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Valorization and Characterization of Maritime Pine (*Pinus pinaster*) Wood from the Maamora Forest in Plywood Panels

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Abstract: Morocco has undertaken reforestation, since, the 1960's to meet its needs for timber. Among these species, there are softwood in general and especially the Maritime pine (*Pinus pinaster*) because of its rapid growth, its relatively short life span and its strong rooting. The physical and mechanical study of 4 trees of the reforested Maritime pine (*Pinus pinaster*) from the Maamora forest (Machraa El Kettane) in Morocco at maturation age showed that according to the Growth Constraint Indicators (GCI) of the four trees, the Maritime pine wood is quite nervous with an average stress of about 75 µdef. The sawing performance of the resulting plots is close to 58%, the flows have medium quality, the artificial drying of the planks with a moisture content of 54% lasted 165 h. As a result, the final humidity is 10%. The physical and mechanical characteristics allowed to classify this wood in moderately nervous, semi-heavy and soft wood and usable as ground-wood or in sawn-wood for the manufacture of boxes and carpentry. The wood of the Maritime pine (*Pinus pinaster*) from the Maamora forest (Machraa El Kettane) was subject to transformation into plywood panels. These panels were made in three folds that have a density variation between 520 and 550 at 12% moisture, a medium flexural strength of 24 MPa, an average compressive strength of 25 MPa and a rolling shear that varies between 2.1 and 2.6 MPa. These plywood panels of Maritime pine can be classified as panels with medium density and high rigidity.

Key words: Maritime pine, physical properties, mechanical properties, plywood panel, GCI, Machraa El Kettane

INTRODUCTION

The growing demand for forest products in Morocco has been detrimental to its natural resources, especially, timber. To overcome this problem, Morocco was obliged to import wood for construction, furniture and carpentry. The importation rate has made the country's trade balance largely in deficit with regard to timber and timber products. Among these imports, the volume of softwood with medium technical characteristics is very important.

Consequently, to deal with this deficit in terms softwood's resources, Morocco has adopted a reforestation strategy, since, the sixties. The natural surfaces of the maritime pine in Morocco do not exceed 12,000 ha, divided between the Rif (mountains of Chefchaouen, Ketama, etc.), the Middle Atlas (surroundings of lfrane, Bou Iblane, Bou Nacer, etc.) and the High Atlas. Thanks to its ecological plasticity, its rapid growth, its longevity quite weak, its strong rooting, its adaptation to poor soils as well as its various socio-economic virtues (bark, wood, resins), the Maritime pine (*Pinus pinaster*) was chosen as the second most used specie in reforestation (National Reforestation Plan) with an area of about 54000 ha. Which represent 10% of the total area reforested. Currently, these plantations have reached the age of exploitation.

The wood of this specie is not appreciated by the local companies because of its knottiness, its resin content and its sensitivity to blue stain. The main economic activity of this specie is intended for the traditional sawing, the manufacture of benches, crate-packing as mine posts formwork and mainly as firewood.

Very few researches are conducted on these physical and mechanical properties (Meite *et al*., 2007; Grazide,

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2014; Castera, 2005; Thibaut *et al*., 1992; Bekkioui, 2009; Dumail *et al*., 1998; Ohta *et al*., 1985; Bettayeb and Azzaoui, 2010). The trends identified by the researches focus on genetic improvement (Chagne, 2004; Keller, 1973), fire resistance (Fernandes *et al*., 2008; Rigolot and Frenandes, 2005), Maritime pine studies (Loup *et al*., 1991), artificial resin pockets (Marpeau and Castera, 1999), the dynamic behavior of young maritime pine (Sellier, 2004), the formative period and the distribution of the compression wood along the stems (Polge and Illay,1967), the bending studies that were conducted for the description of root systems (Dupuy, 2003), the modeling of the biomechanical behavior of growing trees (Ancelin, 2001).

The purpose of this study is to determine the physical, mechanical and technological properties of reference of maritime pine wood. It also, aims to determine the technical and economical possibilities of valorization of this essence by sawing and peeling for a better use of this kind of wood.

MATERIALS AND METHODS

Vegetable matter: The four sample trees are from reforested plantations of maritime pine randomly selected from the region of Mechra El Ketan (Western Maamoura). The choice was made on dominant trees not forked with a well-balanced crown in a homogeneous group of maritime pine with a diameter between 20 and 35 cm. The trees are felled and cut into ridges of approximately 1.30 m long Fig. 1.

In the Table 1, we reported the measurements of some mensurational characteristics such as Total height (Th), circumference at a height of 1.30 m from the ground ($C_{1,30}$), circumference at the base of the trees (C_{base}) and the thickness of the bark (E_c).

