

Effect of Air Drying, Solar-Assisted Air Drying and Sticker Thickness on Mahogany (*Khaya senegalensis*) Wood

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Abstract

This study was conducted at Elfaid Um Abdalla saw-mill in Southern Kordofan State to improve Mahogany timber quality by improving air drying process. 6.25 cm thickness lumber boards of 210 cm length were prepared and stacked using three thicknesses of stickers (2.5, 3.75, 5 cm) and replicated three times for each sticker under shade and under direct sun light. This was done to determine the effect of stickers and shading on drying rate and magnitude of defects that occurred during the drying process. Moisture loss was recorded every two days by weighting sample boards inserted in the center side of each stack. Data analysis was done using JMP statistical package. The study showed that there was no effect of the three kinds of stickers and shading on moisture loss during the drying process, while there was effect of shading and stickers on number of defects that are caused with the drying process.

The study recommends using 2.5 cm sticker thickness and shading to decrease defects that are caused by drying.

Keywords: Air drying; Solar drying; Wood defects; Mahogany wood

Introduction

The development of technology of wood, which has been going on for the past eight decades or so, was dictated by the rising competition of metals and other alternative material. The total consumption of sawn timber in the Sudan is about 150,000 m³ per annum; 21% of this goes into building construction and 24% for joinery; 80% of the total consumption is imported soft wood, this is in spite of the fact that our existing forests can supply all our requirements from this commodity. This is partly due to prejudice from the users part against using local woods, and prejudice was attributed to the lack of information about properties and specifications relating to local wood, with good design following the appropriate specifications. Great losses occur through abuse and lack of proper treatment [1]. Losses due to lack of proper drying of wood are colossal. This investigation is an attempt to improve on less costly drying methods without increasing the liability to drying defects.

Material and Methods

The site

This experiment was carried out in Elfaid Um Abdulla Sawmill. This is located in Elfaid region (Latitude 11°40' N, Longitude 30° 30' E) in Southern Kordofan State in the northern part of the central clay plain of the Sudan within the dry land savannah zone. This experiment was conducted during the period between April and June, 2005.

Drying yard preparation

A flat, clean, well drained yard was prepared inside the sawmill yard for wood stacking. Permanent cemented foundations of three rows for each pile were established (total of 54 rows, 27 of them under shed and the other 27 rows under direct sun) and oriented north to south to allow air circulation. The space between the piles was one meter wide.

Timber used for the experiment was 6.25 × 15 × 210 cm in size. This board was organized in 18 stacks (9 under shade and 9 under direct sun light) and oriented east to west.

Sample boards were selected and placed in each pile after being

weighted to measure moisture loss rate. These sample boards were weighed periodically and estimated moistures loss was calculated.

Data collection

Used timber boards were selected as mentioned below (Figure 1) for each stack, then two 2.5 cm sections from each sample board was cut avoiding areas near knots and area closer than 30 cm to the end of the timber.

The sections and sample boards were numbered and immediately weighed accurately. The weight of the sections and sample boards were recorded. Those samples were end coated and placed in the timber stacks in locations where they will dry at the same rate as the rest of the timber. Samples for moisture content were placed in an oven (105°C), until they were oven-dry. They were reweighed and the oven dry weight obtained.

Moisture content (MC) of each section was calculated from equation (1) and average initial MC of the sample board was obtained.

$$MC\% = \left[\frac{\text{Wet weight}}{\text{Oven dry weight}} - 1 \right] \times 100 \quad (1)$$

Oven dry weight of the sample board was estimated using average MC above for each board equation (2).

$$\text{Est. O. D. Weight} = \left[\frac{\text{Wet weight}}{100 + MC\%} \right] \times 100 \quad (2)$$

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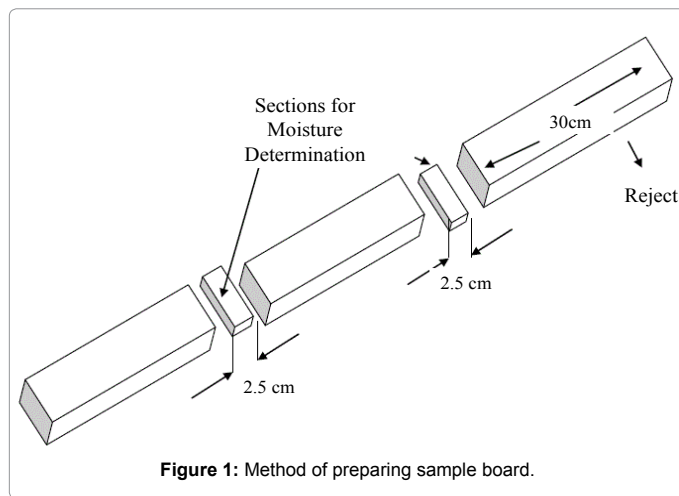


Figure 1: Method of preparing sample board.

