Some mechanical properties of red-bud maple (Acer trautvetteri Medw.) wood grown in different districts

Süleyman Korkut[1a], Ümit Büyüksarı[a]

ABSTRACT

In this study, some mechanical properties of red-bud maple (Acer trautvetteri Medw.) wood were studied. To determine the effects of growth sites on some mechanical properties of red-bud maple wood, total of six trees were taken from three different districts (West Blacksea Region (Düzce), East Black Sea Region (Trabzon-Maçka) and Middle Black Sea Region (Ordu-Çambaşı). Samples were taken from approximately equal altitude (1500m).

Mechanical tests were made to determine the cleavage strength, shearing stress parallel to grain and tensile stress parallel to grain for mechanical properties according to Turkish Standards.

The cleavage strength, the shearing strength and the tensile strength parallel to grain were found to be 1.105 N/mm^2, 17.627 N/mm^2 and 104.898 N/mm^2, respectively. The results also indicated that the growth regions had statistically significant effect on mechanical properties of red-bud maple wood.

Keywords: Red-bud maple, Acer trautvetteri Medw, mechanical properties.

ÖZET

Bu çalışmada, Kayın Gövdeli Akçaağaç (Acer trautvetteri Medw.) odununun bazı mekanik özellikleri incelenmiştir. Bu amaçla; üç farklı bölgeden (Batı Karadeniz Bölgesi (Düzce), Orta Karadeniz Bölgesi (Çambaşı-Ordu) ve Doğu Karadeniz Bölgesi (Maçka-Trabzon)) ve yaklaşık 1500 m rakımdan toplam 6 adet Kayın Gövdeli Akçaağaç alınarak bazı mekanik özellikler üzerine büyüme yerinin etkileri belirlenmiştir.

Mekanik özelliklerden yarılma direnci, liflere parallel makaslama direnci ve liflere parallel çekme direnci ilgili Türk standartlarına gore tespit edilmiştir.

Çalışma sonunda; yarılma direnci 1.105 N/mm^2, liflere parallel makaslama direnci 17.627 N/mm^2 ve liflere parallel çekme direnci 104.898 N/mm^2 bulunmuştur. Ayrıca Kayın Gövdeli Akçaağaç odununun yarılma, liflere parallel makaslama ve liflere parallel çekme dirençleri üzerine büyüme bölgelerinin etkili olduğu saptanmıştır.

Anahtar Kelimeler: Kayın gözdeli karaağaç, Acer trautvetteri Medw, mekanik özellikler.

INTRODUCTION

Except tropic zones, over 100 taxons of maples grow in areas of North America, Europe, North Africa and Asia. Maples are, similar to oaks and willows, can easily self hybridize [1].

About 9 maple species and 19 maple taxons are native to Turkey. Tatarian maple (*Acer tataricum* L.), Red-bud maple (*Acer trautvetteri* Medw.), Norway maple *(A. platonoides* L.), Montpelier maple *(A. monspessulanum* L.),

[1] Corresponding author: Tel: ++903805413723 / 143, Fax: ++903805413778,
e-mail: korkut_s1@ibu.edu.tr, suleymankorkut@hotmail.com

[a] Düzce University, Faculty of Forestry, 81620 Düzce TURKEY.

Cretan maple *(A. sempervirens),* Balkan maple *(A. hyrcanum* Fret. M.), Hedge maple (*A. campestre* L.), Cappadocium maple *(A. cappodocicum* Gledt) and Divergent maple (*A. divergens* Pax) are the most important species grown in Turkey [2].

In 1980s, maple woods produced from Turkish forests exceeded 10 000 m^3 yearly [3]. However, since then, maple lands has been gradually decreased and today it covers about 3000 ha land area and with less than 1000 m^3 total standing wood volume [4].

Red-bud maple shows an expansive distribution from Istranca mountains to eastern Black Sea Region (BSR) and primarily in Kapıdağ peninsula in the southern Marmara. It can be found between 100 and 2100 m elevations and from humid to semi-humid climates. It participates as an individual tree or as small groups into mixtures of different conifer and broadleaved stands. The tree can grow up to 25 m height. Bark of the mature tree is not fissured and smooth. The sapwood can vary from pinkish-white to light brown. It has heavy- and hard wood [5, 6].

Oven dry density of maple species were found to be between 0.55–0.80 gr/cm^3 [5, 7]. Yaltırık [8, 9] separated maple trees into two groups regarding the wood density of the maple specimens. The first group has the density of 0.58-0.66 gr/cm^3 and the second group has the density of 0.66-0.80 gr/cm^3. Red-bud maple wood is classified to be in the first group.

Maple is commonly used in a variety of fields, such as furniture, panels, parquet, lumber, LVL, glulam, musical instruments, tool handles, stock of a rifle, decoration material, horizontal beam, shoe-making, airplane propeller, wood bridge, etc [10].