Felling techniques

Selection criteria of the trees: The choice of the 4 sample trees used in our study was made in such a way that the trees are rectilinear, straight not sufficiently branched and in good health (Fig. 2). We took the values of the Growth Constraint Indicators (GCI) on 8 positions (North, Northeast, East, Southeast, South, Southwest, West and Northwest) from the periphery of the tree, at a height of 1.3 m from the ground for the measurement of the Growth Constraints (GCI) of standing trees by the single hole method.

Measurement of the Growth Constraint Indicators (GCI) of standing trees: The principle described by Archer (1987) consists in measuring the variation of the distance between two points due to the drilling of a central hole of 20 m. First of all, there is the barking of the tree at a height of 1.30 m from the ground in order to reveal the cambium. Then, after having planted the two reference points separated with a distance of 45 mm and with a depth of 10 mm (Fig. 3), we install a frame that rests with three supports on the barked tree.

This frame consists of a chassis equipped with a Mitutoyo type comparator with a precision of micron. The gauge of the comparator presses on one of the two points while the chassis rests on the other point. Two elastic angles are used to press the frame on the tree. A hole with a diameter of 20 mm is then drilled between the two points and a positive or negative movement is observed, depending on the case where the wood is stretched or compressed. We stop drilling when the value indicated by the comparator is stabilized.

The measurement is based on the local modification of the growth field in the plan L_T. This unique hole method is inspired from traditional techniques of measuring self-stress in materials. The relation that exists between the variation of distance between the points D_d and the aging deformation (in the longitudinal direction) a_L is given by the formula:

$$a_L = k^*D_d$$

Where:

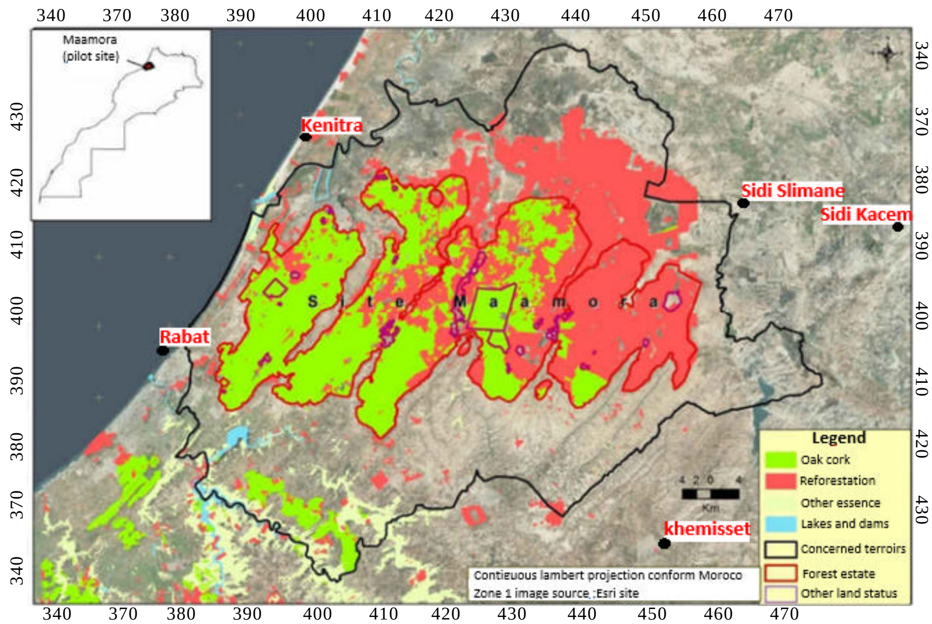
K = Constant in micro deformation (μ)
D_d = Variation of distance between the points (μ)
a_L = Maturation deformation (in micro deformations)

Measurements are carried out before felling on eight holes drilled on the circumference of the trees in order to obtain a field of distribution of exploitable growth constraints on the whole periphery of the trunk.

