ASSESSMENT OF TECHNOLOGICAL KNOWLEDGE RELATING TO EUCALYPTUS CAMALDULENSIS DEHN.

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INTRODUCTION

Eucalyptus camaldulensis Dehn (synonym “ Eucalyptus Rostrata Schlect” and popularly known in Australia as River Red Gum) is the most extensively grown eucalyptus in Australia where it is found in all the states except Tasmania. There are two types of Eucalyptus camaldulensis - meredonial (in moderate zone) and tropical.

This Eucalyptus is one of the first types to be planted outside Australia and its area of cultivation at present exceeds 500,000 hectares. It plays an important role in reforestation across the world because of

- Its ability to grow fast in not so fertile soil even in prolonged dry seasons
- Its ability to reject any other vegetation to sprout around it.
- A high level of tolerance to inundation (and hence it’s Australian name) and to a certain degree of salinity in the soil.
- It’s multiple uses in rural forestry (as hedging, wind-screens, pickets, boards, posts, and poles for conventional constructions and fuel wood).

In the dry regions of tropical Africa the short supply of wood for fuel and for timber is a problem, which is becoming difficult to solve. It is in this context of short supply of wood that the CIRAD-Foret (erstwhile CTFT) aims to study the possible growth in the expansion of these species of plants such as Eucalyptus camaldulensis.

Technology

Characteristics of the trunk

In Australia, the height of Eucalyptus camaldulensis varies from 25 to 50 m with some origins having trunks, which are quite crooked and even forked. There are also considerable variations amongst those from different origins (Willan 1982).

In the northern part of the continent these trees have huge trunks, which are tall and slender, while in the subtropical regions the trunks of the trees are wide and short with a well-ornamented top (Ayensu, 1980)

The most interesting origin for having straight trunks would be “ Lake Albacutya for the Mediterranean climate (Santiago Barros, 1987)“, Pet ford”and “Katherine”(not as good a quality) for tropical climate and “Broken Hill” for arid climate (Ayensu, 1980). And in general the species from the regions like “Gulf of Carpentaria” and “Timor Sea” are reputed for their good forms (William1082).

The condition in which the plant grows also plays a significant role in its external morphology. It has been noted that with certain types of moist conditions, it is possible to obtain trees having a high growth rate and beautiful, long, round and slim wood. According to Guiscatore, 1979 the trees of the plantation of Burkina Faso, (during High Voltage Period **(" a cette epoque Haute Volta"))** where there is shallow water, have good height and form.

In fact the best form of trunk is obtained from Eucalyptus camaldulensis when it grows in densely populated conditions, which allows it to maintain a good apical form (Hillis, 1978).

Anatomical Characteristics Of The Wood.

Microscopic level

FIBRE

The length of the fibres, their diameter and the thickness of the inner wall increase with age. The maximum length the fibre can grow to is reached after 20 yrs (Chudnoff, 1961) but the intra specific variations of their characteristics in relation to their age is more pronounced than the interspecific variability (Sesbou, 1981).

VESSELS

The frequency of the vessels is variable. Its changes depend on the individual plant and it's environment, and diminishes from the pith to the bark (Sesbou, 1981).

OTHER ELEMENTS

The ligneous rays are more often bi- seriate, sometime tri seriate and rarely uni- seriate, whatever may be the origin of the plant (CTFT, 1963).
The parenchyma is abundant, circumvascular and dispersed. The tylosis are in large numbers in the heartwood and very rare in sapwood but if stocked in damp condition, they (tylosis) may appear and their presence in the vessel may restrict the movement of liquids in the wood during the process of drying and impregnation.

In general, the variability in the amount of fibres, vessels and parenchyma in the inner part of the same tree may be as considerable, as well as between two trees (Sesbou, 1981).

MACROSCOPIC LEVEL

The number of rings in Eucalyptus camaldulensis is determined by the rain, which if badly distributed may cause formation of several rings per year (Sesbou, 1981). The rings in general are not very distinct and this may again vary in the inner part of the same tree as well as amongst different trees.

The width of the sapwood is more or less constant and is independent of the height of the tree (Chudnoff, 1961) and rather seems to be linked with the growth. The area of the sapwood represents 16 to 17 % of the cross- section area, which is closely related to the height of the trees; with high as well as low growth rates (Sesbou, 1981)

The sapwood matures late and is pinkish – red in colour (CTFT, 1968).

In fact the intra individual variations are similar to inter specific variations as far as the physical aspect and the structure of the wood is concerned.

