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EVALUATION OF NATURAL DURABILITY OF *FICUS SUR* AND *COLA GIGANTEA* FROM TWO ECOLOGICAL ZONES OF GHANA

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ABSTRACT
Dwindling stocks of primary timber species poses a threat to wood industry and the focus is gradually shifting towards lesser used species (LUS) in an attempt to broaden wood resource base in the country. *Cola gigantea* and *Ficus sur* are among the lesser used species (LSU) being promoted for commercial utilization. For effective promotion and utilization of these two timber species, their natural durabilities among other wood properties have to be assessed in order to determine their commercial value. The natural durability of the two species from dry semi-deciduous (DSDZ) and moist semi-deciduous ecological zones (MSDZ) were tested using the white rot fungus *Coriolopsis polyzona* under the accelerated laboratory method in accordance with the ASTM D 2017-05 standard. A total of 360 wood blocks each measuring (14mm x 14mm x 14mm) from transverse and longitudinal sections of the wood were used for the study. Both species were found to be moderately durable with average weight loss of 36.1% and 33.6% for *F. sur* and *C. gigantea* respectively. Wood samples of *F. sur* from DSDZ with average weight loss of 30.2% were found to be less susceptible to the test fungus than samples from MSDZ with a mean weight loss of 37.0%. In order to prolong the service life for outdoor use, both species have to be treated with recommended wood preservatives.

KEYWORDS: Durability, *Ficus sur*, *Cola gigantea*, *C. polyzona,* ecological zone and wood blocks.

INTRODUCTION

The continuous decline of timber resources in the forest estate due to overexploitation, urbanization, agricultural activities etc has necessitated broadening of the wood resource base of the country. Lesser used timber species (LUS) are now gaining prominence because of the dwindling volumes of the primary timber species. The government of Ghana is actively pursuing the use of LUS and plantation species to reduce the pressure on the more popular timber species. Out of the about 680 tree species in the Ghanaian forest only about 126 of them occur in sufficient volumes to be considered exploitable as a raw material base for the timber industry (Ghartey, 1989). Until the turn of the century, about 90% of Ghana's wood exports were supplied by about 20 species, and about six species contributed about 60% of the total production (Upton and Attah, 2003). This called for broadening the wood resource base which was being used by the timber industry. Natural durability of a timber is one of the most important parameters that need to be evaluated in order to determine the commercial value of the timber. According to Negi (2004), natural durability is the ability of wood to resist attack by bio-degraders such as decay-fungi, bacteria, termites and marine-borers. The more durable a timber is the more valuable it would be. It is said that there is a well-established market for naturally durable timbers because these timber can be utilized in confidence when exposed to biodegradable agents such as termite and fungi (McCarthy *et al.*, 2009). Naturally durable timbers are strongly accepted by country like Japan which has high level of requirements on timber treated with preservatives (McCarthy *et al*., 2009). Decay fungus attacks the chemical components (cellulose, hemicelluloses and lignin) of wood and thereby causing strength loss. Certain decay fungi colonize the heartwood (causing heart-rot) and rarely the sapwood of living trees, whereas others confine their activities to logs or manufactured products, such as sawn lumber, structural timbers and poles. The extent of strength loss varies depending on the type of fungi involved, wood species and lumber dimensions. Natural durability varies enormously in any given species, not only between trees, but also within the same tree (Baill`eres and Durand, 2000). It is therefore difficult to state with any certainty how durable a wood is for a particular species, as durability depends on several different factors, including the genetic origin of the tree, silviculture, climate, and the local environment. *C. gigantea* and *F. sur* are among the lesser used species being promoted in Ghana. These two species occur in abundance in the forest of Ghana, but their natural durability and other properties have to be determined before the two species can be used effectively. *Ficus sur* belongs to the family Moraceae and widely distributed throughout tropical Africa from Cape Verde east to Somalia, and south to Angola and South Africa. The heartwood is white to yellow and not clearly demarcated from the sapwood. The grain is fairly straight or interlocked with moderately coarse to coarse texture. The wood is slightly sticky when freshly sawn due to inherent latex. The wood is porous and lightweight with basic density between 300 — 650Kg/m^3 (Oteng-Amoako, 2006). Although the wood is not much used commercially, locally, it is used for construction, furniture, mortars for grinding flour, kitchen utensils, pots, boxes, beer troughs, drums and beehives. It is also suitable for sporting goods, agricultural implements, and hardboard and particle board. The wood was formerly used for making brake blocks and bed boards for ox wagons. Wood from the branches is made into knife-handles in the Central African Republic. The wood is also used as fuelwood and in South Africa small pieces of wood are used as firesticks to ignite fire by friction (Lumbile and Mogotsi, 2008). *Cola gigantea* belongs to the Sterculiaceae family and occurs primarily in drier forests. It particularly thrives in semi-deciduous forests in West Africa, from Ivory Coast to Congo and very common in the dry semi- deciduous ecological zone of Ghana. The tree can grow to about 50m high and 5m in girth with 90cm as the prescribed minimum felling diameter (Oteng-Amoako, 2006). Oteng-Amoako (2006) classified the wood as non-durable and of medium density. The wood is used locally for the production of coffins and other products for which durability is not essential. According to Essien *et al*., (2012) *C. gigantea* can be used as a suitable raw material for pulp and paper production. This study was carried out to determine the natural durability of *F. sur* and *C. gigantea* from the dry semi-deciduous and moist semi-deciduous forest zones of Ghana.

