Crown Biomass Relationships of Lebanon Oak in Northern Zagros Forests of Iran

Sheyda Khosravi, Manouchehr Namiranian, Hedayat Ghazanfari, Anoushirvan Shirvani

Abstract – Nacrtak

*Allometric relationships for estimating the biomass of the crown of Lebanon oak (*Quercus libani *Oliv.) have been developed through using biometric parameters such as the diameter at breast height, tree height, crown length, and crown width. The study was conducted in Armardeh forests in Iran's northern Zagros mountains; for a long time the local people have been pollarding the crown of oak trees in these forests for their traditional uses. After the local people entirely cut the crowns of 48 sample trees, the weight of the crowns and their constituting components (leaves and branches) were measured. The results showed that the amount of the crown biomass of Lebanon oak at the stand level is about 4.98±0.81 tons ha^{-1} (95% confidence interval), 79% of which are branches and the rest are leaves. All the equations, representing the relationships between biometric parameters and the biomass of the crown or its components, were highly significant ($p<0.001$), and the adjusted coefficient of determination (R^2_{adj}) was in the range of 0.51–0.65. The most suitable relationship was a multiple regression between the crown width and the tree height, as independent variables, with the crown biomass, as the dependent variable (R^2_{adj} = 0.65). These relationships can be helpful for evaluating the crown biomass production of Lebanon oak, and can be useful for planning a sustainable forest management.*

Keywords: Allometric relationships, Biomass, Crown, Lebanon oak, Northern Zagros

1. Introduction – *Uvod*

The dominant tree species of Baneh forests in the northern Zagros, one of the richest ecosystems in Iran, is *Quercus* spp. As forest dwellers depend strongly on forests, specific relationships, the so-called traditional forestry, have been developed in these areas for a long time (Valipour et al. 2009), mostly aimed providing fodder for farm animals, firewood and also wood (Ghazanfari et al. 2004). In view of the fact that most of the forest inhabitants live, in poverty, by farming animals, they are highly dependent on oak forests for feeding these animals. Therefore, each traditional owner of a forest divides the whole area of his forest into 3 or 4 parts, and each year in late August, he cuts all the crowns of the trees in one of these parts (Jazirei and Ebrahimi-Rastaghi 2003; Moradi et al. 2010). The branches cut from each tree are, along with their leaves, divided into a number of different sets named »Bakhe« by the local people. These Bakhes are kept within the crowns of trees or in nearby houses so that, during winter, they can be used as a food source for farm animals, and their wood can be used as firewood for heating. Hence, short-rotation forestry is traditionally done on the crowns of oak trees. On the other hand, animals grazing in the forest for more than seven months have threatened the natural regeneration (Ebrahimi-Rastaghi 2003; Valipour et al. 2011). Though the Forest and Rangeland Organization's policy of Iran is to conserve these forests, it has not been successful so far due to the lack of social acceptance and local participation (Ebrahimi-Rastaghi 2003; Ghazanfari et al. 2004). At the moment, the sustainability of these forests is facing a serious problem (Valipour et al. 2011), as the investigation of the correct management strategy lacks fundamental information, such as the information on forest biomass.

The tree biomass plays an important role in sustainable management of forests (Zianis and Mencuccini 2004), and can be regarded as an indicator for biological and economic productivity of the site (Cole and

