5 meters) was cross-cut into two parts as butt and top (Figure 2A) and these were labeled accordingly. A circular saw, of type – Wadkin AGS 250/300 – Tilting Arbor Saw bench was used to cross-cut and rip the bamboo culms on species basis (Figure 2A and 2B).

Table 1: Some bamboo species extracted from three localities in Ghana

Daboase Bamboo species	Kusi/Kade Bamboo species	Amantia Bamboo species
Dendrocalamus latiflorus	*Guadua chacoensis*	*Bambusa bambos*
Bambusa bambos	*Dendrocalamus brandisii*	*Bambusa vulgaris* (from the wild)
Guadua angustifolia	*Bambusa vulgaris* var. *vittata*	
Guadua chacoensis	*bambusa vulgaris*	

Figure 1: Extracted bamboo culms labeled for easy identification

Figure 2: A- Cross-cutting & B- Ripping of bamboo culms with wood processing machine

Figure 3: Treated Bamboo strips stacked for air-drying

Figure 4: Re-ripping of dried bamboo strips

The bamboo culms were ripped into four or more pieces, depending upon their diameters (Figure 2B), to facilitate air drying of the samples. The strips were labeled according to the type of species, source, culm number and part of the culm. These were dipped into a mixture of chemicals (Dursban and Anti-blu 37-37) in a container for treatment in batches for ten minutes. This prophylactic treatment was undertaken to prevent fungi and insects attack.

On removal from the container they were stacked for air drying (Figure 3). When the moisture contents ranging between 16% and 18% were attained, all the stacked bamboo samples were re-ripped into smaller strips to make them easier for planing (Figure 4) and were labeled again to maintain their codes. The ripping process of all the bamboo species were closely observed and assessed for their ease and quality of ripping. The ease of ripping was classified as: easy to rip, moderately easy to rip, slightly difficult to rip and difficult to rip (Table 2). The quality of finish of ripped bamboo samples were graded as smooth, moderately smooth, rough and woolly.

Table 2: Ease of ripping and planing of some bamboo species from three localities

Daboase			Kusi / Kade			Amantia		
Bamboo Species	Classification		Bamboo Species	Classification		Bamboo Species	Classification	
	Ripping	Planing		Ripping	Planing		Ripping	Planing
Dendrocalamus latiflorus	E	E	*Guadua chacoensis*	ME	E	*Bambusa bambos*	E	E
Bambusa bambos	E	E	*Dendrocalamus brandisii*	E	E	*Bambusa vulgaris*	ME	ME
						Bambusa vulgaris (from the wild)	D	SD
Guadua angustifolia	SD	E	*Bambusa vulgaris* var. *vittata*	E	E			
Guadua chacoensis	ME	E	*Bambusa vulgaris*	ME	ME			

Planing of bamboo strips

After ripping, a narrow bandsaw machine was used to remove the diaphragm and or other shoot stub at the nodes from each strip of the bamboo. A thicknesser planing machine (610 x 230 mm “D.A.A”) of spindle speed 5,200rpm with 20° and 30° cutting angles and 6, 9 and 14 m/min feed speeds were used;, hence six (6) planing operations/tests. Fifty (50) bamboo strips (from butt and top) per species per test (that is 300 strips per species) were randomly selected for the planing tests. These were selected based on ASTM D 143-94. Both sides of all the bamboo strips on species basis, were planed (Figure 5), assessed, evaluated and graded in terms of surface quality. These were based on their smoothness of cut (degree of generation of machining defects), uniformity in thickness and absence of any groove. This was in accordance with ASTM D 1666-87, with some adjustments, on the basis of three quality grades (Grade 1 = excellent or defect-free, grade 2 = defective but possible to be remedied by sanding and grade 3 = defective beyond remedy). The percentage excellent (defect-free) samples per species per site was estimated for each planing condition, as shown in Table 3 and the mean percentages evaluated per bamboo species (Table 4). The ease of planing of the bamboo species from the three sites was also assessed (Table 3).

