A NOTE ON PHYSICAL AND MECHANICAL PROPERTIES OF *EUCALYPTUS TERETICORNIS, E. SIDROPHOLIA* AND *E. KITSONIANA*

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Abstract

This study is continuation of work on determination of physical and mechnical properties of fast growing *Eucalyptus* species which are currently extensively being planted in Pakistan. The strength properties of three species viz. *E. tereticornis*, *E. kitsoniana* and *E. sidropholia* were determined and found to be better than those of commonly grown local species of hardwoods. The results of current study indicate good utilization potential of these Eucalyptus species for many purposes.

Introduction

A number of *Eucalyptus* species have been introduced to a considerable extent in Pakistan over the years. Amongst these, *E. camaldulensis* and *E. tereticornis* have shown to be more adaptable under a variety of ecological conditions and consequently, are being planted more than other species of the genus. In the mean time, a number of field studies have also been established to determine suitability of other species under different ecological conditions. Recently, *E. kitsoniana* has been found to grow well under both irrigated and non-irrigated conditions (1). The statistics regarding the true extent of *Eucalyptus* plantings in Pakistan are not known. However, it is believed to be substantial and growing with years. These plantings represent a useful timber resources in view of shortage of wood in the country. Till now eucalyptus wood has not been commercially used because of lack of information about its technological properties and problems of seasoning. Most of the *Eucalyptus* species develop growth stresses in wood and spiral in the grain due to their fast rate of growth. These characteristics result into various defects when the wood is sawn and seasoned, and the recovery of sawn wood is very low. The presence of starch in the sapwood makes it highly susceptible to insect and fungal attack thereby reducing its service life.

In view of above, a number of studies have been carried out in Forest Products Research Division to investigate technological, sawing, seasoning, wood working, pulping and paper making properties of wood of different *Eucalyptus* species to facilitate its utilization (2). The results were encouraging in this regards. This paper reports the technological properties of three *Eucalyptus* species, namely, *E. tereticornis*, *E. sidrophoha* and *E. kitsoniana* grown locally in field experiments.

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Material and Methods

The test material was obtained in log form from Pakistan Forest Institute Campus. The logs were converted into planks of thickness of 7 cms and then stacked in airseasoning shed for about 3–6 months for air-drying. One airseasoned plank from heart wood portion of every log was selected for determination of technological properties. At least 8–9 planks of different sizes were obtained for testing for each species. The testing was carried in accordance with the procedures given in standard methods (3). While an effort was originally made to condition air-seasoned specimens to a uniform moisture content of 12 per cent before testing, some test specimens inevitably had a moisture content slightly higher or lower than this value. For this reason, most of the air dry strength values were adjusted to values for moisture content of 12 per cent.

Test specimens of the following sizes were prepared from each plank for determination of different strength properties:

i.	Static bending	:	2 cm x 2 cm x 30 cm
ii.	Impact bending	:	2 cm x 2 cm x 30 cm
iii.	Crushing strength parallel to grain to grain	:	2 cm x 2 cm x 6 cm
iv.	Tensile perpendicular to grain	:	2 cm x 2 cm x 7 cm
v.	Cleavage	:	2 cm x 2 cm x 4.5 cm
vi.	Hardness	:	2 cm x 2 cm x 10 cm
vii.	Shear strength	:	2 inch x 2 inch x 2.5 inch
viii.	Crushing strength to grain	:	2 inch x 2 inch x 2 inch

All strength tests were made in accordance with the ISO and BS 373 except the shear test which was performed according to ASTM standards.

Results and Discussion

Table 1 gives the average values of physical and mechanical properties of locally grown woods of three *Eucalyptus* species of this study. These values are the adjusted values for 12% moisture content in wood specimens. On the basis of these properties, *E. sidropholia*, *E. kitssoniana* and *E. tereticornis* can be classified as very heavy, hard, strong and stiff timbers. This is especially the case for first two species, which exhibit very high wood density (on air-dry weight and volume basis), modulus of rupture, modulus elasticity, compressive strength and hardness values. Because of high strength properties timbers of three *Eucalyptus* species can be used for all purposes in which highly strong and hard timbers are needed. These include wooden columns, beams, floor and ceiling joists, roof truss members, props, furniture, paving blocks, floors, ship decking and load bearing blocks. Further, this study shows that wood density indirectly correlated to the most of the strength properties in *Eucalyptus* species. The results also indicate small co-efficient of variation for all properties, and the actual values are much less than limiting values for them. This may be due to uniformity of test materials.

When strength properties of *E. tereticornis* of current study are compared with those values determined earlier for the same species, the former are found to be hihger than the latter (Table 1). These differences are due to the fact the test materials of two studies came from two different localities e.g. Peshawar in NWFP and Shikarpur in Sind. These localities are more than 1000 km apart and have variable tree growth conditions, therefore, considerable variation in strength properties of a *Eucalyptus* species should be expected when it is grown at different sites and additional studies of this nature are needed to determine full range of variation in wood quality within a species. The strength properties of *E. camaldulensis* were also determined in the past (2). Its average values are compared with those of three species of current study in Table 2. *E. camaldulensis* appears to be much weaker timber than other Eucalyptus species. This could be due to differences of genetic factors and in growth rate of these species raised on different sites.