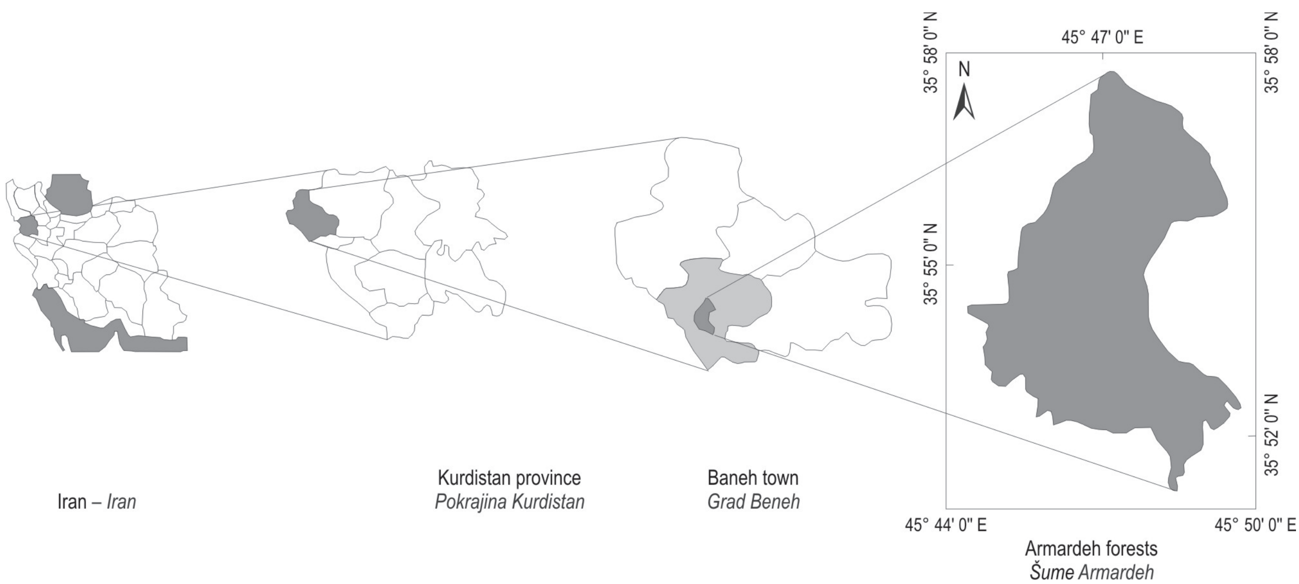


Fig. 1 The location of the study area within the Kurdistan province, Iran
Slika 1. *Istraživano područje pokrajine Kurdistan, Iran*

Evel 2006). In most researches, tree biomass was estimated with the use of regression equations, which were derived through performing regression between the destructively measured dry weight of trees, as the dependent variable, and the tree dimensions as the independent variables (Nelson et al. 1999). Independent variables are easily-measurable biometric parameters such as the diameter breast height (DBH), height, basal area, and the crown dimensions. Dependent variables can be above-ground biomass including some components such as stem, branch, bark, leaf and/or needle, bud, cone, and under-ground biomass in the form of coarse and fine roots. For instance, in a research done on two species of *Quercus variabilis* and *Q. mongolica* in central Korea, highly significant allometric equations were found between DBH and the above-ground biomass, wood and bark, live and dead branches, twigs, foliage and annual production (Son et al. 2004). In another study, Cienciala et al. (2008) developed allometric relationships between the above-ground biomass and the variables such as age, DBH, tree height, the length, and width of the crown for 51 destroyed samples from two species of oak trees (*Q. robur* and *Q. petraea*) in Czech Republic. In general, conducting researches on the biomass of oak trees is necessary to develop an understanding of natural oak tree ecosystems (Son et al. 2004).

In view of specific conditions of our forests, which are closely connected with tree crowns, as mentioned above, the present study aims at establishing some useful allometric relationships through using destructive samples for predicting the crown biomass in a stand of natural oak trees in Baneh forests. Our research is focused on Lebanon oak (*Quercus libani* Oliv.), as it is one of the main species constituting Zagros forests.

2. Materials and Methods – *Materijal i metode*

2.1 Study Area – *Područje istraživanja*

The study was conducted in Armardeh forests (35˚51′40‵‵–35˚57′55‵‵ N and 45˚44′20‵‵–45˚49′55‵‵ E) 12 kilometers SW of Baneh, which is a town in the Kurdistan province in the western part of Iran (Fig. 1). The dominant species of these forests include *Q. libani, Q. infectoria,* and *Q. brantii.* The annual precipitation is about 760 mm (Valipour et al. 2009), most of which is in late autumn to early spring.

2.2 Data Collection – *Prikupljanje podataka*

After choosing the suitable stand, the traditional owner's prior consent was obtained before the study began. The density of trees in the stand of interest was estimated to be 370 tree ha^{-1}, 302 of which were *Q. libani* and the others were *Q. infectoria* (Khosravi et al. 2012).

Usually, regression researches for the direct estimation of biomass are made on the basis of a small number of trees, and therefore, not representative of the whole forest (Sawadogo et al. 2010). Hence, in this study, 50 Lebanon oaks were randomly selected in order to determine with acceptable accuracy the crown biomass at the stand level. The trees were measured for DBH, tree height, crown length, and crown width. It should be pointed that two perpendicular diameters of the crown were measured, the arithmetic mean of which was considered as the crown width. Two trees with highly lopsided crowns, heavily defoliated, and broken tops were excluded from our calculations (Brown 1978). Statistical analyses were carried out on the remaining 48 trees.

