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Full Length Research Paper

Bark Measurment of Beech (*Fagus orientalis* Lipsky.) in Tosakoti - Hyrcanian Forest

Ali Shekholeslami[a*], Farid Kazemnezhad[a], Saied Akhshabi[b]
[a] Department of forestry, Islamic Azad University, Chalous Branch, Chalous, Iran
[b] Msc. Student, Islamic Azad University, Chalous Branch, Forestry Department, Iran
* Corresponding author: islamiali@gmail.com, Iran, Mazandaran, Chalous, Islamic Azad University, Chalous Branch , Iran.

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Abstract: In 2008, various aspects of the tree stem profile were measured and 200 bark samples removed from 55 individual stems of beech species at Tosakoti sites in Mazandaran provinces in the north of Iran in the Hyrcanian forest. Hyrcanian forests are located at green strip extending over the northern slopes of Alborz range of mountains and the southern coasts of the Caspian Sea. Bark thickness was measured from each stem with bark gauges at 6 different relative heights. The measured stem variables used in this study are diameter over bark at relative heights 1, 10, 30, 50, 70 and 90%; bark thickness at the same relative heights; diameter over bark at breast height; bark thickness at breast height; tree height; tree age. In this study, bark amount is expressed either as double bark thickness or as the proportion of over bark diameter or volume. Percent of bark volume of beech trees is about 6.04% of tree volume. Average double bark thickness was greatest at the base (1% relative height) 18 mm and decreased uniformly towards the top (90% relative height) 8 mm. Bark proportion (from the diameter) decreased from the base to the 20% relative height being 4% at its minimum. After that the bark proportion increased first slowly then rapidly being finally 10% at a relative height of 90%. The general form of bark curves at different breast height diameter classes is highly similar and therefore we can assume that the general form of a bark curve does not depend on tree size.

Keywords: Bark thickness, Bark Volume, Proportion of over bark diameter, Iran

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Introduction

Bark is the outermost layers of stems and roots of woody plants. Plants with bark include trees, woody vines and shrubs. Bark refers to all the tissues outside of the vascular cambium and is a nontechnical term (Raven et al, 1981). It overlays the wood and consists of the inner bark and the outer bark. The inner bark, which in older stems is living tissue, includes the innermost area of the periderm. The outer bark in older stems includes the dead tissue on the surface of the stems, along with parts of the innermost periderm and all the tissues on the outer side of the periderm. The outer bark on trees is also called the rhytidome (Taylor, 1996). Bark thickness decreases more or less regularly from ground to tip, with the rate of taper usually, (but not necessarily), correlated with the rate of taper of the stem under bark. Despite this variation, a relationship between average bark thickness at breast height, bark volume and stem variables (diameter over bark, height) can usually be established. The ratio of diameter under bark to diameter over bark often follows a consistent and predictable pattern with increasing height on a tree trunk: in many tree species, particularly conifers, the ratio of diameter under bark / diameter over bark increases up the bole, i.e. bark percentage by volume decreases with height, in other species, e.g. many hardwoods, the ratio is almost constant with height and, in a few species, it decreases with height. Slower growing trees tend to have thicker bark than fast growing trees mainly because the faster growing trees shed more bark (Brack et al, 1985).
Literature on the relationship between bark thickness and diameter at breast height are limited for many species in hyrcanian forests. In Iran, Sarikhoni (1984) found average bark volume ranges from 6 to 10% and 10 to 15% of over bark volume for beech and hornbeam prospectively in Nowshahr forest in the north of Iran. Zobeiri (2000) derived a regression equation for the relationship between double bark thickness and diameter at breast height for 206 stems of

beech in forests of Noshahr forest in the north of Iran. Namiranian (2006) derived a regression equation for the relationship between double bark thickness and diameter at breast height for 104 stems of beech in forests of Noshahr in the Hyrcanian forests.