Periodically, every three days sample boards were re weighed to obtain anew current moisture content and daily moisture loss equation (3).

$$\text{Current MC} = \left[\frac{\text{current weight}}{\text{Est. O.D. weight}} - 1 \right] \times 100 \quad (3)$$

Average daily moisture loss of the timber was calculated following equation (4). The difference between the successive timber weights were added and divided by the number of days that the sample took to reach the final weight.

$$\text{DML} = \left[\frac{(w1-w2) + (w2-w3) + (w3-w4) + \dots}{\text{Number of days}} \right] \quad (4)$$

Where DML = Daily moisture loss

Timber defects

After the constant weights of timber were reached, 3 stacks were taken from every treatments (sun, shade) with every stack representing one sticker size of the (2.5, 3.75, 5 cm). Every stack contained 49 pieces. Surface and end checks were counted for every piece. For the bowing, the height and length were measured as in equation (5).

$$\text{Bowing} = \frac{\text{height}}{\text{Length}} \quad (5)$$

Data analysis

Analysis of variance was carried out first followed by the least significant difference (L.S.D) looking for significant differences between sticker sizes and between stacks under shed and those under direct sun and trends. Regression analysis was also carried out between time as the independent variable and the moisture loss and MC as the dependent variable. The data was analyzed using JMP statistical package (1995) SAS Corporation.

Results and Discussion

The main purpose of air-drying timber is to evaporate as much water as possible from wood [2]. Table 1 show the initial and equilibrium moisture content of *Khaya senegalensis* wood under shading and under direct sunlight.

The study showed that the initial moisture content (IMC) and

Equilibrium moisture content (EMC) of *Khaya senegalensis* timber when it was dried under shade were not significantly different from IMC and EMC of timber dried under sun.

Drop in moisture content

Figures 2 and 3 shows the relationship between moisture content and time for mahogany timber, and the results of the regression analysis for samples by sticker thickness for shade and direct sun. The samples of mahogany timber started drying at almost the same initial moisture content values, 52-58%, which implies that there is no variation in moisture content of the wood among and within trees in mahogany stem wood. Also, the average equilibrium moisture content attained by the samples was approximately the same, 6.82 and 7.12% (Table 1). The time needed to reach equilibrium moisture content was not more than 35 days for all the samples. Moisture content dropped steeply during the first 20 days. This means that great moisture loss was experienced until wood reaches the fiber saturation point and then moisture loss rate slowed down. For safe drying moisture loss at this stage should be slowed down to avoid distortion and different types of checks especially surface, end checks and start of splits [3]. The results of the polynomial regression of the moisture content values on time for each sticker thickness under shade and under direct sun are shown in Figures 1 and 2. This result indicates that regression coefficients (R square ranged from 0.93 to 0.98) were highly significant. According to this degree of precision the relationship between moisture content and time for mahogany sawn wood (5 cm) can be estimated and explained by the second order polynomial regression equation at specified day during the same period of the year in which this experiment was carried out (April to June).

Moisture loss

The main objective of air seasoning is to reach the equilibrium moisture content or reach a constant level of moisture [4]. Air seasoning