It may be noted that due to the existence of slight deformities in the vessels and the fibres, in the species, in certain pockets of Kino, the wood produced may be defective.

PHYSIO – MECHANICAL CHARACTERISTICS

Physical Characteristics

These characteristics have been determined in the laboratories of CIRAD-Foret on the basis of 9 sample trees originating from Burundi (2 samples), Bukina Faso (4) and Uruguay (3).

The following categories are based on the average values of the characteristics of Eucalyptus camaldulensis Dehn, which correspond to the French norms set by the NFB trials 51-003 to 51-006 and 51-013.

The wood of Eucalyptus camaldulensis has a weight, which varies from moderately heavy to considerably heavy. It's density is 0.68 to 0.98, its physical characteristics are variable like all other eucalyptus.

PHYSICAL CHARACTERISTICS OF THE WOOD AT 12% HUMIDITY.

	Density at 12% humidity gm/cucm	Hardness	Retractibility Volumetric Total %	Coefficient of Retractibility Volumetric %	Tangential Retractibility	Radial Retractibility	T/R
Average Values	0.81		4.3	13.8	0.49	9.6	1.8
Coeff of Variation	12 %		21%	17 %	13%	21 %	19%
Nos. of sample Trees	9	9	9	9	9	9	9
Category	heavy	moderately heavy	average	average nervosity	average	average	

MECHANICAL CHARACTERISTICS

The characteristics presented in the table are determined on the basis of the sample trees chosen as per the French norms set by NFB 51-007 to 51-012.

The resistance to the cross-sectional and axial cohesion are average while splitting, during perpendicular traction to fibres and also during cutting and shearing.

MECHANICAL CHARACTERISTIC OF THE WOOD AT 12% HUMIDITY

	ss Sectional Resistance Cohesion			Axial Cohesion			
	Splitting N/mm	Traction to Fibre MPa	Cutting and Shearing MPa	Resistance to Compression MPa	Static Flexion MPa	Elasticity MPa	Energy absorbed in Dynamic Flexion Joules
Average Value	21.4	3.3	7.5	64.4	123.4	12463	29
Coeff. of Variation	22 %	24%	19%	16%	22 %	25%	39%
Nos. of Sample Trees	9	9	9	9	9	8	9
Category	Av.	Av.	Av.	Av.	Av.	Av.	

Note: The values given for the characteristic of splitting and perpendicular traction to the fibres, for cutting/shearing, for compression and for static flexion represent unitary force of rupture.

COMPARATIVE TABLE OF THE PHYSIO-MECHANICAL CHARACTERISTICS OF EUCALYPTUS CAMALDULENSIS DEHN IN SEVERAL COUNTRIES.

(next page (attachment))

The plantation zones, the environment and the local cultivation techniques determine the physio-mechanical characteristics of the wood of Eucalyptus camaldulensis. Besides, these characteristics are also the function of the age of the tree.

CHEMICAL CHARACTERISTICS

The wood of Eucalyptus camaldulensis is characterised by the presence of small amount of cellulose and high amount of lignin, as compared to those present in the average tropical woods (29%). The amount of ash produced varies but is less than the average (1.1%). Lastly, it is richer in water extract than any other tropical wood.

Chemical characteristics of the wood

extracted as related to the weight of the anhydrous wood	(0)	(7)	(11)	(35)	(20)
Extract of Alcohol Benzyme	3.9	4045	4.6	1.6	6.3
Extract of water	4.4	5024	6.5	4.5	6.0
Extract of Soda	18.2	1509	-	17.2	20.0
Lignin	32.6	30.4	66.5	26.8	31.2
Pentosan	15.6	16.8	-	14.2	18.7
Raw Cellulose	40.2	-	-	-	-
Treated Cellulose	37.6	38.3	-	-	34.4
(“Holo”) Cellulose *	-	-	-	70.5	-
Alpha Cellulose *	-	-	-	42.8	-
Mannan	0.35	-	-	-	-
Ash	0.41	0.65	0.8	0.9	0.55
Silica	0.0013	0.001	-	0.2	-
Balance	95	95.6	-	-	97

* % of dry extract as against non extract
(0) CIRAD Foret Measure (Burkina Faso, Senegal, Congo and Madagascar confused).

CHRACTERISTIC OF DURABILITY AND PRESERVATION

Durabilty

Like all other woods of tropical and temperate climate, the sapwood is not resistant to fungus and termites. The heartwood has high resistance to fungus but is susceptible to termites (Guiscafre, 1979 and CIRAD-Foret measurement 1987).