Van Laar and Geldenhuys (1975) derived six regression equations for the relationship between double bark thickness and branch-free stem length for groups of species in forests of the southern Cape (nowWestern Cape Province) (double bark thickness equals the over-bark diameter minus the under-bark diameter of the stem at a certain point) in South Africa. Williams et al. (2005) derived six regression equations for the relationship between bark thickness and diameter at breast height for sex tree species used medicinally in South Africa. Johnson and Wood (1978) derived a simple linear model reliably predicts bark thickness of radiata pine in the Australian Capital Territory.

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Laasasenaho et al. (2007) modeled bark thickness of Picea abies with taper curves in Finland.

Hyrcanian forests are located at green strip extending over the northern slopes of Alborz range of mountains and the southern coasts of the Caspian Sea. This area ranges approximately 800 km long and 110 km wide and has a total area of 1.8 million hectare. Hyrcanian forests encompass various forest types including 80 woody species (trees and shrubs). They are suitable habitats for a variety of hardwood species such as beech, hornbeam, oak, maple, alder, and Large-leaved lime (Sagheb-Talebi et al., 2003).

This paper quantifies the relationship between bark thickness and diameter at breast height for two tree species used industrially in Iran. The purpose of this investigation is to measurement of bark thicknesses, and derived a regression of bark thicknesses and the diameter at breast height of the study trees.

Material and Methods

Tosakoti forests are located in Tonokabon forests in the North of Iran. The altitude varies from 400 to 2300 meters above see level. All the investigated areas have obvious homogeneity in geology and climate. Most precipitation occurs from early autumn to early spring. The climate is very humid with mild winters (August with the highest average maximum temperature of 0.1 °C and February with the coolest month with an average minimum temperature of 2.6 °C); a yearly average temperature of 11°C and a yearly precipitation of 1100 mm, were recorded (1976-2006) at the nearest meteorological stations in Tonokabon city.

In 2008, various aspects of the tree stem profile were measured and 200 bark samples removed from 55 individual stems of beech species at Tosakoti sites in Mazandaran provinces in the north of Iran. Bark thickness was measured from each stem with bark gauges at 6 different relative heights. The measured stem variables used in this study are:

- diameter over bark at relative heights 1, 10, 30, 50, 70 and 90% (di); bark thickness at the same relative heights (bi); diameter over bark at breast height (d1.3); bark thickness at breast height (b1.3); tree height (h); tree age (t).

Trees were selected from various size classes based on the stem diameter at breast height (dbh, 1.3 m above the ground). None of the individuals sampled had suffered any prior harvesting damage and the bark on the bole was intact. Stem diameter-classes were 5 cm classes. Once a tree was selected, the following information was recorded: the diameter of the stem at breast height and for relative height of the tree; branch-free bole length and age of tree. Stem diameter was measured using a forestry ‘diameter tape’ that allows diameter to be read directly from a circumference measurement. Vertical height and branch-free bole length were estimated using a height pole marked in 3 m intervals. After harvesting each tree, bark samples were cut and removed at each selected points. Bark thickness was measured on site using a Vernier calliper (accuracy: 0.01 mm). Regressions between dbh and the bark thickness of the samples were calculated and also, regression equations are calculated between dbh, height, age and bark thickness for the two species using Spss 16 and Excel 2003.

Results

Minimum and maximum values, means (x) and standard deviations (S.D.) of the central sample tree measurement characteristics (d1.3, b1.3, h, and t) are presented in Table 1. In this study, bark amount is expressed either as double bark thickness or as the proportion of over bark diameter or volume. Percent of bark volume of beech trees is about 6.04% of tree volume.

