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Wood Properties and Utilization of Pollard Shoots of Indian Tulip Tree (*Thespesia populnea* (L.) Sol. ex Corrêa)

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Abstract:Forests are declining in India under severe socio-economic pressure resulting short-rotation plantation wood species as a major choice for industrial raw material. Due to shortage of raw materials, industries have to raise the fast-grown plantations of suitable wood species. Indian tulip tree (*Thespesia populnea* (L.) Sol. ex Corrêa) is one of the fast growing lesser-known tree species which is heavily pollarded and its shoots are used as fuelwood in coastal regions of South Gujarat. Since, *T. populnea* has potential for many industrial applications; therefore, a study was carried out to evaluate the physical and mechanical properties of pollard shoots of this species to check the wood quality for effective utilization. Total 20 wood samples of pollard shoots (5-10 cm diameter) from 5 trees of *T. populnea* in the girth class of 110-160 cm were collected from road side plantation in Navsari, Gujarat. The physical and mechanical properties were evaluated in air-dry condition and compared them with corresponding published values for teak (*Tectona grandis* L.f.) and 3, 4- & 5-year-old Malabar neem (*Melia dubia* Cav.). Considering physical properties, very low wood density and high volumetric shrinkage were reported in *T. populnea* compared to teak and *M. dubia*. Among mechanical properties, static bending, compressive strength and hardness of wood from pollard shoots of *T. populnea* were found to be better than 3 years old *M. dubia*. This indicates that wood from pollard shoots of thin to moderately thick diameter of this tree species can be utilized for tool handles, light construction, light packing cases and furniture.

Keywords: Static bending, Compressive strength, Volumetric shrinkage, Hardness, Wood density

Forests are declining in India under severe socio-economic pressure. Providentially, the declining rate of India's forests has come down with the enactment of the Forest Conservation Act, 1980 (Saravanan 2014). Now, the total forest and tree cover in the country is 24.62 per cent and in the state of Gujarat it is about 10.41 per cent which is low against the country's target of bringing 33.00 per cent of its geographical area under forest and tree cover as envisaged in the National Forest Policy, 1988 (ISFR 2021). The mean annual increment (MAI) of India's forest is scanty of 0.5 to 0.7 m^3 per hectare in comparison to the global average of about 2.1 m^3 per hectare (Saravanan 2014). The low productivity of Indian forest (4% of the total demand) has increased the widening gap between the demand and supply of both domestic and industrial requirement of timbers. The demand for raw materials in the furniture, construction, plywood and pulpwood industries is constantly rising, and is projected to increase further due to economic growth and a rise in population. Currently, the potential of timber production in India is 45% of the total demand. This indicates that there is a need for more timber production on a sustainable basis through agroforestry and plantation programmes to meet the domestic demand and reduce the reliance of India on imports of timbers. Due to shortage of raw materials, the industries have to establish the short-rotation fast-grown plantations of suitable wood species with tree improvement programmes for maximum yield (Sujatha et al 2023). Furthermore, there is also a need to explore the wood properties of lesser-known tree species for various end use applications. Among several lesser-known species, *Thespesia populnea* is one such species which is currently used as fuelwood in coastal regions of South Gujarat; however, this species may be suitable for timber, pulpwood and many other industrial applications after knowing its wood properties.

Thespesia populnea [(L.) Soland ex Correa] belongs to the family Malvaceae is well-known as Indian tulip tree and locally known as Paras-pipal (Troup, 1921). In India, it is a common species in the coastal tracts of the Indian Peninsula and in mangrove swamps. It is a fast-growing evergreen shrub or medium sized tree up to 20 m height with a broad dense crown with often crooked stem. The tree grows in short twists and turns with numerous limbs; therefore, lumber is only found in short lengths. Clear bole is around 2-2.5 m and girth at the breast height (GBH) is around 0.6-1.2 m. It is easily recognized by fissured grey dark brown bark, large yellow flowers with purple centre and a dense crown of green glossy heart shaped leaves (Anonymous 2022). The timber of this species is supposed to be of great local utility, being used for furniture and agricultural implements. It is an easy timber to saw and work and can be brought to a smooth

surface and also takes a high polish. The wood can be carved into bowls, tools and figures. Timber is in demand for turnery and toys. It is also suitable for helves, tool handles, shuttles and other textile accessories. Wood is used for food containers, slit drums and cabinetry. It is also used as fuel wood (Anonymous 2022).