Figure 5: A-Planing of bamboo strips with a thicknesser machine, B- Planed bamboo strips

RESULTS AND DISCUSSION

Ripping of Bamboo culms

The ease of ripping the eight (8) bamboo species is presented in Table 2. Generally the top portions of all the bamboo species were observed to be easily ripped than the butt. Ripped surfaces of the species were observed as smooth, moderately smooth and woolly. The ease of ripping was exhibited by *Dendrocalamus latiflorus, Bambusa bambos, Dendrocalamus brandisii* and *Bambusa vulgaris* var.*vittata* while moderately ease of ripping was recorded for *Guadua chacoensis* and *Bambusa vulgaris*. The ripping of *Guadua angustifolia* and *Bambusa vulgaris* (from the wild) were classified as slightly easy and difficult, respectively. These could be attributed to their differences in the wall thicknesses, the amount of water in the cell walls, degree of silica content and the density, which decreased along the culm towards the top as well as the shape of the culms. Reports indicates that 1% change in moisture content of wood has significant effect on density and surface quality of wood after machining (Davis, 1962; Kollman and Cote, 1968). The degree of saw blunting was severe with the butt culms than the top. The frequency of saw blunting was highest with *Bambusa vulgaris* (from the wild), which may be due to poor culm quality (crooked), over-matured culms and high silica content because of poor management of the species grown in the wild. This was followed by *Guadua angustifolia,* (which might be due to its comparatively high culm wall thickness with quite shorter internodal length) while the lowest was recorded for *Dendrocalamus latiflorus* (might be due to its longer internodal length even though its density was the highest).

Planing of bamboo strips

Table 2 also indicates the ease of planing of the bamboo species extracted from Daboase, Kusi/Kade and Amantia localities. Table 3 shows the quality of finish of the species after planing with 20° and 30° cutting angles while Table 4 is the mean percentages of defect-free samples of the species from the three sites.

Planing of the bamboo species was visually observed to be easier with *Guadua angustifolia* followed by *Guadua chacoensis, Bambusa bambos, Dendrocalamus brandisii, Dendrocalamus latiflorus and Bambusa vulgaris* var. *vittata* (Table 2). *Bambusa vulgaris* from plantation was moderately easy to be planed while *Bambusa vulgaris* extracted from the wild was examined to be slightly difficult to plane. The factors contributing to their ease of planing could be attributed to differences in the wall thicknesses, amount of water in the cell walls, degree of silica content and the density, which decreased along the culm towards the top as well as the. shape of the culms, The surface quality of the culms increased with increasing density and thickness.

The surface finish or quality of finish (based on smoothness in terms of the degree of machining defects and uniformity in thickness) for all the bamboo species was better with the strips from the butt portion than those from the top. This implies that more defects were generated on the planed surfaces of the top portion of the bamboo strips than the butt. The reasons for the good performance could be attributed to comparatively its high density, high thickness of the culm walls, high level of silica content (as it decreases towards the top of the culm), and the shape or form of the strips. Other factors that might have affected the surface quality, generally, include the use of inappropriate machine for the planing activities and inexperienced of the machinist in processing bamboo. The defects that were identified include non-uniformity of thickness along each strip, groove, unplaned portions, fuzzy/woolly and chipped grains.

There were no significant differences in surface quality between the bamboo species from Daboase, Kusi/Kade and Amantia (Table 3). This shows that the environmental conditions (especially soil, temperature, humidity, rainfall) may not have any significant effect on the bamboo species from the three localities. For instance, the percentage defect-free strips of *Bambusa bambos, Guadua chacoensis* and *Bambusa vulgaris* (from plantation) from the three sites and with the three feed speeds are equivalent to both cutting angles.

Generally, surface quality of the bamboo samples increased with decreasing feed speed. As shown in Table 4, the lowest feed speed (6m/min) recorded the highest percentage of surface quality for each of the bamboo species. This was followed by the medium (9m/min) and the highest (14m/min) feed speeds.

Again, there were variations in the percentage surface quality for each bamboo species for the two cutting angles. All the species recorded better surface quality/finish with 20^{o} degree cutting angle than 30^{o} (Table 4). For instance, *Bambusa vulgaris* (from the

Table 4: Mean percentage surface quality of planed samples of some bamboo species from three localities with 20^{o} and 30^{o} cutting angles and three feed speeds using a thicknesser machine