Table 1: Mensurational characteristics of the 4 samples of trees

				E_c (mm)		Moisture (%)			
Tree's numbers	$C_{1.3}$ (cm)	C_{base} (cm)	Total heigh (m)	Max	Min	N	O	S	E
1	111	130	16.6	29.87	15.17	82.7	80.5	75.8	80.6
	95								
2	103	122	14.5	26.55	15.66	82.4	81.2	80.5	81.0
	94								
3	106	142	18.5	36.58	24.89	81.7	80.5	80.4	81.3
	89								
4	114	146	20.8	27.60	22.44	82.4	81.5	81.6	82.0
	100								

(a)



(b)

Fig. 1: a) The reforestation zone of the Maritime pine in the Maamora forest and b) The distribution of the 4 sample trees

Felling and cutting of the 4 Maritime pine trees: Before felling the tree, we first determined the fall direction based on the factors influencing the direction of fall (wind direction, shape, tree position and site). Then we removed the observable buttresses at the base of the trunk. This allows a better control of the fall direction. The notch has two distinct saw-cuts: the upper line attacks the tree at 45° and must not exceed one quarter of

Fig. 2: Hybrid Maritime pine tree sample

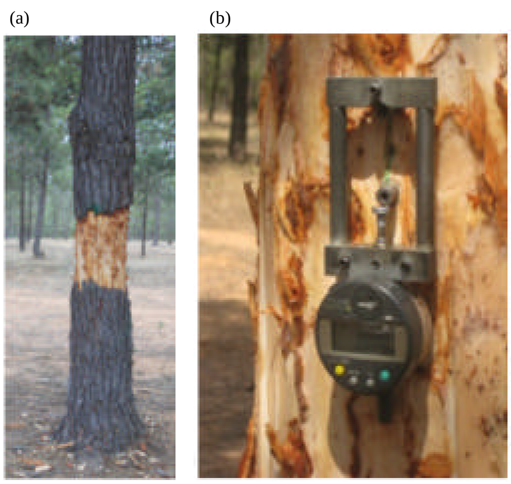


Fig. 3: a) Barked tree of the Maritime pine tree and b) Measuring device of the DRLM

the diameter of the tree, the lower line is horizontal (floor of the notch) and must join the top line. The horizontal saw line should be approximately 3 cm above the floor of the cut (Fig. 4).

Log sawing: The experimental material consists of 08 logs of Maritime Pine of 1.30 m long that have been qualified and numbered with reference to the rules in force, regarding the classification of the unhewn timber and that was taken from the base of the four sample trees.

The sawing is done in blocks in a localsawmill at the Forest Technology Center of Rabat (F.T.C.R.). This is a parallel sawing oriented in the direction of = the highest value of growth constraint.

Drying and conditioning of maritime pine wood: The sawn wood was naturally pre-dried and then dried using

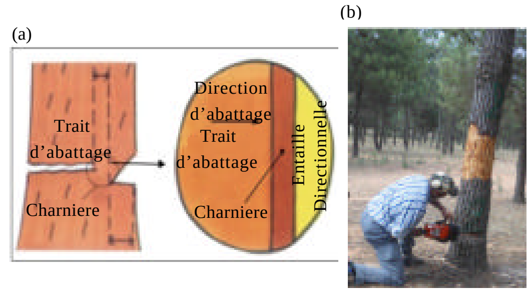


Fig. 4: a) Directional notch having an opening of 45° and a depth corresponding to about 1/4 or 1/5 of the diameter of the trunk and b) Maritime pine tree felling

a conventional, semi-industrial dryer "Cathild" to visualize and control in real time moisture, temperature, ventilation speed and equilibrium humidity.

Taking into account the physical and mechanical characteristics of reference of the maritime pine wood, the drying table described in Table 2 was used.

The dryer is initially filled with planks stacked as horizontal rows and separated by 2×2 cm^2 rods in other words six rods per row. The choice of the conditions of drying takes into account the physical and mechanical properties of reference of the maritime pine wood, namely the shrinkage, the density, the hardness and the initial state of humidity.

Physical and mechanical properties: The tests concerning measurements of the physical and mechanical properties of reference were carried out within the Physical and Mechanical Laboratory of the Forest Technology Center of Rabat (F.T.C.R).

Considering that for each type of test there is a well-defined form of test pieces (Famiri *et al*., 2012; Fournier *et al*., 1991, 1994; Hills and Brown, 1978; Maziri, 2010; Bailleres, 1994; Archer, 1987; Sallenave, 1971), these tests were carried out on small healthy test pieces made from the diametrical planks taken from the ridges of the maritime pine woods, following a parallel sawing.

Description of the physical tests: The test for the determination of the basic physical properties of wood consists in taking cubic test pieces with 20 mm edges (Fig. 5), according to standards NF B 51-004 and NF B 51-005.