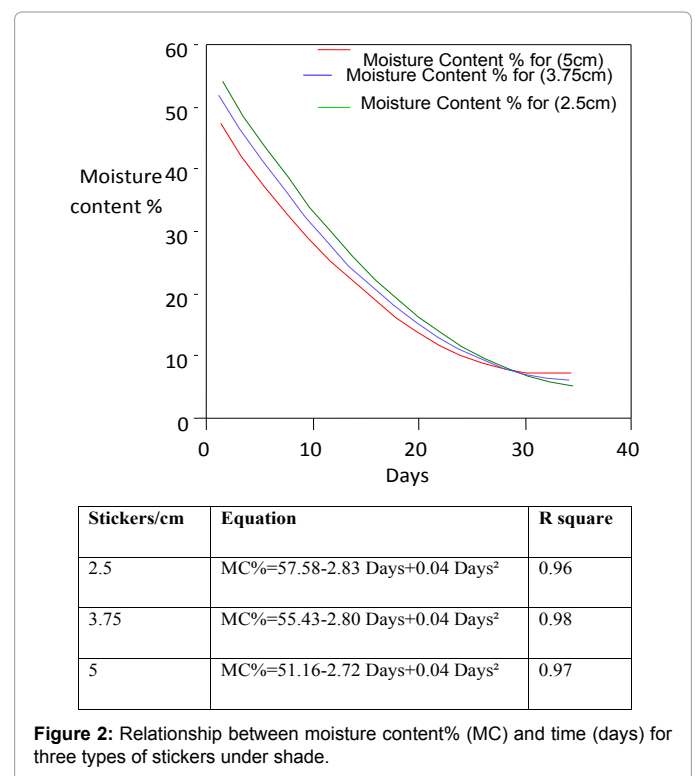


Figure 2: Relationship between moisture content% (MC) and time (days) for three types of stickers under shade.

Shading	Initial Moisture Content %	Equilibrium Moisture Content %
Shade	54.18 a	6.82 a
Sun	56.06 a	7.12 a

P ≤ 0.480

P ≤ 0.815

The same letters on one column represent no significant differences.

Table 1: Moisture content of *Khaya senegalensis* wood under shading and under direct sunlight.

can be carried out under shading or under direct sun without any shading. Table 2 shows the effect of drying under shade or direct sun on wood moisture loss.

The results showed that shading had no significant effect on wood moisture loss (Table 2); there was no significant difference between moisture loss under the shade and under the direct sun. The results are in contrast with Reeb [5] who reported that shading allowed more control and slowed down the drying process. And contrast with Koch [4] who reported that sun rays made an extra work with air in drying timber so that the moisture loss becomes faster under sun.

Table 3 shows the effect of stickers on wood moisture loss. From these results it was obvious that there were no significant differences in moisture loss between the three sizes of stickers used (2.5, 3.75, 5 cm). It is clear from the table that there are no significant differences in moisture loss between stickers under sun and under shade (Table 4) and this result resembles the effect of stickers on moisture loss under both shade and direct sun light.

Table 3, from this results and the previous results of Table 3 it can be suggested that sticker thickness has no significant effect on moisture loss when wood dried under shading or under direct sun, that may be implied that the three type of stickers thickness gave wood the same chance of air circulation needed for removing moisture coming out from wood.

Wood defects

Table 5 shows the effect of shading and direct sun on surface checks, end checks, bowing of wood with all sticker sizes. The surface checks are among sawn wood defects that decrease its commercial value. The speed of losing moisture from wood can affect the defects of wood positively or negatively [6]. Shading affects water loss from wood during the drying process [5]. Drying under direct sun light showed more checks than drying under shade. These results are acceptable because wood loses more water when it is exposed to direct sun light and creates more defects than the slow rate of seasoning process. So the drying under shade is significantly better for decreasing surface checks. The results showed highly significant differences between drying under shade and under direct sun light on causing end checks defects. Bowing is one of the wood defects that make the stock difficult to work with and cut [7]. From result seasoning of wood under shade and under direct sun light showed no significant differences in bowing defects.

Table 6 shows that effect of different sticker thicknesses on the amount of surface checks, end checks, bowing with or without shading. From this table it is clear that there are no significant differences of wood surface checks when 3.75 cm and 5 cm sticker's thickness are used. Sticker 2.5 cm thickness reduced surface checks significantly than stickers of 3.75 cm and 5 cm thickness. The best sticker sizes were 2.5 cm thickness and 3.75 cm thickness. The 5 cm thickness had more defects than others. These results, which depicts the effect of sticker sizes on end checks. From the above tables the stickers have not affected bowing. This result was accepted because bowing resulted from too wide spacing of stickers [8].

Table 7 shows results of the effect of different sticker thicknesses on amount of surface checks, end checks, bowing of wood dried under shade and direct sun light. Comparison between three sizes of stickers under sun showed no significant differences on surface checks. When the same comparison was made under shade, less surface checks were obtained when 2.5 cm stickers were used with no significant difference between these checks and checks obtained with 5 cm thickness stickers. The worst result was with stickers of 3.75 cm thickness with significant difference from stickers of 2.5 cm thickness. This result can be accepted if we consider the different types of sawing dried differently.