Mulberry (*Morus alba*), Shisham (*Dalbergia sissoo*) and Kikar (*Acacia arabica*) are the principal hardwood species of Pakistan which are extensively grown and their wood utilized for a variety of purposes throughout the country. In Table 2, strength properties of these hardwoods are compared with those of *Eucalyptus* species (5, 6, 7). Only kikar wood which is considered to be the heaviest local wood, has some technological characteristics such as modulus of rupture, maximum compressive strength parallel to grain and hardness, comparable to eucalyptus woods. Of course, mulberry has also the highest value of impact bending strength, Otherwise all their other properties are inferior to those of *Eucalyptus* species. These results indicate that eucalyptus woods can be technologically and econonically used as good substitute of local hardwoods. This is very encouraging for future of *Eucalyptus* planting in Pakistan.

Summary and Conclusion

The results of the present study and comparison of strength properties of four *Eucalyptus* species with other hardwood species indicate that eucalypt woods are very heavy, hard, strong and stiff timbers with superior strength values than the latter. Their wood can be utilized for a variety of commercial uses for technological and economical advantages.

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Table 1. Comperison of physical and mechanical properties of different *Eucalyptus species in air-dry condition*

PROPERTY	SPECIES *E. sidrophølia*			*E. kitsoniana*			*E. camaldulensis*	*E. tereticornis*					
	Av.	S.D.	C.V.%	Ave.	S.D.	C.V.%	Ave.	Actual values Ave.	S.D.	C.V.%	Reported values Ave.	S.D.	C.V.%
Density = $\frac{\text{A.D. Wt.}}{\text{A.D. Vol.}}$ = g/cm^3	0.950	0.034	3.6	0.920	0.022	2.4	0.705	0.739	0.034	4.6	0.710	0.057	8.0
Modulus of rupture: N/mm^2	141	12.0	8.5	168	5.7	3.3	101	137	11.5	8.3	98	17.0	17.3
Modulus of elasticity: N/mm^2	13901	910	6.5	13998	982	7.0	7779	11956	696	5.8	8331	1300	15.6
Max. compressive strength parallel to grain = N/mm^2	72	5.0	6.9	68	5.3	7.7	40	59	6.9	11.6	52	6.0	11.5
Compressive strength parallel to grain at elastic limit = N/mm^2	53	3.1	5.8	51	5.0	9.8	27	40	4.5	11.2	38	4.2	11.0
Compressive strength perpendicular to grain at elastic limit = N/mm^2	20.3	2.0	9.8	18.4	1.8	9.7	—	15.1	1.1	7.2	11.5	1.8	15.7

PROPERTY	SPECIES												
	E. sidropholia			*E. kitsoniana*			*E. camaldulensis*	*E. tereticornis*					
								Actual values			Reported values		
	Av.	S.D.	C.V.%	Ave.	S.D.	C.V.%	Ave.	Ave.	S.D.	C.V.%	Ave.	S.D.	C.V.%
Max. Shear parallel to grain = N/mm^2	21.7	2.0	9.2	16.4	1.5	9.1	19.1	18.2	1.7	9.3	12.4	3.4	27.4
Impact bending M-N/test	0.315	0.049	15.5	0.452	0.056	12.3	0.250	0.293	0.058	19.7	—	—	—
Tensile strength perpendicular to grain = N/mm^2	2.9	0.2	7.6	3.1	0.4	12.9	3.3	2.2	0.1	4.5	3.5	0.5	14.3
Cleavage = N/mm	27	2.1	7.7	32	2.4	7.5	32	22	1.6	7.2	34	6.1	18.0
Hardness = NX100 Side	83.0	5.5	6.6	73.5	8.8	11.9	59.9	55.5	4.3	7.7	36.6	9.2	25.1
End	84.1	4.2	5.0	79.9	5.6	7.0	68.8	66.1	5.6	8.4	51.5	12.4	24.1

S. D. — Standard deviation
C.V.% — Co-efficient of variation %.

Table 2. Comparison of average values of physical and mechanical properties of *Eucalyptus* species with local hard woods in air dry condition.

PROPERTY	SPECIES *E. sidro-pholia*	*E. kitso-niana*	*E. camal-dulensis*	*E. tereti-cornis*	*Morus alba*	*Dalbergia sissoo*	*Acacia arabica*
Density $g/cm^2 = \frac{\text{A. D. Wt.}}{\text{A.D. Vol.}} =$	0.950	0.920	0.705	0.739	0.662	0.730	0.832
Modulus of rupture = N/mm^2	141	168	101	137	110	110	134
Modulus of elasticity = $N6mm^2$	13901	13998	7779	11956	8978	8579	11942
Max. compressive strength parallel to grain N/mm^2	72	68	40	59	53	56	72
Compressive strength parallel to grain at elastic limit: N/mm^2	53	51	27	40	43	44	44
Compressive strength perpendicular to grain=N/mm^2	20.3	18.4	—	15.1	6.8	14.4	15.7
Max. shear parallel to grain=N/mm^2	21.7	16.4	19.1	18.2	15.2	17.0	17.2
Impact bending M-N%mm^2	0.315	0.452	0.250	0.293	0.516	0.183	—
Tensile strength perpendicular to grain N/mm^2	2.9	3.1	3.3	2.2	3.6	1.7	—
Cleavage = N/mm	27	32	32	22	29	22	—
Hardness = N x 100							
Side	83.0	73.5	59.9	55.5	61.0	65.0	57.3
End	84.1	79.9	68.8	66.1	62.0	80.0	57.8