Moisture content: The moisture content is expressed by the following Equation:

$$H\% = \frac{M_h - M_o}{M_o} \times 100$$

Table 2: Experimental conditions of the drying test

Variables	Sequence	V	←(h)	°H (h)	D (h)	HR (%)	T(°C)	HE(%)
S1	Preheating 1	99	02	06			45	75
S2	Preheating 2	99	04		05		50	77
S3	Drying 1	99	10			>50	55	74
		99				50-40	55	69
		90				40-35	55	66
		85				35-30	63	62
S4	Drying 2	80	10			30-27	63	59
		70				27-24	63	59
		60				24-21	63	56
		55				21-18	65	53
		50				18-15	65	50
		40				15-12	65	47
		40				12-09	65	41
S5	Balancing	40	04		10		55	
S6	Cooling	40		004			22	

V: Fan power (%), HE: Moisture Equilibrium humidity (%),← : Ventilation time, °H: Slope of rise or fall of the temperature, T: Temperature (°C), D: Duration of a drying sequence and HR: Control humidity (%)

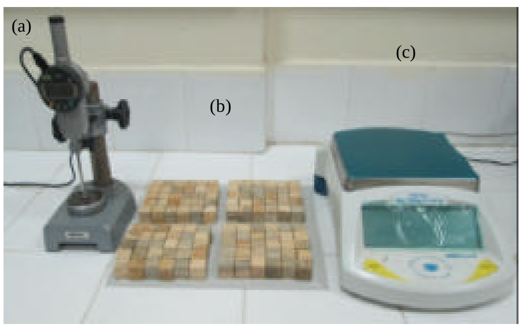


Fig. 5: a) Mitutoyo-type electronic comparator; b) Specimens for physical tests in number of 30/tree and c) Electronic scale

Where:
M_h = Mass of the specimen in the wet state
M_0 = Mass of the specimen in the anhydrous state

Volume shrinkage: This is the variation of the volume of a standardized specimen, from the saturated state to the anhydrous state. This retractability is expressed by the following formula (Sallenave, 1971):

$$R_v\% = \frac{V_S - V_o}{V_o} \times 100$$

Where:
V_s = Volume in the saturated state
V_0 = Volume in the anhydrous state

Linear shrinkage: The volume variation is the result of linear variations of wood in three dimensions: longitudinal, tangential and radial. The wood which is a very heterogeneous material has very different shrinkages in these three dimensions. The radial shrinkage is given by the following relation:

$$R_r = \frac{R_S - R_o}{R_o} \times 100$$

Where:
R_S = Radial length of the specimen in its saturated state
R_0 = Radial length of the specimen in its anhydrous state

The tangential shrinkage is expressed by the following relation:

$$R_t = \frac{T_S - T_o}{T_o} \times 100$$

Where:
T_s = Tangential length of the specimen in its saturated state
T_0 = Tangential length of the specimen in its anhydrous state

Density: The density is the quantity of the woody material contained in a given volume of wood at a rate of moisture of 12%. It is expressed by the following relation:

$$D_H = \frac{M_H}{V_H}$$

Where:
M_H = Mass of the specimen at humidity H%
V_H = Volume of the specimen at humidity H%

Infra-density D_b: This density is in particular an indicator of rigidity. It should be noted that the measurement of the infra-density benefits from a minimum measurement error, since, the anhydrous mass and the saturated volume are two measures where the sources of errors are minimal. It is determined as the ratio of the weight of the test piece in the anhydrous state and its volume in the saturated state. According to the French standard NF B 51-005, it is the most used and it is expressed as follows:

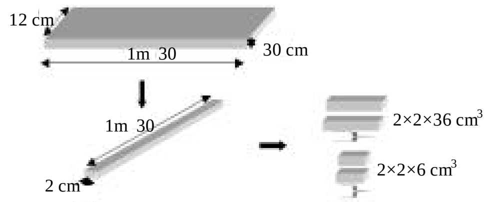


Fig. 6: Confection of test material

Fig. 7: Illustration of the Bing vibratory test

$$V_S = \frac{m_e - m_a}{\rho}; D_b = \frac{M_o}{V_S}$$

Where:

M_0 = Mass of the specimen in the anhydrous state
V_s = Volume of the specimen in the saturated state

The saturated volume V_s is measured by the substitution weighing method where m_e and m_a, respectively designate the mass of the sample in water and in air. The density of the water is calculated by the formula: $\rho = 1$ g/cm^3.

Description of the mechanical tests: The mechanical tests lead to the determination of the mechanical resistance of the material to the forces exerted (Fig. 6).

Description of the BING test: The bars of dimensions 2×2×36 cm^3 following the respective natural directions (RTL) and cut according to the French standard NF B 51-008 were used to determine the modulus of elasticity through the vibratory method of BING (Fig. 7).