In the late summer, the forest owners cut off all the crowns of the sample trees in such a way that all the branches of the trees were pollarded, and bunched these cut branches plus leaves in a number of Bakhes. After that, all the Bakhes were weighed, and their whole sum was considered as the entire fresh crown weight for the corresponding tree from which the crowns were cut. For example, the number of 10 Bakhes with the weights of 3.26, 2.38, 4.08, 2.40, 3.46, 2.54, 2.34, 2.16, 3.02 and 2.62 kg were obtained through pollarding the sample tree 1; therefore, the entire fresh crown weight of this tree amounted to 28.26 kg. Twenty branches of each tree were randomly selected from different Bakhes, and the weights of the leaves and branches were measured separately. A number of leaves and branches were also sent to the laboratory for determining moisture contents. »Samples of leaves and branches were oven-dried at 80°C (Starr et al. 1998; Burger and Delitti 2008; Blujdea et al. 2012). During the drying process, their weights were measured every 24 hours to see whether they had reached the constant weight or not. We established that the leaves stopped losing weight after 48 hours, and the branches did the same after 72 hours. Then, their constant weights were used for determining the moisture contents«. The mean value of the moisture contents of leaves and branches was estimated to be 44% and 33%, respectively.

2.3 Data Analysis – *Obrada podataka*

The crown biomass (B_t: ton ha^{-1}) of Lebanon oak trees at the stand level was calculated with the use of Eq. (1):

$$B_{\mathrm{t}} = \sum_{i=1}^{n} w_{\mathrm{ti}} \times \frac{d_{\mathrm{I}}}{n} \quad (1)$$

Where:

$\sum_{i=1}^{n} w_{\mathrm{ti}}$ sum of the crown biomass of sample trees (in terms of tons),

d_{I} density of the Lebanon oaks in the investigated stand,

n the number of the sample trees (n=48).

± 95% probable limit of error (PLE), equivalent to half of the confidence interval, was calculated with the use of Eq. [2]:

$$\mathrm{PLE} = \frac{tS}{\sqrt{n}} \quad (2)$$

Where:

t student's t,

S the standard deviation,

n the number of the samples (Batcheler and Craib 1985).

After plotting the crown biomass versus the biometric parameters, five simple regression equations including linear ($y = c + \alpha x$), quadratic ($y = c + \alpha x^2 + \beta x$), multiplicative ($ln y = c + \alpha ln x$), exponential ($ln y = c + \alpha x$) and sigmoid ($ln y = c + \alpha / x$) were tested between the independent and dependent variables. The independent variables (x) include the DBH, tree height, crown length, crown width, and the number of Bakhes, while the dependent variable (y) is the crown biomass. Moreover, α and β are the regression coefficients, and c is the interception of the line with the y axis (Zar 1996). To predict the biomass of crowns, leaves and branches, a multiple stepwise regression approach was employed with the use of different combinations of biometric parameters. The adjusted coefficient of determination (R^2_{adj}), the root mean square error (RMSE), and the relative RMSE (RMSE%) were calculated, and (R^2_{adj}) was tested for significance. The appropriate equations with smaller values of RMSE and RMSE% and higher values of (R^2_{adj}) were selected and reported in the Result section. We excluded from our calculations any data point with the studentized residual, i.e. the ratio of the residual to its standard error, larger than ±3 (Cole and Evel 2006; Návar 2009), and recalculated the parameters of the equation. In the present study, statistical analyses were carried out with the use of SPSS 19.

3. Results – *Rezultati*

The descriptive statistics of the biometric parameters and the crown biomass of the sample trees are shown in Table 1. The average DBH and height of these trees were 28.1 and 9.5 cm, respectively. The average crown biomass at the level of sample trees is 16.5 kg (ranging between 2.4 and 41.4 kg), 13.1 kg of which is from branches (ranging between 2.0 and 31.8 kg), and the rest from leaves (ranging between 0.4 and 12.1 kg). The average number of the Bakhes ob-

Table 1 Descriptive statistics of Lebanon oak sample trees ($n = 48$)

Tablica 1. *Deskriptivna statistika uzorkovanih stabala libanonskoga hrasta (*n *= 48)*

	DBH	TH	CL	CW	BN	CB	BB	LB
Mean – *Aritmetička sredina*	28.1	9.5	6.5	3.8	8	16.5	13.1	3.4
Range – *Raspon*	36.4	8.4	9.1	8.9	20	39.0	29.8	11.7
Maximum – *Maksimum*	49.4	12.9	10.6	9.6	22	41.4	31.8	12.1
Minimum – *Minimum*	13.0	4.5	1.5	0.7	2	2.4	2.0	0.4
S. D.	8.51	1.82	2.05	2.16	4.40	9.25	7.32	2.36
S. E.	1.23	0.26	0.30	0.31	0.64	1.33	1.06	0.34

DBH (diameter at breast height), cm – *DBH (prsni promjer)*, cm
TH (tree height), m – *TH (visina stabla)*, m
CL (crown length), m – *CL (duljina krošnje)*, m
CW (crown width), m – *CW (širina krošnje)*, m
BN (Bakhe number) – *BN (svežnjevi krošanja)*
CB (crown biomass), kg – *CB (masa krošanja)*, kg
BB (branch biomass), kg – *BB (masa grančica)*, kg
LB (leaf biomass), kg – *LB (masa lišća)*, kg
S.D. (standard deviation) – *S.D. (standardna devijacija)*
S.E. (standard error) – *S.E. (standardna pogreška)*

tained from pollarding the crown of each tree is 8, within the range from 2 to 22. We estimated the crown, branch, and leaf biomass of Lebanon oak at the stand level to be 4.98±0.81, 3.94±0.64, and 1.04±0.21 ton ha^{-1}, respectively (95% confidence interval).

