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Relationships Between Diameter, Height and Geographical Aspects with Bark Thickness of Lebanon Oak Tree (*Quercus libani* Oliv.) in Armardeh, Baneh (Northern Zagros of Iran)*

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Abstract: The aim of this study was to investigate relationships between diameter and height with bark thickness of Lebanon oak (*Quercus libani* Oliv.) and effect of geographical aspects on bark thickness. This study was done in Northern Zagros forests, Western Iran. Socio-economic problems as well as lack of information about forest situation are main obstacles for proper management in these forests. One hundred and thirty five sample discs were taken from 45 cut trees. Samples were measured and analyzed with Minitab 14 and SPSS 15. Results from One-way analysis of variance, demonstrated that there is no significant difference in bark thickness in various aspects on trees. In order to indicate a proper model for bark thickness estimation from diameter and height, mean of bark thickness of various aspects, with highest correlation with diameter (R = 0.877) and height (R = 0.74), was entered into model. Quadratic and linear equations have best compatibility to estimation of bark thickness from concerned factors. Mean of bark thickness was measured about 12.6 mm. Results can use in management of these forest in order to determine potential values of forest with consider bark as a non-wood forest product (because of valuable raw materials) and effective factor on sprouting ability of oaks (to make a forest regulation model based on coppice method).

Key words: Northern Zagros, Lebanon oak, bark thickness

INTRODUCTION

Zagros forests are one of the main important natural ecosystems that covered about 5 million hectares of Iran (Jazireai and Rastaghi, 2003). Experts divided Zagros geographically into three parts: Northern, Central and Southern Zagros. Northern Zagros is the ouly part of Zagros that have a three species of oaks; Lebanon oak (*Quercus libani* Oliv.), gall oak (*Q. infectoria* Oliv.) and Persian oak (*Q. persica* J.) (Fattahi, 1994; Jazireai and Rastaghi, 2003). Old high dependence of forest dwellers to forests resulted in construction of special relationships named traditional forestry. Traditional forest managers have produced animal fodder from oak leaves with the spatio-temporal organization and 3 years cycles (Fattahi, 1994; Ghazanfari *et al*., 2004). This method is incompatible with Forest, Rangeland and Watershed Organization policies of Iran (Ghazanfari *et al*., 2004). While effects of traditional forest management are unidentified yet, this is evident that these practices influenced forest structure and tree characteristics. Bark as an organism of tree has an important role in cambium protection, critical activities and defence against disease and insects (Sherrill *et al*., 2008). Lebanon oak has a dark grey and plouged bark (Mozaffarian, 2004). Since frequency of lichen and bryophytes have a positive relation to air pollution levels and bark acidity (pH) (Larsen *et al*., 2006), importance of bark in determining rate and type of polluting elements and study the prevention methods against air pollution is revealed (Bohm *et al*., 1998; Larsen *et al*., 2006). Determining of bark thickness-height

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relationship regard to variability of bark characteristics with height was noticed by Levia and Herwitz (2005). To evaluation of total values of forest to implementation in land use and developmental designs, managers can interference bark values as a non-wood forest product (Guedes *et al*., 1991; Saeed, 1995; Makhdoum, 2006). In oaks, bark allocates itself 10-15% of standing volume (Sarikhani, 2001; Namiranian, 2007). The previous models, using diameter and height have obtained to estimating bark thickness (Zobeiry, 2005; Namiranian, 2007). This organism especially in old trees and uneven oak bark create suitable place for microorganisms and insects (Vrkocov *et al*., 2000). In addition act as an easily available pollen trap that can be used to reconstruction and identifying destroyed vegetation (Groenman, 1998). Bark contains valuable raw materials as tannin, methanol and calcinm (Cochet, 1992; Counell and Fox, 1999; Trockenbrodt, 1995; Andrensek *et al*., 2004; Jansen and Kuiper, 2004). In this point of view coppice management have been noticed (Jansen and Kuiper, 2004). It seems to be considerable that resprouting influenced by bark thickness negatively (Smith, 1987; Johnson *et al*., 2001). Bark thickness and its relationship with diameter is one of main important traits in genetic studies to estimation of variance components (Furlani *et al*., 2005), genetic gains and breeding programs (Brito da costa *et al*., 2000).

To estimating bark volnme first step is determining the bark thickness. In order to measuring bark thickness researchers have used bark thickness-diameter and height models. Since bark gauge probably have been companion with bark compaction and thus a lot error, it is necessary to establishment of proper model to bark thickness estimation (Zobeiry, 2005; Namiranian, 2007). We present this model by precise measurement of bark thickness on cross sections directly.

In this study, we considered bark relationships with diameter and height, to indicate estimating model based on these two mentioned factors.