Axial compression test: We then performed an axial compression test on 30 pieces of wood with dimensions 2×2×6 cm^3 (RTL), free from defects in each tree of the maritime pine. This test was carried out using a hydraulic

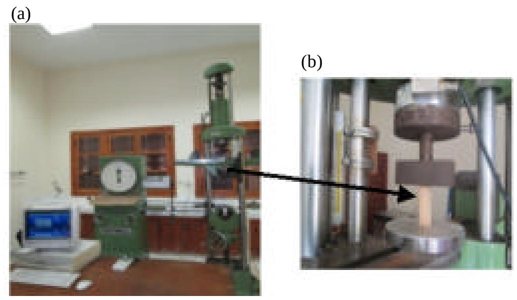


Fig. 8: Illustration of the compression test

Fig. 9: Hardness device

press of a universal brand "Testwell" with a maximum load cell equal to 12 tons for each piece of wood and specie at an average speed of movement and load, respectively about 10 and 9 mm/mn (Fig. 8).

Hardness test: A series of 30 specimens with geometric dimensions 2×2×6 cm^3 following the radial, tangential and longitudinal natural directions (L, T, R) was subject to a hardness test according to the standard in force (NF B51-013) using a hydraulic press of an universal brand "Testwell" with a maximum load cell equal to 12 tons (Fig. 9).

Paneling tests based on maritime pine wood: According to the physical and mechanical results obtained, we can conclude that the wood of the maritime pine can be unrolled as it is a moderately nervous, semi-heavy and soft wood.

Steaming: The 4 log blocks of about 80 cm in length and 72 cm in circumference of the four Maritime pine trees weresteamed in a water bath at a temperature of 70° for 16 h to prevent slit propagation (Fig. 10).

Unrolling: After steaming, the log blocks were unrolled using a laboratory peeling machine (Guillet) at a speed of 80 m/min and a plating thickness of 3 mm. The ball is held by its ends and is animated by a rotation movement.

The knife (as well as the pressure bar) mounted on a tool holder is parallel to the axis of the log and attacks it by the periphery. It detaches a huge long chip which has for width the length of the log and which unfolds as the operation proceeds, at the same time as is carried out the automatic advance of the tool holder corresponding to the thickness plating (Fig. 11).

Initially, we made a “round” of the log giving veneer strips. Once, it is completed, we obtain a continuous ribbon several meters long. The unrolling stops automatically when the knife comes close to the claws.

Drying: The thin veneers that were unrolled were quickly dried in a conventional dryer, type “Cathild” to prevent any distortion and discoloration. Very humid, they are brought on average to a final humidity of 6%.

Fig. 10: Steaming operation of the Maritime pine log blocks

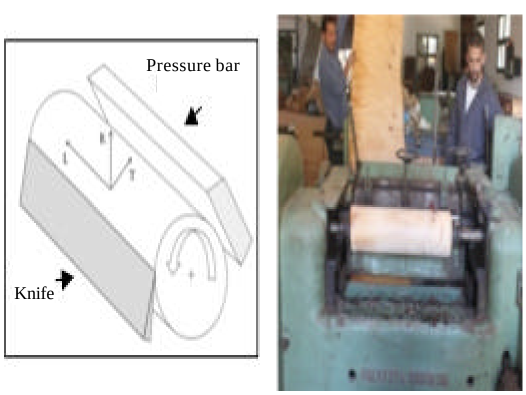


Fig. 11: Unrolling of the Maritime pine wood

RESULTS AND DISCUSSION

Growth Constraints Indicators (GCI): Table 3 shows the mean, maximum and minimum values for the four maritime pine trees and the difference (max-min) of the measurements of the GCI in im. These measurements were made by the single hole method on the standing trees (1.3 m above ground level) at 8 points at equal angular deviations along the circumference.

The frequency distribution according to the GCI classes is shown in Fig. 3. This distribution is characterized by asymmetry to the right to a greater or lesser degree. The tail is characterized by a limited number of high GCI values characterizing a wood with a state of different growth constraints (tension wood) (Fig. 12).

Figure 13 gives an angular representation of the experimental profiles of the GCI measured on the 4 maritime pine trees as well as the average for all the trees. The profile focuses on the highest value of the GCI. The highest GCI value is recorded for the tree “3”.