The regression equations of the tree parameters and crown biomass, and its components, are shown in Table 2. All of these equations were highly significant (p<0.001). The simple regression relationships between the crown biomass and biometric parameters are illustrated in Fig. 2 (*a, b, c* and *d*). R^2_{adj} of these equations varies from 0.51 (*a*) to 0.57 (*d*). Eq. (*e*), which represents the relationship between the number of Bakhes and the crown biomass, has a high value of R^2_{adj} and a small RMSE.

The results of multiple regression show better goodness of fit than the results obtained by simple regression, as the crown biomass was estimated with the use of two parameters – the crown width and tree height (*f* in Table 2). The regression equation for estimating the branch biomass was also calculated in the same way (*g* in Table 2); however, in this case, R^2_{adj} was slightly lower and RMSE higher than the previous one. But, as compared with relationships f and g, the predictor parameters for the estimation of the leaf biomass in equation h were different, and in general, the leaf biomass is less predictable than the crown and branch biomasses (R^2_{adj} = 0.54, RMSE% = 43.78).

4. Discussion – *Rasprava*

The lack of information along with socio-economic problems place obstacles in the way of providing appropriate management of Zagros forests (Valipour et al. 2009). To the best of our knowledge, the present study is the first research conducted on the crown biomass of Lebanon oak trees in Zagros forests, and it was developed on the basis of destructive samples of individual trees (n=48). Hence, there are no available results of other similar researches in these forests to be compared with our results. The data analysis showed that the crown biomass of Lebanon oak constituting 81.5% of the stand trees is equal to 4.98±0.81 ton ha^{-1} (95% confidence interval), 79% of which is kept in branches, and the rest is in the form of leaves. Using 33 destructive samples of *Quercus brantii* in a study into the southern Zagros' forests, which differ from the northern Zagros' forests due to the impact of the local people, and the type and density of species, Adl (2007) estimated the leaf biomass to be 1 317.3 kg ha^{-1}, which is higher than the value of the leaf biomass we estimated.

The independent variable in relationship e (Fig. 2 and Table 2) is the number of Bakhes obtained from the crowns at the tree level cut by the local people. This variable, counted after the trees were pollarded, is a typical traditional parameter of high capability in predicting the crown biomass (R^2_{adj} = 0.88). A very It should

Table 2 Equation description for the estimation of crown biomass of Lebanon oak

Tablica 2. *Opis formule za procjenu biomase iz krošanja libanonskoga hrasta*

	Allometric equation *Alometrijska jednadžba*	*Coefficients – Koeficijenti*			R^2_{adj}	RMSE	RMSE%
		c (S.E.)	α (S.E.)	β (S.E.)			
a	$ln(CB) = c + (\alpha/DBH)$	3.93 (0.19)***	–32.59 (4.58)***	–	0.51***	7.18	43.37
b	$ln(CB) = c + (\alpha/TH)$	4.48 (0.25)***	–16.53 (2.16)***	–	0.55***	7.10	42.89
c	$ln(CB) = c + \alpha ln(CL)$	0.65 (0.56)**	1.10 (0.16)***	–	0.51***	7.20	43.49
d	$CB = c + \alpha(CW)$	4.45 (1.69)*	2.99 (0.38)***	–	0.57***	5.52	34.44
e	$CB = c + \alpha(BN^2) + \beta(BN)$	–2.09 (1.66)	–0.05 (0.16)*	2.81 (0.36)***	0.88***	2.90	18.09
f	$ln(CB) = c + \alpha(CW) + \beta ln(TH)$	–0.85 (0.60)	0.11 (0.03)**	1.38 (0.30)***	0.65***	5.96	35.99
g	$ln(BB) = c + \alpha(CW) + \beta ln(TH)$	–1.14 (0.61)	0.10 (0.03)**	1.42 (0.30)***	0.64***	4.99	38.06
h	$LB = c + \alpha(CW^2) + \beta ln(CL)$	–0.22 (1.13)	0.06 (0.01)***	1.25 (0.67)	0.54***	1.45	43.78