Table 1- Descriptive Statistics of data

	Minimum	Maximum	Mean	Std. Deviation
dbh (cm)	22.00	130.00	70.13	29.59
bark (mm)	9.00	30.20	18.68	5.52
hieght (m)	14.50	35.00	25.70	5.38
age(years)	40.00	220.00	112.85	44.93

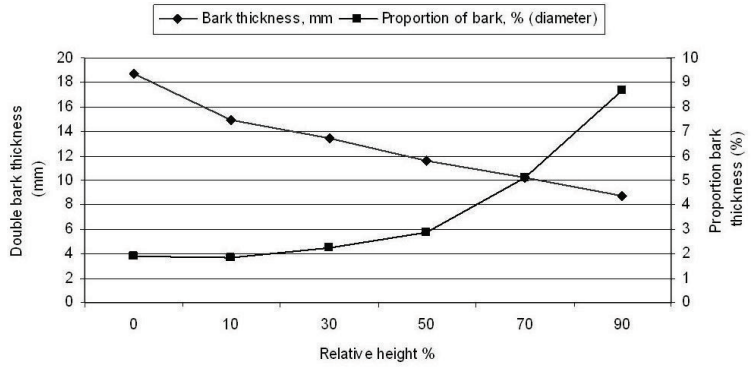

Fig1- Mean values of double bark thickness (mm) and proportional bark thickness (%) as a function of relative height

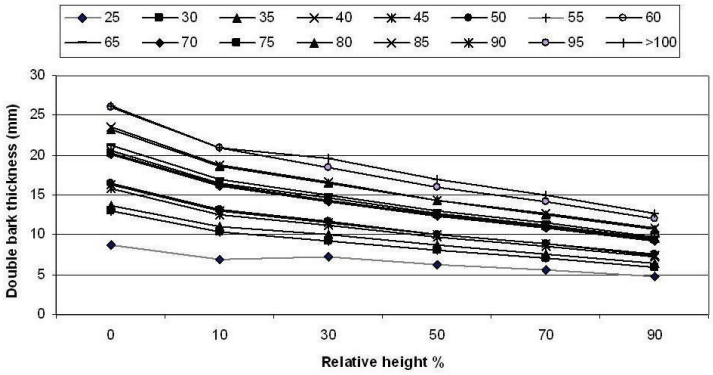

Fig 2 - Double bark thickness (mm) as a function of relative tree height by breast height diameter classes

Average double bark thickness was greatest at the base (1% relative height) 18 mm and decreased uniformly towards the top (90% relative height) 8 mm. Bark proportion (from the diameter) decreased from the base to the 20% relative height being 4% at its minimum (Figure 1). After that the bark proportion increased first slowly then rapidly being finally 10% at a relative height of 90%.

The general form of bark curves at different breast height diameter classes (Figure 2) is highly similar and therefore we can assume that the general form of a bark curve does not depend on tree size.

Models to estimate bark thickness at breast height were made by using the following linear functions (2R= double thickness of bark (mm), $d_{1.3}$= diameter at breast height, h= height, A= age):

- $2R = 0.164 * d_{1.3} + 7.199$ (1)
- $2R = 8.56158 + (0.15553 * d_{1.3}) - (0.10626 * h) + (0.01719 * A)$ (2)

Discussion

Bark proportion from diameter decreased from the base to the 20% relative height being 4% at its minimum. After that bark proportion increased being finally 10% at a relative height of 90%. Otherwise bark increased towards the base of the stem. The analyses of the factors effecting bark thickness of beech proved that correlation between bark thickness and stem diameter is strong. Bark thickness also depends on tree height, tree age, and tree form.

Percent of bark volume of beech trees is about 6.04% of tree volume in the study area, but percent of bark volume of beech trees was about 5.97% of tree volume in the Khirodkenar forest in the north of Iran (Sarikhani (1984).

Bark thickness varies on different parts of the stem. Thicker bark is commonly found near the base of the stem and decreases in thickness with increasing height up the stem. Not only is bark thickness affected by the height up the stem, but also by the age of the individuals (assuming age is related to size). The generally larger and older trees exhibit a more pronounced decrease in bark thickness between 0.5 m and 2.0 m than do the smaller individuals.

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