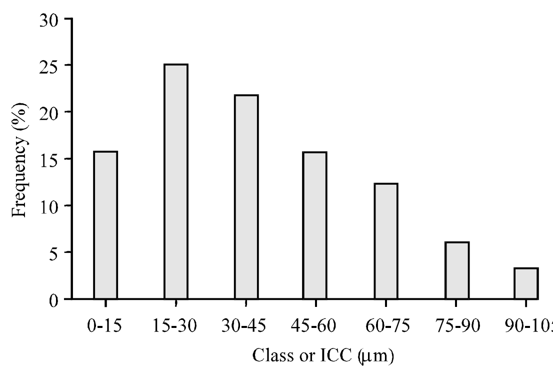


Fig. 12: Histogram of GCI values measured on the surface of maritime pine trees

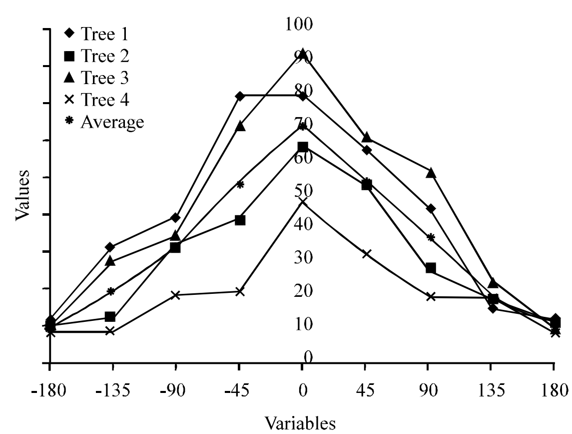


Fig. 13: Experimental profiles of the average of the GCI and for each tree

Table 3: GCI measurement's results for the four hybrid pine trees before felling

	ICC (µm) a 1.3 m/sol before felling											
Tree's number	North	Northeast	East	South east	South	South west	West	North west	Average	Max	Min	Max-min
1	64	80	44	47	17	35	13	80	47.5	80	13	67
2	14	35	65	28	43	19	53	12	33.6	65	12	53
3	10	25	31	71	68	38	58	93	49.2	93	10	83
4	33	9	19	20	20	48	9	21	22.3	48	9	39

Table 4: GCI profile adjustment parameters following the SASSUS model

Average profiles	Max	Min	Moy	θ_0	$\delta\theta_0$	Max-Min
4 trees of the Maritime pine	72	11	35	1.5	45	61

Table 5: Saw yield 1 ($R_{sawing,fo}$, $R_{sawing,cf}$) $R_{sawing,2}$

Tree	Billon	V_{billon} (m^3)	$R_{sawing,fo}$	$R_{sawing,cf}$	$R_{sawing,2}$
1	1	0.253	78.250	76.790	59.320
1	2	0.282	72.212	74.960	57.911
2	1	0.264	82.620	81.459	58.122
2	2	0.225	73.132	78.546	57.633
3	1	0.207	75.534	78.867	60.133
3	2	0.274	71.675	70.765	56.454
4	1	0.208	74.023	72.298	58.603
4	2	0.192	77.089	78.945	56.489

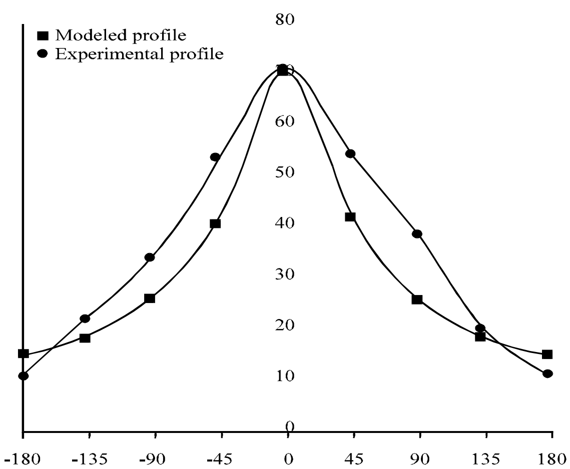


Fig. 14: Average profiles of the GCI adjusted according to the model

In Table 4, we give the adjustment parameters θ_0 and $\delta\theta_0$ of the growth constraints indicators profiles according to the Sassus model. From the adjustment parameters adopted for the green oak trees, we have drawn in full line, the GCI adjustment curve and in points, the experimental mean values (Fig. 14). We note that the difference between measurements and adjustment is greater for the low GSI values (asymmetry of the average profile). In spite of this difference, the Sassus model gives a satisfactory result and allows to describe the angular variations of the GCI characterizing the normal wood (low value of the GCI) and the tension wood (high value of the GCI).