The statistical analyses are significant at 95% confidence interval (***$p<0,001$; **$p<0,01$; *$p<0,05$; and non-significant) – *Statistička je analiza značajna za interval pouzdanosti od 95 % (****p*<0,001; ***p*<0,01; **p*<0,05; nije značajan)*

nsp>0,05,

RMSE (root mean square error), kg – *RMSE (srednja pogreška korijena)*, kg

RMSE% (relative RMSE) – *RMSE % (relativni* RMSE)

CB (crown biomass), kg per tree – *CB (masa krošnje)*, kg *po stablu*

BB (branch biomass), kg per tree – *BB (masa grančica)*, kg *po stablu*

LB (leaf biomass), kg per tree – *LB (masa lišća)*, kg *po stablu*

DBH (diameter at breast height), cm – *DBH (prsni promjer)*, cm

TH (tree height), m – *TH (visina stabla)*, m;

CL (crown length), m – *CL (duljina krošnje)*, m

CW (crown width), m – *CW (širina krošnje)*, m

BN (Bakhe number) – *BN (svežnjevi krošanja)*

be noted that the local people, experts at traditional pollarding, could predict, with an acceptable accuracy, the obtainable number of Bakhes from pollarding a tree before cutting off the crown, just by seeing the crown spread area and the diameter of each tree.

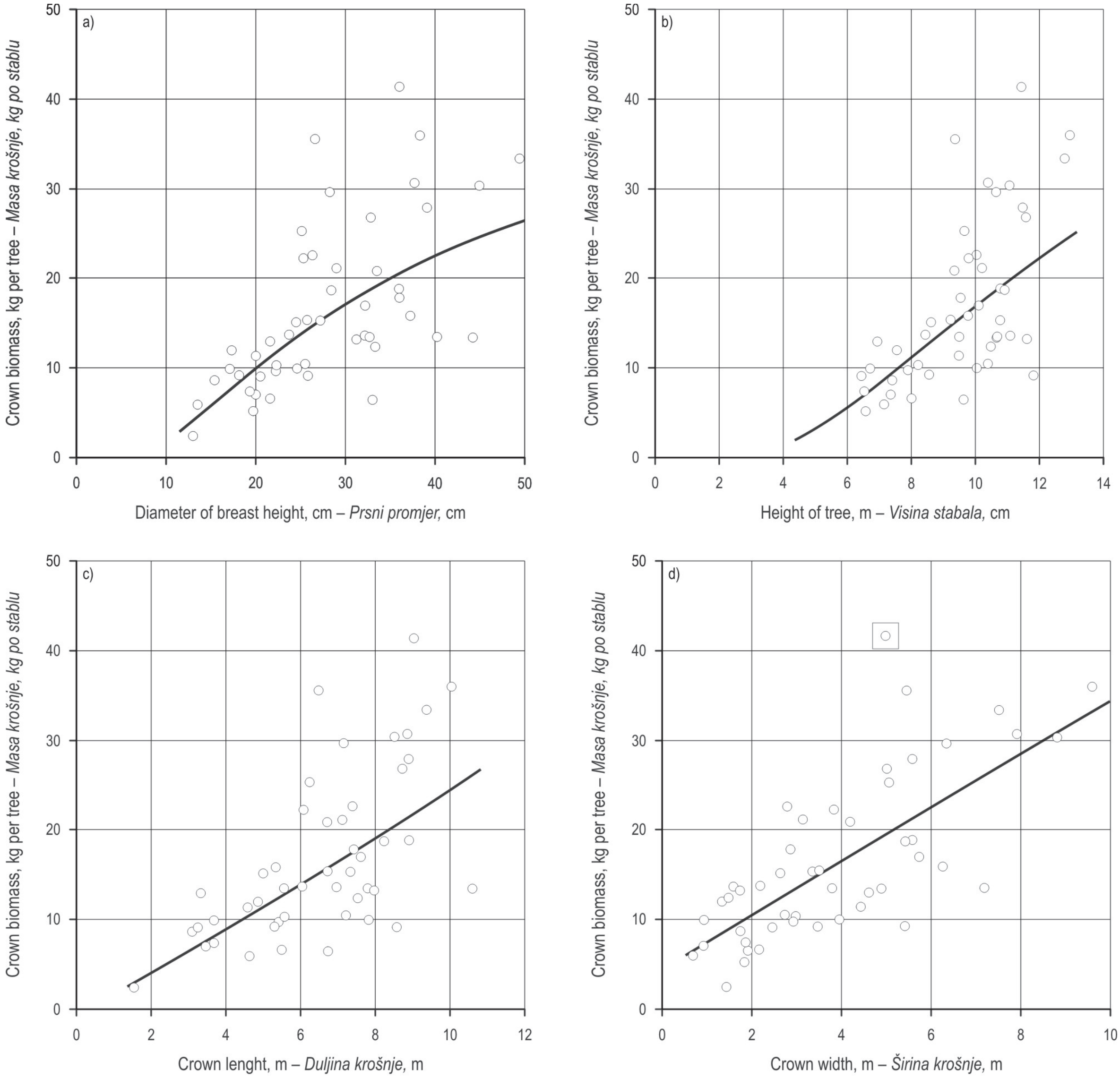
DBH has been used in most studies conducted on allometric relationships as a common parameter for predicting the crown, branch and leaf biomass (Bartelink 1997; Son et al. 2004; Mitsopoulis and Dimitrakopoulos 2007; Singh et al. 2011; Zečić et al. 2011). However, in the present study, this parameter is less capable of predicting the crown biomass (R^2_{adj} = 0.51). Among simple regression equations, linear equation d, which describes the relationship between the crown width and the crown biomass, was more acceptable. By adding the height as another variable, a better goodness of fit for the estimation of the crown and branch biomass was observed (*f* and *g* in Table 2). However, the crown width and length were more suitable for predicting the leaf biomass, which is less predictable (*h* in Table 2).

