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Variation in specific gravity of wood of *Quercus leucotrichophora* A. Camus (Banoak) from different provenances in Himachal Pradesh

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Abstract
The present study was conducted to determine the specific gravity of wood of *Quercus leucotrichophora,* procured from the live trees having diameter at breast height (d.b.h) ranged from 25cm to 30cm of different provenances in Himachal Pradesh. Specific gravity of wood is a measure of the amount of structural material a tree species allocates to provide support and strength. It is the most important wood characteristic because its knowledge allows the prediction of greater number of properties than any other trait. In recent years, wood specific gravity has become more important when exploring the universality of functional traits of plants and estimating their global carbon stocks.To estimate the specific gravity, banoak wood samples were collected from a total of 22 provenances in Himachal Pradesh, India. Variation in specific gravity was recorded both in sap wood and heart wood portion of studied banoak trees. The sapwood specific gravity was 7 per cent less than the heartwood specific gravity on average basis and was found to be maximum in Bahadurpur (0.765) whereas lowest was recorded in Jarri (0.629). Highest heartwood specific gravity was observed in Kalapul (0.796) and lowest in Jarri (0.734).

Keywords: Specific gravity, strength, sap wood, heart wood

Introduction
Oaks (*Quercus* spp.) are the dominant, climax tree species of the moist temperate forests of the Indian Himalayan region where about 35 species of *Quercus* are extensively distributed between 1000-3500 m elevations (Troup, 1921) [14]. Five species of evergreen oak namely; *Quercus glauca, Q. leucotrichophora, Q. dilatata, Q. semecarpifolia* and *Q. baloot* grow naturally in the Western Himalaya which comprises of the eastern part of Himachal Pradesh and state of Uttarakhand. Among these oak species, ban oak forms most extensive forests between 1000 - 2500 m elevations. Their uses includes wood for fuel, acorns for human consumption and leaves for fodder, bark for tannin, wood strips for weaving baskets, charcoal for smelting ore, timbers for ship building, mining timbers, railroad ties, pulpwood for paper, lumber and laminates for furniture, paneling and flooring. The demand for wood products from oaks nevertheless continues to increase and compete with other less tangible values. Oak wood has a density of about 0.75 g/m^3 creating great strength and hardness. The wood is very resistant to insect and fungal attack because of its high tannin content.In hill states of India, besides fuel wood and timber, the local people use oak wood for making agricultural implements. The leaves are used as fodder during lean period and bedding for livestock.

Specific gravity of wood is a measure of the amount of structural material a tree species allocates to provide support and strength. It is a most important wood characteristic because its knowledge allows the prediction of greater number of properties than any other trait (Zobel and Talbert, 1984 and Bowyer and Smith, 1998) [17, 1]. Specific gravity is the ratio of the density of a material divided by the density of water at 4˚C which is used as a basic to standardized comprehension among species and products. Wood density is not distributed evenly along the stem radius. Variations in wood density are very important for wood industry and can be used to estimate intra-species and inter-species variation of the wood density and indicate variation available for selection in tree improvement programs.

Materials and Methodology
Procurement of wood samples from field: Wood samples were collected with increment borer from live standing trees of *Quercus leucotrichophora* from different provenances in

Himachal Pradesh, elevation ranged from 1000-2500 m above sea level. Small cylindrical piece of wood of known diameter and length at DBH was taken by using increment borer, from trees having diameter ranging from 25-30cm. The length of samples ranged from 10-12cm and it contained the portion of bark, sapwood and heartwood. Wahlgren and Fassnacht (1959) [15] have suggested that increment cores extracted at breast height can be safely used to estimate whole-tree density and increment borer is a useful tool for collecting samples from living trees. Freshly extracted sample were marked to differentiate sap wood and heart wood portion and specify with replication number of that provenance. Three replicates from three random selected oak trees with distance of 100m were taken within a provenance.

Determination of Specific gravity

Different wood samples from different provenances were separated into sapwood and heartwood of 3-5 cm length. Fresh cylindrical samples were marked with carbon pencil and their fresh weight was taken. Then all samples were dipped in water separately in small beaker, up to their fiber saturation point. Record the increase in weight day by day to find the constant weight at maximum fiber saturation point. After maximum saturation point with water treatment, samples were first dried in air and then dried in oven at 105$\pm$2 ^{o}C up to constant weight. The difference in weights before and after water treatment was taken to find the specific gravity of sapwood and heartwood samples. Specific gravity of wood samples was calculated by the maximum moisture content method (Smith 1954) [13].