MATERIALS & METHODS

Wood samples

Three matured trees each of *Cola gigantea* and *Ficus sur* were selected from Pra-Anum Forest Reserve in the Moist Semi-deciduous Forest (MSDZ) and Afram Headwaters (Abofour) Forest Reserves in the Dry Semi Deciduous Forest Zone (DSDZ) forest zones of Ghana. The average diameters of the trees at 1.3 meter above ground (dbh) were 66.40 cm and 50.40 cm for *C. gigantea* and *F. sur* respectively. The mean lengths of the clear bole between the first branch and the terminal point of buttresses were 17.97 m and 11.40 m for *C. gigantea* and *F. sur* respectively. Wood disc samples were taken from butt (10%), mid (50%) and top (90%) height positions along the straight boles for *C. gigantea* but only the top and butt were taken for *F. sur*. The wood discs were then processed into strips of sapwood, outer-heartwood and inner-heartwood. The wood strips were subsequently cut into cubes of 14mm x 14mm x 14mm. A total of 216 and 144 wood blocks of *C. gigantea* and *F. sur* respectively were used for the study.

Test of wood samples

The decay test was conducted using simple accelerated laboratory (soil block) method in accordance with the standard (ASTM D 2017-05), (ASTM, 1999). Wood blocks (14 mm^3) of *C. gigantea* and *F. sur* were tested using the white rot fungus *Coriolopsis polyzona*. 500 ml glass jars were used as decay chambers. The jars were half-filled with screened top soil. Wood strips (50 mm x 15 mm x 3 mm) of *Triplochiton scleroxylon* were soaked in water for 12 hours and placed on top of the soil in the jars. The jars were loosely closed with screw-lids and sterilized at 121ºC at 1 atm for 20 minutes. After cooling, the jars were inoculated aseptically by planting two 6 mm discs of actively growing mycelium of the test fungus about 10 mm from the end of each wood strip. The inoculated jars were then incubated in a growth room at 25ºC and a relative humidity of 70% for 6 weeks for the mycelia of the fungus to completely colonize the wood strip.

After 6 weeks incubation period, the wood blocks (14 mm x 14 mm x 14 mm) were oven dried at 103 ± 2ºC to consistent dry weight, sterilized at 121ºC at 1 atm for 20 minutes and placed transversely on the mycelial mats in the growth chambers. The glass jars were then incubated again for 12 weeks for the *Coriolopsis polyzona* to feed on the wood blocks. After incubation, adhering mycelium was removed and the blocks were then oven dried at 103 ± 2ºC to consistent dry weight. The percentage weight loss caused by the fungus was then determined as:

% Weight loss= $W1 - W2/W2 \times 100$

W1=Initial dry weight, *W2*=Final dry weight

Evaluation of decay rating of *C. gigantea* and *F. sur*

The decay rating of *C. gigantea* and *F. sur* was based on the weight loss classification adopted from US Standard ASTM Designation (D2017-05) below:

Average weight loss (%)	Decay resistance class
0-10	Highly resistant (Class I)
11-24	Resistant (Class II)
25-44	Moderately resistant (Class III)
45 and above	Susceptible (Class IV)

RESULTS

The sapwood of *Ficus sur* from the top portion of the wood recorded the highest weight loss (43.20%) whereas the least weight loss (33.17%) was recorded from the inner-heartwood from the top part of the wood obtained from the Pra-Anum Forest Reserve within the Moist Semi-deciduous forest zone (MSDZ) as shown in Figure. 1 after 12 weeks of incubation. Along the wood (i.e from butt, mid to top), the weight loss of *F. sur* increased from the butt to the top whereas a decrease in weight loss was observed across (i.e from sapwood, outer-heartwood, to inner-heartwood) the wood from the sapwood towards the inner-heartwood. However, no significant differences (p>0.05) in weight loss was observed across (F=11.59, df=2, p=0.07) and along (F=0.28, df=1, p=0.65) the wood of *F. sur* from the MSDZ.