Red-bud maple is maple species that only spread up Turkey and Caucasian in world. Red-bud maple grows fast at different altitude and climate conditions. Red-bud maple also has economic value for the forest industry and the technological properties of this wood species should be studied.

Although red-bud maple (*Acer trautvetteri* Medw) is native to Turkey, the wood properties of the tree have not been studied in detailed. The aim of this study is to determine the effects different sites on some mechanical properties of red-bud maple wood which is economic for forest industry. Therefore, in the light of obtained data, the optimal utilization fields of this red-bud maple wood will be suggested. This study will fill the gap about the world literature for red-bud maple wood.

MATERIALS and METHODS

Total of 6 trees from 3 different districts (taken 2 trees from each districts) were taken to study the mechanical properties of red-bud maple wood. The districts were (West Black Sea Region (Düzce), East Black Sea Region (Trabzon-Maçka) and Middle Black Sea Region (Ordu-Çambaşı)).

A 20 by 20m^2 field was chosen randomly from the sites. In these fields, the diameters at breast height (d1.30) of trees were measured, and their arithmetic mean was calculated. Based on the obtained information, 2 trees were selected and cut according to average diameter at breast height. During the selection, extreme cases were avoided such as excessively knotty, containing reaction wood or slope of grain etc. Logs were removed as a 1.5m sections between 2 and 4m length through stem. North directions of logs were marked [11]. Table 1 shows some properties of sample trees taken from the sites.

Table 1: The properties of sample trees

Districts	Trabzon		Düzce		Ordu	
Tree No	1	2	1	2	1	2
Age of trees	80	83	84	93	68	66
Diameter of $d_{1.30}$ (cm)	38	38.6	36.3	38.2	26	25.2
Lenght of tree (m)	17.6	21.4	20.4	23.6	15,4	13.6
Altitude (m)	1340		1306		1520	
slope (%)	60		61		67	
Direction	K		K		K	
Average temparature (°C)	14.5		13		14.1	
Relative humidity (%)	71		74		71	
Ave. total rainfall (mm)	830.1		837.5		1038.8	
Type of soil (30-60cm)	Sandy clay		clay loam		Sandy clay loam	

Boards with 8 cm width were cut from logs taking pith as a center. Boards were taken from North to South and from West to East directions according to TS 2470 [12]. Sawdust was removed from board surfaces and they were placed in a room for air-drying. Following air-drying process, small and clear specimens were cut from the boards according to Turkish Standards to determine shearing strength parallel to grain (TS 3459) [13], tensile strength parallel to grain (TS 12503) [14] and cleavage strength (TS 7613) [15] and the specimens were conditioned at 20±2°C with 65% relative humidity according to TS 642 [16]. The mechanical properties of the red-bud maple wood were determined.

After the completing the experiments, moisture contents (the moisture content deviation from 12 percent) of specimens were measured according to TS 2471 [17] and strength values were corrected (transformed to 12% moisture content) by using the following strength conversion equation:

$$\delta_{12} = \delta_m * [\ 1 + \alpha\ (M_2 - 12)\ ]$$

Where δ_{12} = strength at 12 percent moisture content (N/mm^2), δ_m = strength at moisture content deviated from 12 percent (N/mm^2), α = constant value showing relationship between strength and moisture content, M_2= moisture content during test (%).

The obtained results were statistically evaluated by using the analysis of variance (ANOVA) and Duncan's mean separation test to compare between relationship growth regions and some mechanical properties.

RESULTS and DISCUSSION

Arithmetic mean standard deviation, variance, coefficient of variance and number of specimens in connection with the cleavage strength of red-bud maple wood were given on the Table 2.

Table 2: The values of cleavage strength

Districts	Trabzon	Düzce	Ordu
Arithmetic mean (N/mm^2)	1.089 A	1.098 A	1.129 A
Standard deviation	0.237	0.151	0.144
Variance	0.056	0.022	0.021
Coefficient of variation	21.76	13.75	12.75
Sample size	50	50	50

Homogeneity groups: same letters in each columns indicate that there is no statistical difference between the samples according to the Duncan's multiply range test, $p<0.05$.

The mean values of the cleavage strength in Trabzon, Düzce and Ordu, were found to be 1.089 N/mm^2, 1.098 N/mm^2 and 1.129 N/mm^2, respectively. The general mean value of the cleavage strength was 1.105 N/mm^2.

Acer trautvetteri Medw had lower cleavage strength compared to the other maple species. This can be a result of anatomical structure and low density of the wood. However cleavage strength of red-bud maple wood found to be higher than *Fagus orientalis* Lipsky [18]. It is known that rays significantly affect the cleavage strength of wood. Increasing the amount of rays in wood decreases the cleavage strength. In addition, wood density affects this strength.

Arithmetic means, standard deviation, variance, coefficient of variance and number of specimens in connection with the shearing strength of red-bud maple wood were given on the Table 3.