Specific gravity was determined by using following formula:

$$\text{Specific gravity} = \frac{1}{\frac{Mm - Mo}{Mo} + \frac{1}{GS}}$$

Where,

Mm = Fresh/Green weight of the sample having maximum moisture

Mo = Oven dried constant weight of the sample

GS = Average density of wood substance a constant, having value 1.53

Results and discussion

Data presented in given table-1 represent variation in sapwood and heartwood specific gravity of samples collected from different provenances in Himachal Pradesh. After analyzing data it was found that sapwood specific gravity was found to be maximum in Bahadurpur (0.765), which was statistically at par with Ghanati (0.761), Andreta (0.754), banikhet (0.754) and Sarahan (0.754). The minimum value for sapwood specific gravity was noticed in Jarri(0.629), which was at par with Barog (0.635), Chail (0.645), Rahala (0.647), Badidhar (0.649), Churwadhar (0.664) and Jibhi (0.664). Highest heartwood specific gravity was observed in Kalapul (0.796) and it was at par with Andreta (0.795), Seog (0.795), banikhet (0.790), Bahadurpur (0.789), Barog (0.787), Bechad bag (0.779), Sarahan (0.777), Churwadhar (0.775), Dhami (0.774), Kuhasari (0.768) and Nandli (761). The lowest heart wood specific gravity was recorded in Jarri (0.734), which was found to be statistically at par with Rahala (0.736), Padhar (0.738), Naao (0.741), Nohradhar (0.742), Badidhar (0.746), Panarasa (0.748), Jibhi (0.753), Chail (0.758) and Ghanati (0.758).

Table 1: Variation in Sapwood and Heartwood specific gravity of banoak wood samples

S. No.	Provenances	Sapwood Specific gravity	Heartwood Specific gravity
1	Andreta (Kangra)	0.754	0.795
2	Badidhar (Solan)	0.649	0.746
3	Bahadurpur(Bilaspur)	0.765	0.789
4	Baniket(Chamba)	0.754	0.790
5	Barog(Solan)	0.635	0.787
6	Bechad Bag(Sirmaur)	0.718	0.779
7	Chail(Solan)	0.645	0.758
8	Churwadhar(Sirmaur)	0.664	0.775
9	Dhami(Sirmaur)	0.723	0.774
10	Ghanati(Shimla)	0.761	0.758
11	Jarri(Kullu)	0.629	0.734
12	Jibhi(Kullu)	0.664	0.753
13	Kalapull(Kangra)	0.680	0.796
14	Kuhasari(Mandi)	0.709	0.768
15	Naao(kullu)	0.720	0.741
16	Nandli(Mandi)	0.728	0.761
17	Nohradhar(Sirmaur)	0.683	0.742
18	Padhar(Mandi)	0.713	0.738
19	Panarsa(Mandi)	0.722	0.748
20	Rahala(Kullu)	0.647	0.736
21	Sarahan(Sirmaur)	0.754	0.777
22	Seog(Shimla)	0.671	0.795
23	Mean	0.699	0.766
24	SE (D)	0.018	0.017
25	$Cd_{0.05}$	0.037	0.035

Significant variation in specific gravity of wood species from different provenances may be due to various factors, including the geographic location of trees and moisture content which varies by species, d.b.h., age, and stem position (Miles and Smith, 2009) [8]. Purkayastha *et al.* (1980) [9]; Grzeskowiak *et al.* (2000) [4] and Rao *et al.* (2002, 2003) [10, 11] have reported that the different species and sites have a significant impact on wood specific gravity. Wood density varies among trees of the same species, as well as within a tree, where it usually increases from pith to bark and with height (Wate *et al.* 1999) [16] and is considered one of the most informative properties about the physical-mechanical behavior of wood for timber, pulp and paper production [Lima *et al.* (2000); Raymond and Muneri (2001)] [7, 12].

Values for heartwood specific gravity averaged 7-10 per cent greater than those for sapwood. Greater specific gravity values for heartwood may have resulted from accumulations of polyphenols and other extractives in the heartwood not normally found in sapwood (Hiller *et al*. 1972) [5]. Specific gravity of both sapwood and heartwood was found to be highest in provenances with lower elevation. According to Kennedy and Smith (1959) [6] findings in *Populus terichocarpa*, they reported that as the site changed from good to poor, the specific gravity increased from 0.331 to 0.383. Similar results were found by Zobel and Van Buijtenen (1989) [18] in Sitka spruce and Cox *et al.* (2001) [2] in *Shorea acuminata, S. ovalis, S. leprosula* and *Dryobalanops aromatic.* Dhillon and Sidhu (2007) [3] had measured specific gravity (at d.b.h) and noticed significant differences with respect to locations.

Conclusions

The data obtained from the study were subjected to appropriate statistical analysis and revealed that provenances with low elevations have more specific gravity comparatively with higher elevation. As the low elevation area are more under stress conditions, therefore oak trees got wood with more density.

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