FIGURE 1: Average weight loss (%) of *Ficus sur* wood from the Pra-Anum Forest Reserve (MSDZ) exposed to *C. polyzona* (Data are ± standard deviation).

A similar trend of weight loss was also observed for *F. sur* obtained from Afram Headwaters Forest Reserve within the dry semi-deciduous forest zone (DSDZ). However the lowest weight loss (21.7%) for *F. sur* was recorded from the inner heartwood of the butt from DSDZ (Fig. 2). On the contrary, the lowest (33.17%) weight loss was recorded for inner heartwood from the top portion of wood/tree from MSDZ. Nonetheless, the differences in weight loss were significant ($p<0.05$) across ($F=51.50$, $df=2$, $p=0.019$) and along ($F=19.11$, $df=1$, $p=0.048$) the wood of *F. sur* from the DSDZ.

FIGURE 2: Average weight loss (%) of *Ficus sur* wood from Afram Headwaters (DSDZ) exposed to *C. polyzona* (Data are ± standard deviation).

The maximum weight loss (46.03%) for *Cola gigantea* was recorded for sapwood from the top portion of the wood whilst the minimum weight loss (34.57%) was recorded for the inner heartwood from the butt of wood samples obtained from the Pra-Anum Forest Reserve within the moist semi-deciduous forest zone (MSDZ), (Fig. 3). Differences in weight loss across ($F=61.77$, $df=2$, $p=0.001$) and along ($F=11.28$, $df=2$, $p=0.022$) the wood of *C. gigantea* from the MSDZ differed significantly.

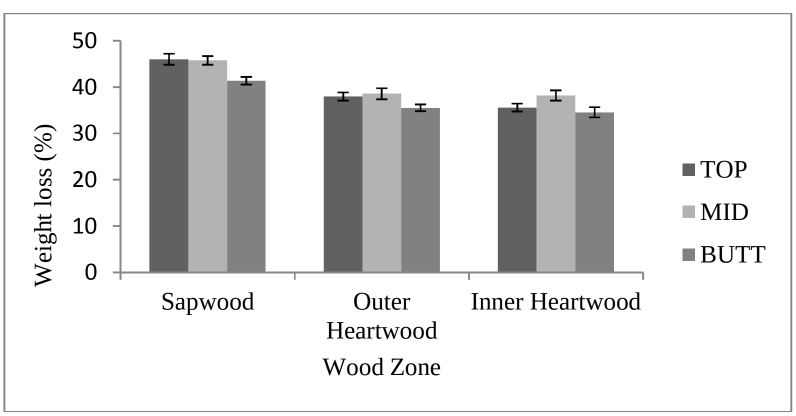

FIGURE 3: Average weight loss (%) of *Cola gigantea* wood from Pra-Anum Forest Reserve (MSDZ) exposed to *C. polyzona* (Data are ± standard deviation).

The results obtained for wood of *C. gigantea* from the Afram Headwaters in the dry semi-deciduos forest zone (DSDZ) was akin to the results from the MSDZ. The highest weight loss (38.30%) was obtained for sapwood from the top whereas the minimum weight loss (13.6%) was recorded for the inner heartwood from the butt (Fig. 4). Differences in weight loss different across (F=13.39, df=2, p=0.016) and along (F=8.77, df=2, p=0.034) the wood of *C. gigantea* from the DSDZ were significant. The weight loss across and along the wood in *C. gigantea* showed a similar trend as observed in *F. sur*.

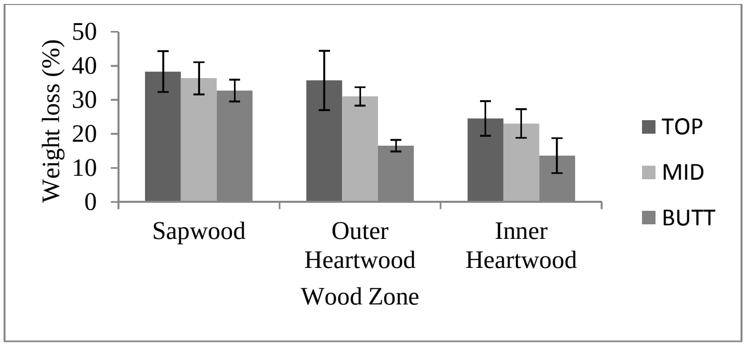

FIGURE 4: Average weight loss (%) of *Cola gigantea* wood from Afram Headwaters (DSDZ) exposed to *C. polyzona* (Data are ± standard deviation).