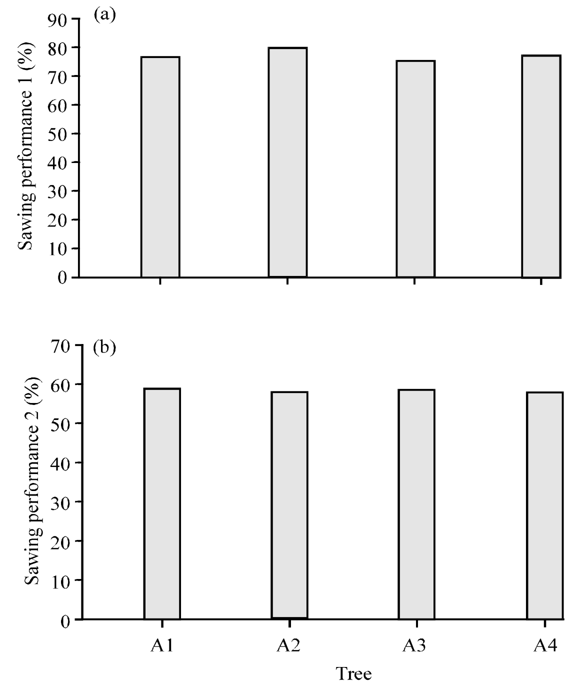


Fig. 15: Histrogrames showing average yield per tree

Saw yield: From the mensurational measurements taken on the pads of the four trees of the maritime pine, we calculated the saw yield (ratio of the sum of the volumes of the lumbers and the volume of the log block) of the open sides $R_{sawing,fo}$ and of the counter faces $R_{sawing,cf}$. of the sawn planks as well as their secondary saw yields after edging $R_{sawing,2}$. Table 5 contains the results found (Fig. 15).

Conditioning of the Maritime pine wood: The artificial drying lasted about a week (165 h) regarding an average thickness of 27 mm, a mean wood moisture of 54% initially and a final humidity of 10% (Fig. 16).

At the end of the artificial drying, very few defects were observed (some deformations on the planks in the upper part of the folds).

Natural drying has the advantage of being less abrupt because of the rotation of the day and the night during which the relative humidity of the air always rises to a high value. It does not require any source of energy and appears relatively simple to conduct.

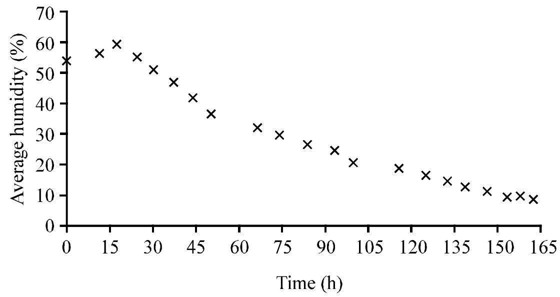


Fig. 16: Drying kinetic of the Maritime pine wood in the Cathild dryer

Table 6: Proprietes physiques de reference du bois de 120 eprouvette normalisees issu 4 arbres de Pin Maritime de la foret de Maamora (Machraa El Kettane)

Variables	Average	Coefficient of variation
Moisture (%)	11.000	8
Density at 11(%) moisture	0.569	13
Anhydrous density	0.518	14
Infradensity	0.452	12
Volumetric releasing (%)	14.500	12
Tangential releasing (%)	7.200	12
Radial releasing (%)	5.100	11
Fibers saturation point (%)	32.500	13

Table 7: Mechanical properties of reference of the wood of 120 standard specimens from 4 maritime pine trees of the Maamora forest (Machraa El Kettane)

Variables	Average	Coefficient of variation
Elasticity module Timoshenko E_d (MPa)	9859	12
Dynamic shear modulus G_d (MPa)	1407	11
Resistance in axial compression Ca (kg/cm²)	356	13
Modulus of elasticity in axial compression E'_a (MPa)	2141	11
Hardness number monnin N	0.29	13

However, the temperature and hygrometry of the air are not controlled which enhance insects and fungi attacks.

The physical and mechanical properties of reference: The results of the physical and mechanical characterization of Table 6 and 7, respectively shows that the maritime pine wood is soft with a Monnin hardness number of 2.8 N, light with an average density of about 0.55, moderately resistant with a low modulus of elasticity of 11.8 GPa and nervous with an average coefficient of retraction around 0.46%. The comparison of these results with the average characteristics of "conventional" softwoods Scots pine, Douglas fir, Fir, Spruce shows that the maritime pine wood perfectly supports the comparison with respect to these softwoods as much for its mechanical strengths as for its stability characteristics.

These technological characteristics, therefore, classify the maritime pine wood of the Maamora as a moderately nervous, semi-heavy and soft wood that can be used as round wood or sawn wood for boxes manufacture and carpentry. It is suitable for gluing regarding the manufacture of reconstituted solid wood and also for turning (Fig. 17).