From these results the effect of stickers on end checks defects under the direct sun light was highly significant, 5 cm sticker thickness was the worst ones in causing end checks defects and 2.5 cm and 3.75 cm were not significantly different from each other. While under shade there were not significant differences between amounts of end checks for the three sizes of stickers. So to minimize the end checks defects the wood can be dried under shade with any of these sizes of stickers. For drying under direct sun light small sticker sizes can be recommended for less amount of end checks. On the other side, the comparison between stickers under the sun only for bowing magnitude showed significant difference. The best sticker sizes were 2.5 cm and 3.75 cm because they resulted in less magnitude of bowing defects, while no significant

Shading	Mean of moisture loss (Kg/day)	Rank
Sun	0.177	a
Shade	0.187	a

P ≤ 0.334

SE ± 0.007

CV = 11

The same letters on one column represent no significant differences.

Table 2: Effect of shading on moisture loss over all stickers.

Stickers thickness (cm)	Mean of moisture loss (Kg/day)	Rank
2.5	0.188	a
3.75	0.175	a
5	0.182	a

P ≤ 0.56

SE ± 0.009

CV = 11

The same letters on one column represent no significant differences.

Table 3: Effect of stickers' thickness on moisture loss under both shade and direct sun light.

Stickers thickness (cm)	Mean of moisture loss under shade (Kg/day)	Mean of moisture loss under direct sun light (Kg/day)
2.5	0.183 a	0.193 a
3.75	0.180 a	0.170 a
5	0.167 a	0.197 a
	P ≤ 0.753	P ≤ 0.180
	SE ± 0.02	SE ± 0.009
	CV = 12	CV = 9

The same letters on one column represent no significant differences.

Table 4: Effect of stickers on wood moisture loss when drying process takes place under shade and direct sun light.

Shading	Mean of surface checks (No/board)	Mean of End checks (No/board)	Mean of Bowing (cm)
Sun	4.03a	1.91a	0.003a
Shade	2.48b	0.4b	0.003a
P	0.0001	0.0001	0.83
SE	0.27	0.14	0.0004
CV	104	168	140

The same letters on one column represent no significant differences.

Table 5: Effect of shading on wood defects over all stickers.

Stickers thickness (cm)	Mean of surface checks (No/board)	Mean of End checks (No/board)	Mean of Bowing (cm)
2.5	2.54b	0.64b	0.003a
3.75	3.92a	0.60b	0.003a
5	3.31a	2.22a	0.004a
P	0.012	0.0001	0.074
SE	0.33	0.17	0.0005
CV	104	168	140

The same letters on one column represent no significant differences.

Table 6: Effect of stickers thicknesses on wood defects under both shade and direct sun.

Shading	Stickers thickness (cm)	Mean of surface checks (No/board)	Mean of End checks (No/board)	Mean of Bowing (cm)
Sun	2.5	3.47 a	0.86 b	0.003 ab
	3.75	4.55 a	0.80 b	0.002 b
	5	4.08 a	4.08 a	0.005 a
	P	0.305	0.0001	0.017
	SE ±	0.5	0.3	0.0007
	CV	86	128	144
Shade	2.5	1.61 b	0.43 a	0.002 a
	3.75	3.29 a	0.41 a	0.004 a
	5	2.53 ab	0.37 a	0.004 a
	P	0.030	0.894	0.213
	SE ±	0.44	0.09	0.0006
	CV	127	166	135

The same letters on one column represent no significant differences.

Table 7: Effect of stickers thickness on wood defects under shade and direct sun.

differences was found between these defects when we use 2.5 cm and 5 cm thickness stickers. This result also may be due to differences in type of sawing method mentioned before. Under the shade there was no significant difference between stickers that causes bowing.

Conclusion

According to the results of this study the following points can be concluded:

1. No significant difference in initial moisture content in mahogany wood from tree grown in Um abdalla forest.
2. When mahogany wood is dried under direct sun light or under shade no significant differences were noted in equilibrium moisture content.

3. Time needed for drying mahogany sawn wood using air drying method (under direct sun light or under shade) in South Kordofan, summer season is very short (35 days).

4. Rate of daily moisture loss is very high at the first stage of drying (first two weeks) until wood reaches the fiber saturation point and then the moisture loss rate slows down.

5. There was no significant difference between sticker sizes or shading on moisture loss.

6. There were obvious effects of shading on surface and end checks. Shading decreased these defects and this is an evidence of shading importance.

7. Stickers also affect surface and end checks when the stickers are large these defects increased and this lead to suggest smaller stickers for minimizing timber defects.

8. Bowing, is not affected by shade or stickers thickness.

Recommendation

Using shade for air drying method is very important for minimizing surface and end checks in drying mahogany timber.

2. Two and a half cm sticker thickness is recommended for wood drying because it is the best for minimizing defects.

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