T. populnea is available in plenty around the coastal belts of the South Gujarat. It responds well to pollarding and coppices well. Currently, the pollard shoots of this species are mostly used in fuelwood. However, this species is lesser-known for various industrial applications. Therefore, a study was carried out to evaluate the physical and mechanical properties of wood from pollard shoots of *T. populnea* and compared them with corresponding published values for 'standard teak' (*Tectona grandis* L. f.) and 3, 4 and 5-year-old Malabar neem (*Melia dubia* Cav.) to check its wood quality for effective utilization.

MATERIAL AND METHODS

Total of 20 wood samples of pollard shoots (5-10 cm diameter) from 5 trees of *T. populnea* in the girth class of 110-160 cm were collected from the different blocks of Matwad road side plantation in Navsari, Gujarat. The area is located at coastal region of South Gujarat at 20° 95' N latitude, 75° 90' E longitude and at an altitude of 12 m above the mean sea level. The climate of Navsari is tropical warm with fairly hot summer, moderately cold winter and warm humid monsoon with average annual rainfall of about 1600 mm. In the current study, destructive method of sampling was adopted to collect wood samples from pollard shoots of *T. populnea*. The pollard shoots were converted into scantlings of 2 x2 x 40 cm cross section to prepare test samples from pith to periphery in four radial direction after air drying. Physical and mechanical tests were conducted as per the Indian Standard Specification IS 1708 (Part 1-18):1986 (Fig. 1a-b). Considering the physical properties, moisture content and volumetric shrinkage were determined by oven-dry method, while basic density was determined by water displacement method. The mechanical properties such as static bending, compressive strength parallel to grain, compressive strength perpendicular to grain, hardness and nail & screw holding power of of wood were tested by the Universal Testing Machine (Fig.1c-e). The data of all the parameters generated in the study were subjected to the basic statistical analysis .

RESULTS AND DISCUSSION

Considering the physical properties, the mean basic density and volumetric shrinkage based on oven-dry weight of wood samples from pollard shoots of *T. populnea* were 0.249 g/cm^3 and 47.0 %, respectively (Table 1). Orwa et al (2009) reported that the wood of *T. populnea* is light to medium in weight and basic density varied from 0.400 to 0.770 g/cm^3 at 15% moisture content in the main stem and very low to low shrinkage in this species. Similar results were also reported by Anon (2022) in an ITTO report. On contrary, very low wood density and high volumetric shrinkage in *T. populnea* were reported in the present study which may be due to the thin diameter of juvenile wood of pollard shoots. In comparison with teak and *M. dubia*, wood density of *T. populnea* recorded 37 per cent value of teak wood density and 50 per cent value of *M. dubia* wood density, while volumetric shrinkage of this species was seven times more than teak and three times more than *M. dubia*.

Considering the mechanical properties, the mean value of MOR (modulus of rupture) and MOE (modulus of elasticity) in static bending were 786.8 kg/cm^2 and 72.6 x10^3 kg/cm^2, respectively. In compressive strength parallel to grain, the

