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Allometry of Rash (*Fagus orientalis*) in Caspian Forests of Northern Iran (Case Study: Gonbad Region)

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Abstract: With allometric knowledge and by using the regression relationships could achieve the relationship between diameters at breast height with other quantitative sizes. In present study, the biomass on the earth of East Beech trees *Fagus orientalis Lipskys* at parcel 206 Series 2 Jomand forest at Golband area was estimated. Initially 8 trees based on research method were select and quantitative and qualitative measurements were done and were discontinued. Then pieces of the trunk and branches of trees, for example, were selected and after evaluation of the quantitative data from all parts of their trunks and branches were extended. By the regression relationship between trunk diameter at breast height with dry trunk wood, dry weight of trunk skin, dry weight of branches, total dry weight of the trunk and branches and also relation of diameter at breast with trunk volume, trunk skin volume and trunk wood volume was fit with very good correlation. Finally, using these relations, the total biomass in Beech trees plot and their biomass per hectare evaluated. Relation of diameter at breast with total dry weight of the trunk and branches y = 0.1731x2.3 were fitted with R2 = 0.9925. Using this relationship, ground biomass of beech trees in the plot, 34671.69 kg equal 69343.38 kg per hectare was estimated. The relationship of diameter at breast with trunk volume, y = 0.0002x2.3505 with R2 = 0.9863 were fitted. By using this relationship, trunk volume, was estimated 149.19 cubic meters per hectare. The average diametrically growth from 1380 to 1384 (5 years) were 1.41 cm, which is based on relationships obtained in plan, can receive that the biomass on Earth on 1380 equivalent to 65.7 t/ha which to 1384 (next 5 years) 3.6 tons per hectare increased and an average in recent 5 years 0.7 t/ha in the biomass on Earth is increased. Provided that the average diametrically growth in the next year and coming year remain with same constant amount, we can expect that the biomass on Earth of beech masses annually 0.7 t/ha increases.

Key words: Allometry · Biomass on ground · Diameter at breast · Beech

INTRODUCTION

Human for a long time required forest and its services and it is supplied needs such as the need for fuel, hunting, medicine, etc.

Today although the increase in population and consequently the modern civilized life, to provide such requirements human need to know the forest is less than the past, but in addition to the needs, other important values such as environmental values of forests in soil and water conservation, CO_2 absorption, reducing noise pollution and the economic value are found and trying to find a way to measure these values and enhance the economic value of forests and in short, having detailed knowledge of the forests for sustainable forest management.

And even some scientists in this field, accurate estimates off forest biomass for forest development budgets known as necessary.

For this allometry, one of the useful methods to estimate the biomass on Earth was developed and implemented. In this scheme by measuring equal diameter at breast and with using regression relationship body dry weight and tree branches is obtained.

Descriptive information, status and growth of the mass production can predict the future and in plans, could show the amount of tonnage and standing volume per hectare.

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This plan was implemented on East Beech that results will be described later.

Research Background: Extensive research and studies have been conducted in allometry. It will include the following:

Harrington RA, Fownes SH. (1992) [1] carried out the allometry study on multipurpose four species of tropical *Eucaliptus camaldulensis*, *Acasaauri culiformis*, *Coliricidia sepium*, *Leucaena divercifolia*. So that by measuring the diameter, other data calculated from regression equations and is easily measured.

Siccama T (2003) [2] did allomrtry study on the *Sassafras albidum* and obtained the regression relationship.

Olesen T (2001) [3] in geometric and comprehensive description of carbon storage potency (asymmetry) of *Atherospermam oschatum* species crown in the forest canopy has used allometric analysis to evaluate factors affecting the Crown geometric relationships.

Stuth J (1997) [4] in the considering of range hybrid models, is addressed the allometry of the large number of woody species that have a major role on the regional climate change.

Makela A, Vanninen P (1998) [5] were studied the Effects of tree size and their competition on the form and biomass distribution the ground of *Pinus sylvestris*. This is the rate of most of the trees structure to young age trees that have been affected by competition. They found that in this comparison, crown allometric ratios is almost equal but differences in crown size and eventually the leaf and shoot biomass of these two data series are observed.