Preservation

The heartwood of Eucalyptus camaldulensis is not impregnable and has weak resistance to termites. Hence an impregnation of the sapwood is necessary for making use of these species as unhewn timber (impregnation by soaking or if possible by autoclave method by the **"(double vide)"** technology). The impregnated sapwood is made up of a protective muff around the heartwood producing thus, a material which has adequate durability for external use (CTFT, 1968 and Guiscafore 1979).
The external use of untreated sawed Eucalyptus camaldulensis necessitates a systematic elemination of the sapwood. To avoid the risk of termite attack specially in the tropical zone, the conventional techniques (like separating the ground floor
by a material which is resistant like concrete stone, and by treating the termite prone areas with pesticides etc.) should be used.
The techniques/methods suggested by the authors are various and very easy to use. It is easy to impregnate sapwood with Tanalith C (35 % of $CuSO_4$, $5H_2O$, 45% of $Cr_2O_7K_2$ and 20 % of $As_2O_5,2H_2O$)as well as creosote (CTFT,1968) . It has been found that the Lindane or the penta chlorophenol treatment is as effective as the creosote treatment (Karschons, 1970). Bertaux and Vanwijnsberghe (1990) recommend the use of CCA (i.e. Salts of copper, chromium and arsenic), which is more easily available than the creosote in tropical countries.

As far as the procedure for treatment is considered, El Abid (1984) has recommended Bethell (Fig1) method rather than Boucherie (Fig.2) and Schwatz, Deon er Dalois have suggested a new procedure by auto clave treatment (Fig. 3) which gives high quality protection to the wood of Eucalyptus camaldulensis.

These trials for strengthening by auto clave method conceived and produced by CIRAD – Foret were held with two different impregnation cycles (one comprising of empty phase followed by pressure phase and the other only by pressure phase) particularly on Eucalyptus camaldulensis. These have revealed:

- The gross absorption on production for preservation rise at any pressure.
- The gross absorption recorded with a cycle without pressure is visibly more than that obtained with the cycle with pressure (from 24.4 to 34.4 Kg/cum to Cryptogil C salt of type CCA for the first, against 17.2 to 22.8 Kg of salt/ cum. for the other).
- The penetration of the product in the wood is very good. (Schwartz, 1985)

USES

Production of Energy

There is a crisis of fuel wood in developing countries; in Africa, this crisis is concentrated mainly in the Sahelian borders, mediterranean coast of North Africa and the densely populated northern region. In order to fight against this crisis a study of Eucalyptus camaldulensis adopted for cultivation in this region is of great value.

Fuel Wood

The calorific value of the Eucalyptus camaldulensis is very high as in most of the average tropical wood (of 19200 to 20500 KJ/Kg. according to Doat, 1977) which being higher than the leaves produced for this purpose.

High calorific power of the wood :

Origin	P.C.S. KJ/Kg.	Reference
Australia	20000	Ayensu 1980
Burkina Faso	19735	CTFT measurement
Birmania	20768	CTFT measurement
Israel	20100	Midgley 1984
Portugal	19520	Goes 1979
Senegal	20262	CTFT measurement
Senegal	19969	CTFT measurement
Senegal	20035	CTFT measurement
Senegal	20342	CTFT measurement
Senegal	18654	Beauchesne, 1991
Sudan	19589	CTFT measurement
?	19708	Doat, 1977
?	19700	Willan, 1982
Average	19875	

Coal

The value of the wood of Eucalyptus camaldulensis in producing energy may be estimated by the charcoal it produces, which has the advantage of having a High Calorific power, which is much superior to that of wood; Nevertheless the carbonisation process is not always as profitable as it should be. Therefore Beauchesne has shown that in 1991 in Ngaoule and at Senegal the profit margin from the sale of coal was twice less than that from that of fuel wood.

Table of Characteristics of Coal from Eucalyptus camaldulensis

	(0)	(20)	(2)
P.C.S (KJ/Kg)	33430 to 34472	34416	30249 to 32571
Density	0.40 to 0.46	0.4	0.41 to 0.44
Friability	11 to 33	20.8	-
Ash	1.8 to 3.1	1.5	2.8 to 4.7
(%) Volatile Compound	6.1 to 6.5	7.75	10.2 to 21.2
(%) Water Recovered	6.0 to 7.6	6.8	4.0 to 5.2
Balance %	31.8 to 34.4	34	27.6 to 36.6
Origin	Senegal	Senegal	Senegal

(0) CIRAD Foret Measurement

The density is slightly more than that of charcoal made from tropical wood (for those species which are normally carbonised, the density varies in general from 0.2 to 0.3)

These coals contain very little volatile matter. They are on the whole moderately friable (This is to be considered during transportation and use in metallurgy of iron).