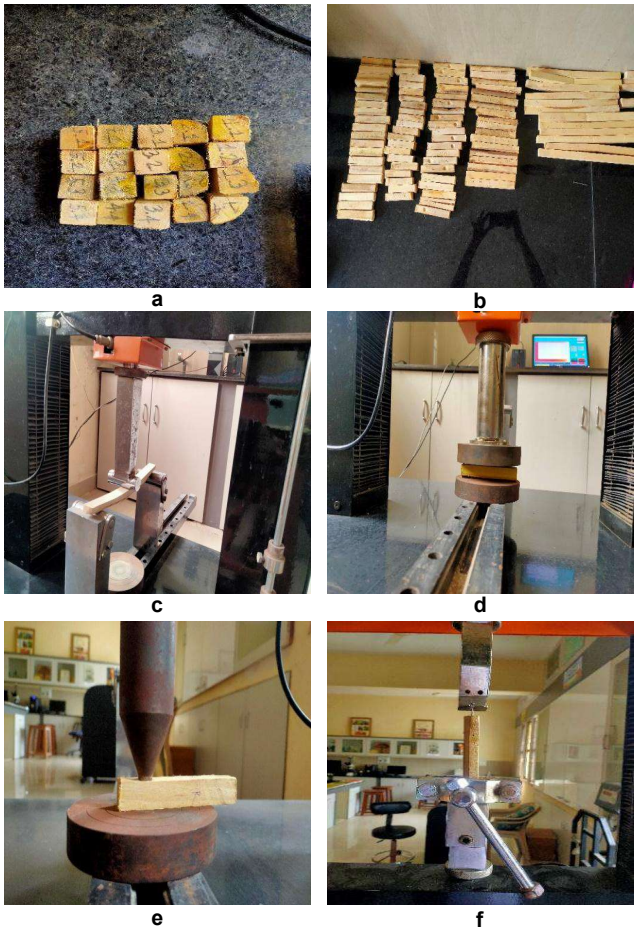

Fig. 1a-f. Test samples and testing of mechanical properties of *T. populnea* by Universal Testing Machine (a) samples for physical test (b) samples for mechanical test (c) static bending (d) compressive strength (e) hardness (f) nail and screw holding power

Table 1. Comparative profile of physical and mechanical properties of wood from pollard shoots of *T. populnea* with teak (*T. grandis*) and Malabar neem (*M. dubia*) in air-dry condition

Wood properties		*T. populnea*	Teak*	*M. dubia***		
				3 years	4 years	5 years
Moisture content (%)		15.9 ±2.14	12	12	12	12
Basic density (g/cm^3)		0.249±0.04	0.672	0.418	0.485	0.500
Volumetric shrinkage (%)		47.0±4.16	6.5	-	14.6	17.0
Modulus of rupture, MOR (kg/cm^2) in static bending		786.8±200.01	941	492.6	808.3	851.9
Modulus of elasticity, MOE (1000kg/cm^2) in static bending		72.6±23722.94	117	52.9	63.2	68.4
Maximum crushing stress (kg/cm^2) in compressive strength parallel to grain		358.3±78.45	520	-	-	-
Compressive stress at elastic limit (kg/cm^2) in compressive stren perpendicular to grain		33.3±8.87	99	31.8	68.8	104.2
Hardness (kg)	Side	444.2±64.51	500	173.7	264.1	324.2
	End	490.6±75.96	480	234.9	270.4	400.4
Nail holding power (kg)	Side	42.3±10.56	89	77.45	137.8	171.9
	End	32.3±10.12	71	59.4	65.4	91.9
Screw holding power (kg)	Side	60.4±11.80	398	248.2	325.6	366.4
	End	50.5±6.56	294	223.0	231.2	270.0

Source: * Shukla et al (2007) and ** Saravanan et al (2014)

mean value of maximum crushing stress was 358.3 kg/cm^2 and in compressive strength perpendicular to grain, the mean compressive stress at elastic limit was 33.3 kg/cm^2. The mean f side and end hardness were 444.2 kg and 490.6 kg, respectively. The mean nail holding power on side and end surfaces were 42.3 kg and 32.3 kg while, screw holding power on side and end surfaces were 60.4 kg and 50.5 kg, respectively. in an revealed that MOR and MOE of *T. populnea* in static bending were 1202 kg/cm^2, 119019 kg/cm^2, respectively according to ITTO report (Anonymous 2022). However, the compressive stress parallel to grain was 581 kg/cm^2. Warrier (2010) observed more bending strength, compressive stress, hardness and nail and screw holding power in the main stem of *T. populnea* in comparison to teak. In the current study static bending strength (MOR and MOE), compressive strength, and hardness of wood from pollard shoots of *T. populnea* were lower than teak but better than 3 years old *Melia dubia*. However, the nail and screw holding power was less than teak and *M. dubia* which may be due to the thin diameter of juvenile wood of pollard shoots in *T. populnea*.

CONCLUSION

The physical properties and mechanical strength of wood from pollard shoots of *T. populnea* is lower than teak wood. Among mechanical properties, static bending, compressive strength and hardness of wood from pollard shoots are better than 3- year-old *M. dubia*. This indicates that wood from pollard shoots of thin to moderately thick diameter of this tree species can be utilized for tool handles, light construction, light packing cases and furniture. However, it is necessary to evaluate the wood of main stem in *T. populnea* for better understanding of its physico-mechanical properties, so that, this lesser known species can be explored extensively for various end uses.

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