All the obtained equations were highly significant (p<0,001); however, even through quite a number of biometric parameters were used, we were not able to estimate very accurately the biomass of crown or its components; this can be due to different reasons, and some of them are as follows:

⇒ the upper structure, i.e. the crown of a tree and the crown geometry (as compared to stem) are influenced by individual tree habitat (microclimate and competition with neighbors), resulting in large variability at this level from tree to tree, and then making it difficult to predict the crown biomass (Sawadogo et al. 2010). Generally speaking, in some species, the predictability of small components like branches and leaves is less accurate than that of larger components (Návar 2009; Sawadogo et al. 2010; Blujdea et al. 2012),

⇒ the poorer predictability for some species could be the result of their intrinsic physical structure due to their genetic behavior (Sawadogo et al. 2010),

⇒ the high dependence of forest dwellers on the forest, and the process of cutting the crowns off the trees in short time intervals have brought all the trees of either small or large diameters to have branches younger than 4 years.



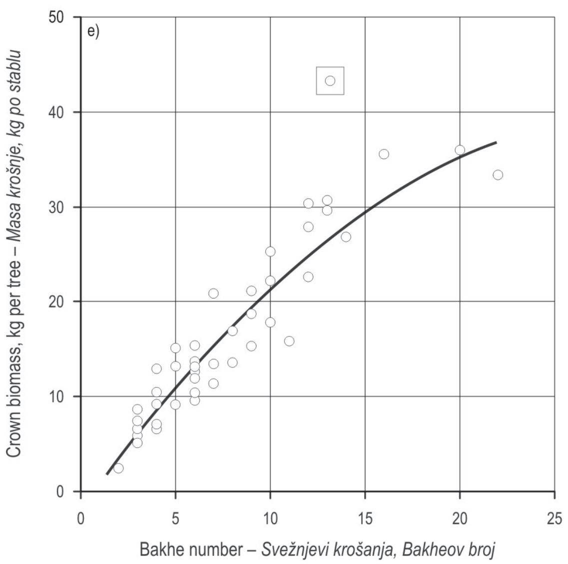


Fig. 2 Allometric relationships of the crown biomass to tree parameters such as DBH (*a*), tree height (*b*), crown length (*c*), crown width (*d*) and the Bakhe number (*e*). In relationships d and e, the studentized residuals of the data points enclosed in squares are higher than ± 3, and hence, they were omitted from our calculations

Slika 2. *Prikaz alometrijske povezanosti biomase krošanja stabala s ovim parametrima: prsnim promjerom stabla (*a*), visinom stabla (*b*), duljinom krošnje (*c*), širinom krošnje (*d*) i brojem svežnjeva krošanja tzv. Bakheov broj (*e*)*

Therefore, the highly significant relation between the tree age and the crown biomass (Socha and Wezyk 2007) could be changed, and highly accurate predictions of the crown biomass become more difficult. Though the exact effects of the traditional forest management are not known, it can be seen that this management influences the forest structure and tree characteristics (Valipour et al. 2009). The results of this study can be helpful in appraising the crown biomass of Lebanon oaks in the study area, and may also prove useful for planning to replace the traditional management with the sustainable forest management. The future researches should focus on comparing the biomass of crown and other components of trees in these forests with the biomass of those components of trees in other stands of these forests, which are less influenced by the local people, so that the effects of traditional impact on biomass of the northern Zagros' forests can be comprehensively understood.