Comparatively wood of *C. gigantea* and *F. sur* from the DSDZ recorded lower weight losses those obtained from the MSDZ (Table. 1). Thus the two lesser used species from the MSDZ were more susceptible to *Coriolopsis polyzona* than the samples from the DSDZ (Table. 1). From the results obtained and as summarized in Table 2, both *F. sur* and *C. gigantea* are moderately resistant to *C. polyzona* with average weight loss of 36.1% and .33.6% respectively.

TABLE 1: Average weight loss of wood of *C. gigantea* and *F. sur* from the two ecological zones exposed to *C. polyzona*.

Species	Ecological zone	Weight loss ± S.D
C. gigantea	MSDZ	39.29±0.97
	DSDZ	27.95±4.50
F. sur	MSDZ	38.81±1.52
	DSDZ	33.40±3.42

MSDZ-Moist Semi-deciduous Zone, DSDZ-Dry Semi-deciduous Zone, S.D- Standard Deviation.

TABLE 2. Natural durability of *C. gigantea* and *F. sur* exposed to *C. polyzona* according to ASTM D2017-05 classification.

Species	Weight loss (%) ± S.D	Decay Resistant Class
C. gigantea	33.6±2.7	Class III
F. sur	36.1±2.4	Class III

S.D – Standard Deviation

DISCUSSION

Several factors have been proposed to contribute to the variation in the natural durability of wood in different tree species (Taylor *et al*. 2002). One of such factors has been attributed to the presence of extractives within the heartwood. For instance, Panshin and de Zeeuw (1980) reported that the natural durability of wood is due to toxic heartwood extractives and principally its cell wall constituents (lignifications) and their relative distributions in the different cell types. It is important to note that chemical extractives do not always act as inhibitors to enhance natural durability of timber but may serve as carbon source or growth stimulator for the test fungi. Baill`eres and Durand (2000) also indicated that natural durability varies enormously in any given species, not only between trees, but also within the same tree and that variability depends on genetic origin of the tree, silviculture, climate, and the local environment. Wood samples of *F. sur* and *C. gigantea* from the DSDZ were relatively resistant to attack by *C. polyzona* as compared to those from the MSDZ. Within the same tree, natural durability increased from the sapwood towards the inner heartwood. A similar trend was also observed from the top to the butt, except *C. gigantea* from the MSDZ where the inner-heartwood of the mid portion of the wood recorded a higher weight loss as compared with the inner-heartwood from the top (Fig. 1). The results of the present study confirms earlier findings by Baill`eres and Durand (2000) that within the same wood species from the same ecological zone, significant variations exists in weight losses. According to Kokutse (2006), variability exists in natural durability between teak trees of different ages, plantations and geographical zones. Although the two lesser used species were found to moderately resistant to the test fungus, *C. gigantea* was found to relatively durable as compared to *F. sur*. This could be attributed to the differences in densities of the two species. The basic density of *F. sur* has been determined as light and medium for *C. gigantea* (Owusu *et al.*, 2011). Although denser wood may have higher durability, some less dense wood may also be durable due to the presence of crystals like calcium oxalate. Earlier studies conducted by Kumi-Woode (1996) on some Ghannaian timber species revealed that *Entandrophragma utile* was highly resistant whilst *Terminalia ivorensis* was resistant to *C. polyzona* after 12 weeks of exposure to the fungus. However, *Nesogodornia papaverifera* was found to be moderately resistant to *C. polyzona* with average weight loss of 37.31% (Kumi-Woode, 1996). The durability of *F. sur* and *C. gigantea* with average weight losses of 36.1% and 33.6% respectively may be comparable to that of *N. papaverifera* which are moderately resistant according to ASTM standard (D2017-05). According to Kumi-Woode (1996), *Ceiba pentandra* with average weight loss of 66.7% is non-resistant to the *C. polyzona*. Amponsah (1980) also reported that *Chlorphora excelsa* and *Triplochiton scleroxylon* recorded average weight loss of 0.42% and 6.2% respectively, after 6weeks of exposure to *C. polyzona*. The lower weight loss obtained for *C. excelsa* and *T. scleroxylon* may be attributed to the short period (6weeks) of exposure to the decay fungus, *C. polyzona*. Kumi-woode (1996) had indicated that the extent of decay is directly related to exposure time to the test fungus. *F. sur* and *C. gigantea* possesses little to moderate decay resistance and therefore extra protection may be needed by treatment with wood preservatives to prolong the shelf life of these two lesser used timber species, especially for outdoor use.

CONCLUSION

Wood of *Cola gigantea* and *Ficus sur* were found to moderately resistant to the white rot fungus *Coriolopsis polyzona* based on ASTM D2017-05 procedures. However, *C. gigantea* is relatively resistant to *C. polyzona* as compared to *Ficur sur*. Both lesser used timber species can used for indoor application but for outdoor application, the two species may be treated with preservatives to enhance natural durability.

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