The High Calorific Powers are superior.

The envisaged uses (as per Harchich and Hatti, 1983) are

- As combustion in household and industrial purpose
- In gasification
- In chemical industry and as active coal after special chemical treatment.

The Forbidden Uses (as per Harchich and Hatti, 1983) are:

- Cement Industry, because of its very low amount of volatile matter.
- Metallurgy of Iron and Metallurgy because of its high quality of ash.

However, this coal is used in big amount in metallurgy of iron with that of other species of eucalyptus especially in Australia and Argentina (Willan, 1982).

Paper Industry

Characteristics of the Fibre

The wood of Eucalyptus camaldulensis contains 47 to 62 % of Fibre (Hillis, 1975), whose maximum length is reached when the tree is about 20 years old (Chudnoff 1961).

Characteristics of the Fibres

Species	Length (Micrometer)	Width (Micrometer	ness of the Wall (Micrometer	Reference
Malawi	880	13.9	2.8	(30)
Uruguay	890	16	8	(7)
?	747	17.7	2.8	(35)

The fibres of Eucalyptus camaldulensis are short, more or less a common feature of all eucalyptus.

Characteristics of the Fibre Paste obtained from Eucalyptus camaldulensis

Species	he Paste (% of weight nt as against weight of anhydric(dry) wood	of Kappa Particles	tance to the tear	Reference
Australia	40.8	24.7	9.6	(21)
Malawi	45.6	27.1	7.1	(30)

According to Palmer, 1989, the paste made from Eucalyptus camaldulensis is more energy efficient than the other eucalyptus used in paper mills.

Yet the quality of the paste from this species is inferior to the paste obtained from Eucalyptus used, mostly in the paper mills like Eucalyptus globulus (CTFT, 1968; Repetti 1979; Ayensu 1980).

The chemical paste treatment is recommended because trials with other high yielding techniques reveal that they are not advisable as they produce wood with a certain colouring. This peculiarity is not a constraint in the chemical paste method.

Yet it should not be implied that the paste from the Eucalyptus camaldulensis has limited use because it still maintains a high standard, which qualifies its use, in industries, in many Countries. In Morocco it is used extensively in the paper mills (CTFT, 1968; Goef, 1979; Ayensu, 1980; Sesbou, 1981)

Use of the paste from Eucalyptus camaldulensis (CTFT, 1968; Hillis, 1978; Willan, 1982) are :

- Paste for dissolving.
- Crude paste for making paper for industrial use and cartons.
- High quality white paste for writing and printing papers.

<u>Boards from Fibres and Particles</u>

The wood reconstituted from eucalyptus wood is more useful than wood from any other trees.

The short fibres do not coagulate and produce excellent material for boards. In addition these boards thus obtained, have high resistance and do not necessitate too much use of resin for joining. (Sharma, 1986).

The boards from particles are excellent quality and produce a material reasonably heavy, which can successfully be used for furnishing and for interior decorations. (CTFT, 1968).

The principle producers of boards from Eucalyptus camaldulensis are Argentina, Spain, India, Israel, Morocco and Portugal.

It is to be noted that an experimental production of beams made of reconstituted wood from the Eucalyptus camaldulensis particles is being done in Morocco.

<u>TIMBER</u>

In Africa the use of Eucalyptus camaldulensis, as timber are numerous and varied. It is mostly used in the following field (Willan, 1981; and Bertaux and Vanwijnsberghe, 1990).

- Heavy and light timber
- Wooden flooring
- Wood for mining
- Railway tracks
- Post and poles
- Ship building

- Coaches and wheels
- Furniture and cabinets
- Carpentry
- Handles for tools
- Boxes and hampers
- Interior decoration
- Match Sticks

SAWN TIMBER

Eucalyptus camaldulensis has very limited use for sawn timber due to the fact that:

- It is prone to develop cracks during the sawing operation. This is an inherent limitation in the growth process of the tree.
- During drying it tends to deform due to a high and heterogeneous shrinkage (this deformity is similar / analogous to the one observed during sawing operation).