Feed speed m/min	Daboase		Kusi/Kade		Amantia	
	Bamboo species	% defect-free	Bamboo species	% defect-free	Bamboo species	% defect-free
6	*Dendrocalamus latiflorus*	78	*Guadua chacoensis*	70	*Bambusa bambos*	76
	Bambusa bambos	76	*Dendrocalamus brandisii*	76	*Bambusa vulgaris*	74
	Guadua angustifolia	82	*Bambusa vulgaris* var. *vittata*	72	*Bambusa vulgaris* (from the wild)	86
	Guadua chacoensis	70	*Bambusa vulgaris*	74		
9	*Dendrocalamus latiflorus*	76	*Guadua chacoensis*	68	*Bambusa bambos*	72
	Bambusa bambos	72	*Dendrocalamus brandisii*	70	*Bambusa vulgaris*	68
	Guadua angustifolia	78	*Bambusa vulgaris* var. *vittata*	68	*Bambusa vulgaris* (from the wild)	80
	Guadua chacoensis	66	*Bambusa vulgaris*	68		
14	*Dendrocalamus latiflorus*	70	*Guadua chacoensis*	60	*Bambusa bambos*	70
	Bambusa bambos	68	*Dendrocalamus brandisii*	68	*Bambusa vulgaris*	66
	Guadua angustifolia	74	*Bambusa vulgaris* var. *vittata*	64	*Bambusa vulgaris* (from the wild)	76
	Guadua chacoensis	62	*Bambusa vulgaris*	64		

wild) at 20° and 6, 9 and 14m/min recorded defect-free percentages of samples of 86, 80 and 76 respectively as against 82%,76% and 72% in the same order of feed speeds at 30° cutting angle. There were no significant differences between 20 and 30 degree cutting angles at $P \geqslant 0.05$.

In terms of mean percentage surface quality, *Bambusa vulgaris* from the wild consistently performed better than the rest with both cutting angles and feed speeds (Table 4). This could be attributed to its age – (which was unknown) and the density. With respect to the plantation species, *Guadua angustifolia*, which had a wall thickness of 12.6mm and a density of 561kg/m^3 recorded the highest percentage defect-free samples at 20° with 6m/min feed speed. This was followed by *Dendrocalamus latiflorus, Bambusa bambos/Bambusa brandisii, Bambusa vulgaris* (from plantation)*, Guadua chacoensis and Bambusa vulgaris* var. *vittata*. The trend is virtually the same for the other planing conditions. This means that the anatomical and physical properties of bamboo species are the major determinant of their planing qualities.

CHALLENGES

The challenges encountered during the ripping and planing operations were that there was regular breakdown of the machines because of the use of wood processing machines instead of bamboo processing facilities, spent too much time in processing, which could be attributed to machinists inexperience in bamboo processing and variation in thicknesses of bamboo culms.

CONCLUSION

The surface qualities of the bamboo species used for the ripping and planing tests were not dependent on the localities where they were extracted from. Again, the paper shows that ripping and planing of the top portions of the selected bamboo culms were easier than the butt portion. The ease of ripping of the bamboo species was classified as easy to difficult and ripped surfaces were generally smooth. Planing quality was better with the butt strips, which had thicker culm walls and higher densities, than the tops bamboo strips. Comparatively ripping and planing of naturally grown *Bambusa vulgaris* samples were slightly difficult than those from plantations. Planing quality of the bamboo species was graded to be better with 20° cutting angle than 30° degree cutting angle but no significant differences existed at ($P \geqslant 0.05$. Surface quality increased with decreasing feed speed and feed speed of 6m/min was the best followed by 9m/min and 14m/min. On the average, the first three bamboo species with very high surface finish with respect to the six planing conditions were *Bambusa vulgaris*-from the wild, *Guadua angustifolia* and *Dendrocalamus latiflorus*. There were difficulties in using wood processing facilities to process bamboo. Frequent breakdown of the facilities used were encountered. The bamboo species studied could be ripped and planed for further processing and hence should be promoted for utilization.

RECOMMENDATION

The authors recommend that the two cutting angles (20° and 30°) could be used with feed speeds of 6 and 9m/min in planing bamboo species, in a situation where wood processing facilities are to be used.

In the government's policy of promoting locally raw materials for utilization, especially for housing, CSIR-FORIG should be resourced to develop technologies for better utilization of bamboo species grown in Ghana.

To be able to make great impact in the utilization of bamboo species in Ghana, it must be ensured that technologies exist in the country for development of the bamboo-based, rurally centered, small-scale industries. There is also the need to harness and manage the bamboo resource to prevent future depletion. Therefore the need to continue bamboo research into production, promotion and efficient utilization for better Ghana is of necessity.

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