MATERIALS AND METHODS

Study Area

The study area is located in 35° 45′ 45″ to 35° 55′ 15″ N longitude and 45° 40′ 55″ to 45° 50′ 45″ E altitude. In political division of the country, Armardeh forest located in Baneh city in the province of Kurdistan (Fig. 1). Annual precipitation is approximately 760 mm and its average elevation is 1550 m a.s.l. These forests are divided to small sections (on average 10 ha) named Galajar. Each section has a particular local owner. The main occupations of villagers are animal husbandry and agriculture. Moderate summer and so cold, snowy winter are characteristics of this region. Forests composed from oak trees including: *Quercus libani* Oliv., *Quercus infectoria* Oliv. and *Quercus persica* J. and Sp. (Fattahi, 1994; Jazireai and Rastaghi, 2003). One hundred and thirty five sample discs were taken from 45 Lebanon oak trees distributed in 5 Galajars (traditioual forestry units).

Measurements including diameter and bark thickness were performed with a precision of 0.1 cm. To each disc (cross section) diameter was measured in two North-South and East-West sides. Bark thickness also was measured in four cardiual points and furthermore in slope direction. These directions were marked on discs previously. Since irregularity in bark surface we were take outermost part of bark as a base for measurements (Fig. 2).

Data Analysis

Data was prepared with Minitab14 and analyzed with SPSS 15.0. Homogeneity test of variances with bartlet test showed that variances are homogenous. But normality test with Kolmogorov-Smirnov indicated that some data is abnormal. These data was transferred with square root transformation. To determine signifying of differences between bark thicknesses in various sides one way ANOVA was used. In order to investigation regression relationship between bark thickness, diameter and height to indicating a proper model for estimating bark thickness, firstly we calculated bark thicknesses

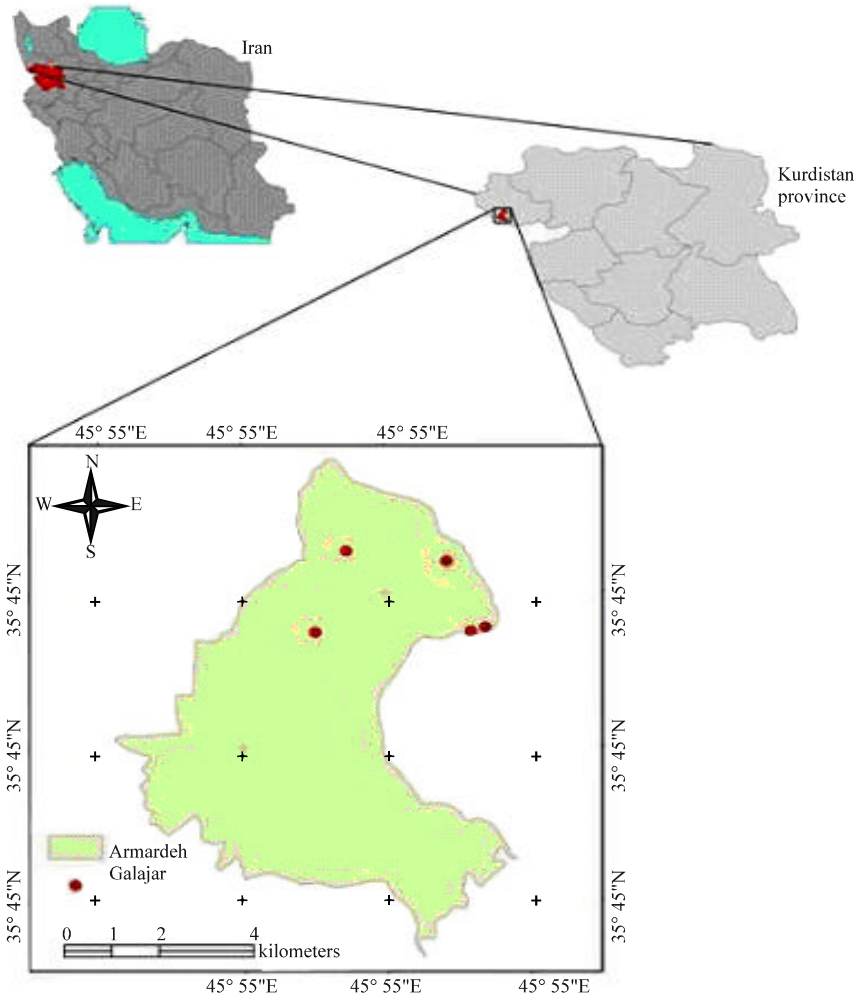

Fig. 1: Location of the study area

Fig. 2: Outermost part of bark was took as a base for measurements

(including bark thickness in various sides and mean of bark thickness in mentioned sides) correlation with diameter and height, so variables with a highest correlation was entered to model. Stepwise regression was performed to produce bark thickness with diameter and height model.

RESULTS

Investigating of mean of bark thickness in various sides showed that the East and slope sides have a maximum and minimum amount of this factor, respectively (Table 1). Maximum, minimum and mean of bark thickness were 26.2, 2.4 and 12.6 mm, respectively. Diameter of samples was ranged from 5.6 to 56.1 cm.