Table 3: The values of shearing strength

Districts	Trabzon	Düzce	Ordu

Arithmetic mean (N/mm^2)	8.691 A	9.686 B	8.029 C
Standard deviation	0.691	0.586	0.520
Variance	0.478	0.344	0.270
Coef. of variation	7.955	6.051	6.472
Sample size	50	50	50

Homogeneity groups: same letters in each columns indicate that there is no statistical difference between the samples according to the Duncan's multiply range test, $p<0.05$.

The mean values of the shearing strength in Trabzon, Düzce and Ordu, were found to be 8.691 N/mm^2, 9.686 N/mm^2 and 8.029 N/mm^2, respectively. The general mean value of the shearing strength was 8.802 N/mm^2.

As presented on the Table 5, shearing strength of *Acer trautvetteri* Medw is lower than that of *Acer platanoides, Acer saccharum* and *Acer pseudoplatanus.* However shearing strength of *Acer trautvetteri* Medw was found to be higher than other maple species. The shearing strength value was 9.9 N/mm^2 for beech. This strength type is important in jointing points of wood products.

Arithmetic means standard deviation, variance, coefficient of variance and number of specimens in connection with the tensile strength parallel to grain of red-bud maple wood were given on the Table 4.

Table 4: The values of tensile strength parallel to grain

Districts	Trabzon	Düzce	Ordu
Arithmetic mean (N/mm^2)	100.329 A	112.111 B	102.255 A
Standard deviation	16.420	16.888	9.698
Variance	269.617	285.204	94.051
Coef. of variation	16.37	15.06	9.48
Sample size	50	50	50

Homogeneity groups: same letters in each columns indicate that there is no statistical difference between the samples according to the Duncan's multiply range test, $p<0.05$.

The mean values of the tensile strength parallel to grain in Trabzon, Düzce and Ordu, were 100.329 N/mm^2, 112.111 N/mm^2 and 102.255 N/mm^2, respectively. The general mean value of the cleavage strength was 104.898 N/mm^2.

Tensile strength parallel to grain was found to be 104.898 N/mm^2 for *Acer trautvetteri* Medw. These values were 100 N/mm^2 for *Acer platanoides* and 82 N/mm^2 for *Acer pseudoplatanus*. This strength is very important especially in the jointing places.

Table 5 shows mechanical properties of some maple species grown in Turkey and in the World [19, 20, 21].

Table 5. Mechanical properties of some maple species and beech

Species	Shear strength parallel to grain N/mm^2	Tensile strength parallel to grain N/mm^2	Cleavage strength N/mm^2
Acer trautvetteri	8.8	104.898	1.105
Acer macrophyllum	7.7	-	-
Acer nigrum	7.8	-	-
Acer rubrum	7.9	-	-
Acer saccharinum	7.2	-	-
Acer saccharum	10.1	-	-
Acer platanoides	9	100	2.19
Acer pseudoplatanus	9	82	1.6
Fagus orientalis	9.9	131.6	0.74

Table 3 and Table 4 showed that growth regions had statistically significant effect on cleavage strength, shearing strength and tensile strength of red-bud maple wood.

Han [22] found that age, site, tree, position, and site and position interaction, and the position and tree interaction significantly ($P \leq 0.05$) affected, modulus of elasticity (MOE) and modulus of rapture (MOR) in the juvenile zone. Age did not significantly affect MOE and MOR in the mature zone, but the effects of site, tree, and interaction of tree and position, and the interaction of position and tree were significant. Red maple (*Acer rubrum* L.) has an increase in MOE and MOR from the pith outward, followed by a leveling off. In the mature zone, MOE and MOR of red maple on the wet site were larger than on the dry site. There were variations among and within trees. The average percentage increase for MOE and MOR of red maple from juvenile wood to mature wood was from 11 to 40. Trends of micro bending properties of MOE and MOR for sugar maple (*Acer saccharum* Marsh.) at the bottom bole position were less pronounced than those of red maple. Sugar maple had higher MOE and MOR than red maple.

Büyüksarı [23] found that the growth regions had statistically significant effect (p value < 0.001) on physical and mechanical properties of maple wood. When the sampling stands within the same growth region is considered only some macroscopic, physical and mechanical properties were statistically significant ($p< 0.05$).

The results indicated that the growth region had significant effect on wood mechanical properties. Therefore, the growth region should be taking into consideration based on utilization areas of the red-bud maple wood. Samples trees in this study were taken from 1300 altitude. It is also known that increase in altitude gave lower wood density for broadleaved woods. Wood density has significant effects on mechanical properties of wood.

Results indicated that the technological properties of red-bud maple wood are comparable to the beech wood, which has an expansive distribution in Turkey. I think forest enterprise give more attention to the red-bud maple wood, which is more valuable wood source for forest industry.

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