Like other species of eucalyptus, it is subject to cracks / collapse (this is a defect due to drying which consists of a local and irregular crumbling of the wood – this phenomenon is different from shrinkage during drying).

The simplest and the most effective method for the recuperation of the collapse is the technique of reconditioning by Vapour (Steam). This method is extensively used by the industry in Australia. (Sesbou, 1981,1990).

In comparison to other species, the cut of Eucalyptus camaldulensis, falls into low classification in a very large proportion.

However when this wood is sawed, Fechtal, 1985, recommends a procedure, which allows a cut (debit) per quarter, in order to limit the problems during drying. Bertaux and Vanwijnsberghe, 1990 recommend sawing by reversing, to eliminate the constraints inherited during growth. CTFT in 1968 recommends a cut (debit) at green stage **("l'etat vert")** as rapidly as possible after felling of the tree and to utilise this wood for sawing in small dimensions.

Scantlings

Eucalyptus camaldulensis is often used as wood for making scantlings, particularly in railways and mines in Africa as well as in Argentina, Spain, Israel, Morocco, Tunisia…. (Goes, 1979).

Unhewn Timber

Majority of the wood from Eucalyptus camaldulensis is used in this form. The uses under this are diverse and are used for market gardening, as for example as poles for tomato cultivation (Sesbou, 1990); to the utilisation for support of transmission lines (CTFT 1968, 1969 and Guiscafre, 1979). The rural uses are after all the more common (CTFT, 1968; Bertaux and Vanwijnsberghe, 1990).

The interests in the utilisation of this origin, in the form of poles and posts has given place to different studies which has allowed to highlight the physical characteristics in the form of unhewed timber.

The Physio-Mechanical Characteristics of the Poles of Eucalyptus camaldulensis

Origin	he Base	Length	pture (cut)	t of Rupture (Cut)	atic Flexion	Elasticity	Ref.
	(cm)	(cm)	(cm)	(Kg.)	MPa	MPa	
y Coast	13-15.6	800	275-300	250-310	51.9-63.7	5490-7059	(8)
na Faso	15-20	700-800	150-350	850-1300	71.6-184.3	039-14216	(18)
na Faso	15-27	600-800	125-875	307-875	1.6 – 102.9	2586-9305	(28)

The mechanical resistance of Eucalyptus camaldulensis in the form of unhewed timber is enough to allow the production of "A" grade support for transmission lines as per the French norms, C 67 – 100 (Guiscafre, 1979).

The same study by Guiscafre has revealed a problem in Eucalyptus camaldulensis from Burkina Faso :

- The end diameter of poles of 11 metres is not sufficient for using them as support for transmission lines. However, the same can be adjusted to 10 metre poles of "E" grade variety and used.

Other Products

Essentials Oils

Extract of essential oils from the leaves of eucalyptus has great interest from economic point of view. As far as Eucalyptus camaldulensis is concerned, Sesbou (1990) mentions existence of a mixture containing high level of Cineol (used mostly in pharmacy and in the manufacture of stain removers) in certain trees particularly of the "Petford" species.

Tannin

According to Fechtal (1984) it is possible to extract 6.38% of tannin (%of dry bark) from Moroccan Eucalyptus camaldulensis. The dry bark contains 8 to 10% tannin while the wood contains 2 to 4 %; the bark represents 23 % of the total volume of ligneous matter. (Goes, 1979).

These mixtures should have minimum tannin level in them as required by the users; but the tannin extracts from the bark of the tree may be a prime material for the tanning of hides and skins, when the bark is represented as a sub-product in the forestial use. (Fechtal, 1984).

Honey

In Morocco, the Eucalyptus camaldulensis plantation serves as a great support for its important apiculture activity. When the condition for apiculture is at its optimum best and the collection is at its maximum, it is well possible that the production of honey crosses 500 kg./hectare.

In Australia, this species of Eucalyptus camaldulensis helps to produce a honey which is clear and golden, with a soft taste but which is not as consistent and as aromatic as that produced from Eucalyptus melliodora.

Conclusion

Eucalyptus camaldulensis has great value in many countries as producer of fuel wood, charcoal, wood for rails, posts and poles. It is also used as windscreens and shades in dry region.

Eucalyptus camaldulensis has multiple uses which extend from apiculture to the production of sawn timber. It can therefore rightly be considered as a forestial tree because of its many industrial uses as well as an agro–forestial tree as it is able to satisfy the needs for wood of its rural population providing them with complimentary revenue.