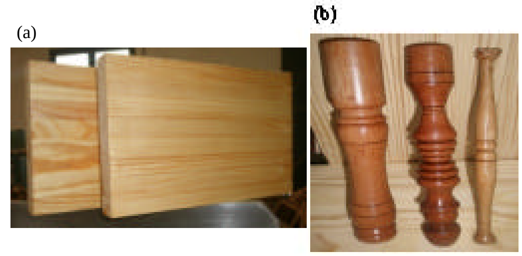


Fig. 17: a) Reconstituted solid wood of maritime pine and b) Turned wood of maritime pine

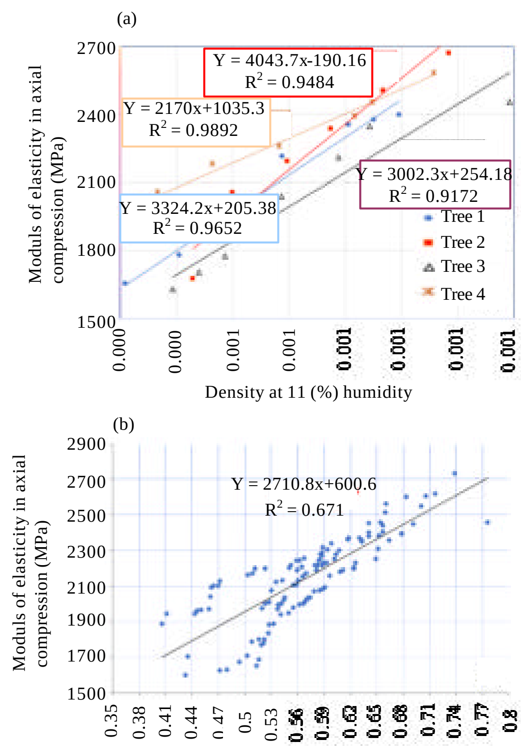


Fig. 18: Evolution of the modulus of elasticity in axial compression of the maritime pine wood from the Maamora forest depending on the density at 11% humidity: a): Four trees and b) Four trees (120 measurements)

Figure 18a shows the variations of the modulus of elasticity in axial compression of the Maritime pine wood depending on the average density at 11% humidity at intervals with a regular pitch of 0.05 for the

Table 8: Average of the physical and mechanical characteristics of three ply plywood (12 mm) of unrolled pine wood

Variables	Minimum	Maximum	SD	Average
Density at 12%	520	550	10	540
Flexural resistivity (MPa)	21	26	2	24
Compression resistivity (MPa)	19	28	3	25
Rolling shear (MPa)	2.1	2.6	2	2.2

four sample trees at the rate of 30 specimens per tree. Figure 18b shows the same variations for all trees, ie a distribution of 120 measurements.

The results obtained show that as the density increases, the modulus of elasticity also increases. In fact, the modulus of elasticity in axial compression increases from <1700 MPa for a density close to 0.44 to more than 2700 MPa for a density of the order of 0.75. This variation could be attributed on the one hand to the texture and on the other hand to the resin contained in this type of wood. Similar results have been obtained by previous work (Thiboult *et al*., 1992).

Characterization of veneers and plywood: The Maritime pine is a wood specie easy to unroll. Indeed with a prior hygrothermal treatment (temperature: 70°C for 16 h), unrolling efforts become very low.

The quality of the veneers produced is globally satisfactory. It is sometimes linked to the intrinsic quality of the wood. In fact, the irregularity of the thickness is insignificant for all the veneers as well as the roughness and the cracking which are very weak. The plywood panels made in three plies which were fabricated from unrolled Maritime pine wood have the following physical and mechanical properties (Table 8).

The variability of the properties of the panels is mainly influenced by the thickness of the unrolled veneer sheets, the type of adhesive and the position of the log blokcs in the tree. These properties allow to classify the plywood panels of the maritime pine in the category of medium density and high rigidity. These properties are mainly influenced by the thickness of the veneer.

CONCLUSION

All these findings regarding the Maritime pine will have a direct impact on the management of forest areas through the improvement of forestry practices, firefighting, landscape management as part of a multifunctional management of the Maritime pine stands.

These results will help stakeholders in the sector to increase their competitivity while improving the management of natural resources.

It is worth noting that Morocco is highly dependent on its imports of timber and derived products which raise to about three billion dirhams each year. Its coverage rate for wood products is currently close to 30%. Wood needs are steadily increasing in particular because of dynamic population growth as the market is increasingly demanding quality products that meet well-defined requirements.

A better understanding of the technological characteristics of the Maritime pine wood and its explanatory factors would allow to consider the development of the use of a portion of the available resource for certain jobs, replacing more conventional softwoods (Scots pine, Douglas fir, Fir and Spruce). In addition, a better valorization of the Maritime pine resource will involve better technological practices such as improving sawing accuracy or better control of drying. These are recurring problems in many situations and that are generally solved by the establishment of local structures dedicated to technical support to enterprises.

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