5. Conclusion – *Zaključak*

In the present study, the crown biomass of Lebanon oak was estimated at the stand level, and the allometric relationships were presented at the tree level for calculating the crown biomass on the basis of biometric parameters. The value of R^2_{adj} in the obtained relations varied between 0.51 and 0.65. On the basis of the results of this study, policy makers in forest management can take effective new measures to improve the traditional way of forests harvesting or can evaluate the feasibility of the replacement of other energy resources with leaf and branch biomass. In view of the fact that these forests are affected by traditional pollarding in short-term periods, in order to make use of the information gained through the present study on a larger scale, the traditional management and the level of the agreement between the existing conditions in these forests and other habitats of Lebanon oak should be considered.

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6. References – *Literatura*

Adl, H. R., 2007: Estimation of leaf biomass and leaf area index of two major species in Yasuj forests. Iranian Journal of Forest and Poplar Research 15(4): 417–426.

Bartelink, H. H., 1997: Allometric relationships for biomass and leaf area of beech (Fagus sylvatica L.). Annals of Forest Science 54(1): 39–50.

Batcheler, C. L., Craib, D. G., 1985: A variable area plot method of assessment of forest condition and trend. New Zealand Journal of Ecology 8: 83–95.

Blujdea, V. N. B., Pilli, R., Dutca, I., Ciuvat, L., Abrudan, I. V., 2012: Allometric biomass equations for young broadleaved trees in plantations in Romania. Forest Ecology and Management 264: 172–184.

Brown, J. K., 1978: Weight and density of crowns of Rocky Mountains conifers. United States Department of Agriculture Forest Service, Intermountain Forest and Range Experiment Station, Research Paper INT-197, Ogden, UT.

Burger, D. M, Delitti, W. B. C., 2008: Allometric models for estimating the phytomass of a secondary Atlantic Forest area of southeastern Brazil. Biota Neotropica 8(4): 131–136.

Cienciala, E., Apltauer, J., Exnerová, Z., Tatarinov, F., 2008: Biomass functions applicable to oak trees grown in Central-European forestry. Journal of Forest Science 54(3): 109–120.

Cole, T. G., Evel, J. J., 2006: Allometric equations for four valuable tropical tree species. Forest Ecology and Management 229 (1–3): 351–360.

Ebrahimi-Rastaghi, M., 2001: The rule of baneh (Pistacia atlantica) in management of beyond northern Iranian forests. Technical Report. Forest and Rangeland Organization, Tehran, Iran. 23 pp.

Ghazanfari, H., Namiranian, M., Sobhani, H., Mohajer, R. M., 2004: Traditional forest management and its application to encourage public participation for sustainable forest management in the northern Zagros mountains of Kurdistan province, Iran. Scandinavian Journal of Forest Research 19 (Supp 004): 65–71.

Jazirei, M. H., Ebrahimi-Rastaghi, M., 2003: Silviculture of Zagros forest. 1rd edn., University of Tehran Press, Tehran, Iran, 560 p.

Khosravi, S., Namiranian, M., Ghazanfari, H., Shirvani, A., 2012: Estimation of leaf area index and assessment of its allometric equations in oak forests: Northern Zagros, Iran. Journal of Forest Science 58(3): 116–122.

Mitsopoulos, I. D., Dimitrakopoulos, A. P., 2007: Allometric equations for crown fuel biomass of Aleppo pine (*Pinus halepensis* Mill.) in Greece. International Journal of Wildland Fire 16(5): 642–647.

Moradi, A., Oladi, J., Fallah, A., Fatehi, P., 2010: An evaluation of the capability of IRS-P6 data for monitoring pollarding forest areas of northern Zagros (Case study: Kurdistan, pollarded forests of Baneh). Journal of Agricultural Science and Technology 12: 299–308.

Návar, J., 2009: Allometric equations for tree species and carbon stocks for forests of northwestern Mexico. Forest Ecology and Management 257(2): 427–434.

Nelson, B. W., Mesquita, R., Pereira, J. L. G., de-Souza, S. G. A., Batista, G. T., Couto, L. B., 1999: Allometric regressions for improved estimate of secondary forest biomass in the central Amazon. Forest Ecology and Management 117(1–3): 149–167.

Sawadogo, L., Savadogo, P., Tiveau, D., Dayamba, S. D., Zida, D., Nouvellet, Y., Oden, P. C., Guinko, S., 2010: Allometric prediction of above-ground biomass of eleven woody tree species in the Sudanian savanna-woodland of West Africa. Journal of Forestry Research 21(4): 475–481.

Singh, V., Tewari, A., Kushwaha, S. P. S., Dadhwal, V. K., 2011: Formulating allometric equations for estimating biomass and carbon stock in small diameter trees. Forest Ecology and Management 261(11): 1945–1949.

Socha, J., Wezyk, P., 2007: Allometric equations for estimating the foliage biomass of Scots pine. European Journal of Forest Research 126(2): 263–270.