Results from one way ANOVA demonstrated that there is no significant difference between bark thicknesses in 5 mentioned sides of discs (Table 2). Correlation analysis of diameter and height with bark thickness showed that mean of bark thickness has a greatest correlation with both diameter and height factors (Table 3). Based on these results, to present a model for estimation of bark thickness from diameter and height, mean of bark thickness was entered to model. These models are quadratic equations for diameter ($R^2 = 0.787$; Eq.1) and height ($R^2 = 0.56$; Eq. 2). Finally bark estimating model was obtained using diameter and height ($R^2 = 0.785$; Eq. 3).

$$b = -1.511 + 0.798d - 0.007d^2 \quad (1)$$

$$b = 20.051 - 3.241h + 0.145h^2 \quad (2)$$

$$b = 6.912 + 0.336d - 0.807h \quad (3)$$

where, b, d and h are bark thickness (mm), disc diameter (cm) and height (m) respectively.

Table 1: Mean of bark thickness (mm) in various sides on discs: East and slope sides have a maximum and minimum amount of this factor, respectively

Side	North	East	West	South	Slope
Mean of bark thickness (mm)	12.5	13.1	13	12.5	12.1

Table 2: One-way ANOVA: Effect of various aspects on bark thickness

Source	df	SS	MS	F	p-value
Factor	4.0	3.061	0.765	0.91^{ns}	0.458
Error	670.0	564.211	0.842		
Total	674.0	567.272			

ns: non significant

Table 3: Correlation analysis of diameter and height with bark thickness; Bm has a greatest correlation with both two factors

Factors	D	H
$N_{(normalized)}$	0.785	-0.627
E	0.786	-0.688
S	0.828	-0.740
W	0.773	-0.680
A	0.781	-0.665
Bm	0.877	-0.740

A: Bark thickness in slope aspect, Bm: Mean bark thickness in various aspect

DISCUSSION

Lack of information with socio-economic problems is main obstacle against proper management of Zagros forests. While, containing of valuable materials (Counel and Fox, 1999; Trockenbrodt, 1995; Andrensek *et al*., 2004; Jansen and Kuiper, 2004) and important role of bark in biomonitoring (Bohm *et al*., 1998; Larsen *et al*., 2006) and biodiversity conservation (Groenman, 1998; Vrkocov *et al*., 2000), its basic characteristics are unknown. This study can be entrance to more extensive investigation.

To establish the best equation between bark thickness with diameter and height, the mean of bark thickness, with a highest correlation with predictor factors (diameter and height) was entered to model. In spite of that the different geographical aspects affected some characteristics of trees (Sunmez *et al*., 2007), present results showed that in this study bark thickness not affected by this factor significantly. Mean of bark thickness (12.6 mm, diameter ranged from 5.6 to 56.1) indicated that ratio of bark volume/ total tree volume in Lebanon oak is noticeable amount. Sarikhani (2001), Zobeiry (2005) and Namiranian (2007) were mentioned that bark allocated itself 5% (for *Carpinous betoulus* L.), 6% (for *Fagous orientalis* Lipsky) and 15% (for *Quercus* sp.) of total tree volume.

Equations showed that bark thickness increase with diameter increases and reduced with height increases followed quadratic model for both diameter and height, respectively. Sunmez *et al*. (2007) obtained same founding for tree diameter and tree age with bark thickness for *Picea orientalis*. While Zobeiry (2005) and Namiranian (2007) proposed linear relationship between bark thickness and diameter, it seems to special form of trees and forest structure has affected these characteristics. These forests are suppressed with pollarding and animal browsing beneath traditional forest management by years (Fattahi, 1994; Ghazanfari *et al*., 2004; Jazireai and Rastaghi, 2003). Pederick (1970) and Sherrill *et al*. (2008) found a high positive genetic correlation between bark thickness and diameter.

Pederick (1970) estimated high narrow sense heritability for bark thickness. These indicated that selection for larger diameter produce individnal with thicker bark. These foundlings similarly may true about present results, since traditional managers have been selected best individnals for pollarding and cut defective them for firewood or building. Although it should be declare cautiously and after more precise investigations merely because Furlani *et al*. (2005) found that narrow sense heritability for bark thickness was low. Since bark characteristics change with height, therefore affect concern factors likely (Levia and Herwitz, 2005); disc height (not total height) was entered to predictor model.

Implementation in Management

In management point of view we proposed to apply these results in two fields: firstly; investigation of appropriate dimension of Lebanon oak trees to sprouting is doing for make a forest regulation system based on coppice regeneration in this region. The mentioned study aimed to dissolve regeneration problems of Northern Zagros forest. To obtain this object primary goal of this study was to determine sprouting ability with both diameter and age of parent stump. In addition to these factors, in this study and similar ones also, bark thickness can be considered as an effective factor, since sprouting ability reduced with increase bark thickness (Smith, 1987; Johnson *et al*., 2001). Secondly; estimation of total values of forest as a base for efficient decision making in relation to other organizations and forest dwellers, is necessary (Saeed, 1995) and it can be used in evaluation of ecological potential to determine land use program (Makhdonm, 2006).

In Zagros forests of Iran non-wood forest products allocate themselves most important portion of values. Oak bark should be taking into account as a one of the main valuable source of these incomes.

In conclusion, since conservation policies of Government of Forests, Rangelands and Watershed Organization in Zagros forests are implementing, bark exploitation and other forest utilizations are prohibited. While these suggestions and results can be useful to evaluating of existing potential to arriving more proper management.

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