Son, Y., Park, I. H., Yi, M. J., Jin, H. O., Kim, D. Y., Kim, R. H., Hwang, J. O., 2004: Biomass, production and nutrient distribution of a natural oak forest in central Korea. Ecological Research 19(1): 21–28.

Starr, M., Hartman, M., Kinnunen, T., 1998: Biomass functions for mountain birch in the Vuoskojärvi Integrated Monitoring area. Boreal Environment Research 3: 297–303.

Valipour, A., Namiranian, M., Etemad, V., Ghazanfari, H., 2009: Relationships between diameter, height and geographical aspects with bark thickness of Lebanon oak tree (Quercus libani Oliv.) in Armardeh, Baneh (Northern Zagros of Iran). Research Journal of Forestry 3(1): 1–7.

Valipour, A., Ghazanfari, H., Namiranian, M., Shakeri, Z., 2011: Lack of regeneration and sustainability crisis of northern Zagros forests of Iran. Development on the margin conference, Bonn, October 5–7, Germany.

Zar, J. H., 1996: Biostatistical analysis, 3rd edn. Prentice-Hall Inc. New Jersey, USA, 662 p.

Zečić, Z., Vusić, D., Štimac, Z., Cvekan, M., Šimić, A., 2011: Aboveground Biomass of Silver Fir, European Larch and Black Pine. Croatian Journal of Forest Engineering 32(1): 369–377.

Zianis, D., Mencuccini, M., 2004: On simplifying allometric analyses of forest biomass. Forest Ecology and Management 187(2–3): 311–332.

Sažetak

Odnos biometrijskih parametara i biomase iz krošanja libanonskoga hrasta na sjevernom Zagrosu u Iranu

Hrastove su šume u blizini gradića Baneh među najvažnijim prirodnim ekosustavima sjevernoga Zagrosa. Zbog siromaštva lokalno stanovništvo siječe krošnje stabala libanonskoga hrasta koje im potom služe kao stočna hrana. Postupak pridobivanja krošanja stabala je sljedeći: svaki šumovlasnik podijeli šumu u tri do četiri dijela te svake godine u kolovozu na pojedinom dijelu šume kreše grane cijele krošnje stabala. Potkresane se grane slažu u svežnjeve tzv. Bakheove svežnjeve. Svežnjevi se pohranjuju i koriste zimi za prehranu stoke.

Istraživanje se bavi mjerenjem biomase dobivene iz krošanja libanonskoga hrasta te uočava alometrijsku povezanost određenih parametara stabla s krošnjom stabla, a sve radi buduće procjene biomase iz krošanja. U tu je svrhu 48 stabala nasumično odabrano te su izmjereni neki od biometrijskih parametara poput prsnoga promjera, visine stabla, duljine i širine krošnje stabala. U kasno ljeto, nakon što je lokalno stanovništvo okresalo grane krošanja te ih složilo u tzv. Bakheove svežnjeve, svežnjevi su vagani. Uzeti su uzorci lišća i grana koji su također vagani te je izmjeren sadržaj vlage. Uzorci su potom sušeni 48 do 72 sata na temperaturi od 80 °C i ponovno vagani.

Analiza podataka pokazala je da biomasa iz krošnje stabala libanonskoga hrasta predstavlja 81,5% dijela stabala i iznosi 4,98 ± 0,81 tona po hektaru (95 % interval pouzdanosti), 79 % otpada na grane, a ostatak je sačuvan u lišću. Sve su dobivene jednadžbe signifikantne (p < 0,001), a prilagođeni koeficijent determinacije bio je u rasponu od 0,51 do 0,65. Međutim, primjenom brojnih biometrijskih parametara i njihova usporedba ipak nije olakšala procjenjivanje biomase krošanja stabala. Lako mjerljivi prsni promjer stabla kao jedan od parametara nije pokazao visoku korelaciju s razvojem krošnje i njezine biomase. Najprikladnija povezanost dobivena je između širine krošnje i visine stabla, kao nezavisnih varijabli, s biomasom iz krošnje stabla kao zavisnom varijablom (= 0,65). Regresijska jednadžba za procjenu biomase iz grana također je izračunata na isti način, međutim, u ovom slučaju, bila je nešto niža od *prethodne. Širina i duljina krošnje stabala pokazale su se kao pogodniji parametri za predviđanje biomase iz lista, što je i teže procjenjiva značajka od procjenjivanja biomase iz krošnje odnosno grana. Rezultati ovoga istraživanja mogu biti od pomoći u procjeni biomase iz krošanja stabala libanonskoga hrasta istraživanoga područja te pri planiranju održivoga gospodarenja šumama.*

Ključne riječi: alometrijska povezanost, biomasa, krošnja stabala, libanonski hrast, sjeverni Zagros

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