Mary A Arthur, Steven P (2001) [6] with comprising the three plots 0.25 Acres of broad-leaved forests of northern Canada, between alometric and direct measurement of biomass on earth, found that there is no significant differences between allometric estimates and direct measurements of biomass on Earth and accurate of allometric method for estimating biomass on the ground has proved.

Niklas Karl J (1998) [7] does some comparisons between the biomass determination and specific distribution of some parts of pychan buds and petrydofits and zhymnosperms. For this purpose specific allometry for leaf and stem biomass production for a total of 12 pychan anzhiyosperm, zhymnospermsand petrydofits species was done and found that pychanallometry is very similar to petrophytes.

Zianis D, Mencuccini M (2002) [8] has been studied the biomass ratios on the Earth of *Fagus moesiaca* trees and eventually general equations for *Fagus* sp*Vermio* Mountains in northern Greece. He had stated that the equal diameter at breast represent the many variables, including total trunks biomass on earth, stems and branches and after equal diameter at breast, height known as the second reagent to estimate biomass, especially shoot biomass. After testing, the general equations for Fagus sp based on other data from several previously published data are developed and confirm their accuracy.

Zianis D, Mencuccini M (2004) [9] has been studied three methods of facilitate the analysis and allometric analysis to estimate the biomass on Earth. And have stated that this study is important because the biomass of trees has a major role in the sustainable management of forests to store carbon estimation.

O `Bbrien ST (1996) [10] has done allometry of 50 trees and shrubs species of Panama area. He obtained the log-linear regression data for each of these species, such as trunk diameter, height, crown starting height and crown area. He found that the diameter at breast had a high correlation with height (R^2 +0.92 p <0.0001,), the Crown area (R^2 = 0.88, p <0.0001) and the crown starting height (R^2 = 0.74, p <0.0001).

TeamBOREAS TE-06 (2004) [11] were collected various information from many of the characteristics of plant biomass, biometry, allometry, leaf area, soil CO_2 and ... for Boreal plants. These data include measurements of parts trees of which includes ground biomass on Boreal areas during the vegetative period between 1994 and 1995 and result in allometric equations and ratios for this region.

David A. King (1991) [12] has done allometry of trees, leaf size and the size of mature trees in older forests of West Oregon State (Oregon) in Massachusetts. His study included under canopy species, upstairs, evergreen broadleaf, deciduous and evergreen trees have needle leaves.

Fownes JH, Grace KT (1998) [13] carried out the allometry of leaf area and evaluate the estimation of total intact and without damage parts leaf surfaces and grazing induced degradation in Sylvepscher system. He studied the *Acasiakoa* and believes that this method is a low-cost method for accurately estimating the changes in tree leaf area that is under control.

Son Y *et al* (2001) [14] investigated the allometry and biomass of *Pinus koaiensis* in natural forests in Korea and mixed deciduous forest and also in seven age classes of forest planting in the center of the Korea have done.

Regression dry weight, trunk skin, trunk wood, branches and needles of needle leaves with diameter at breast and Log pattern matching (10) Y = a + b Log (10) X is obtained. *Pinus koaiensis* biomass in natural mixed forests were 118 tons per ha and biomass in forest plantings in a range from 52.3 t/ha for 11 - 20 years old masses to 317.9 t/ha for 71 - 80 years old masses.

MATERIALS AND METHODS

Materials

Geographical Characteristics of Area: The study area is located on Parcel 206 Series 2, Jomand forestry plan in Golband forest. The average highest level of area1580 meters the, the average slope is 30 percent and the general direction is northeast.

The Meteorological Profile: For determining the regional meteorological profile, 20-year average meteorological data from nearest meteorological station, Noshahr station, is used.

The average annual rainfall in Noshahr station is 1300 mm. The rainy season, autumn, 633 mm with most rain and low rain seasons, spring rainfall is 134 mm.

The average annual temperature is 16 degrees centigrade. The most cold month, January with temperatures 7°C and the hottest month of year is August with average temperature is 25.5 degrees Celsius.

The average relative humidity 83.6 percent, lowest relative humidity is 81.2 percent in July and most relative humidity is 85.6 percent in March.

The average total of sunshine hours in the spring is 548.4 hours, in summer is 535.2 hours, in autumn is 392.2 hours and in winter is 342.8 hours.

Based on this data, ambrothermic curve of the study area using the thermal gradient and the statistics Noshahr weather station is below.

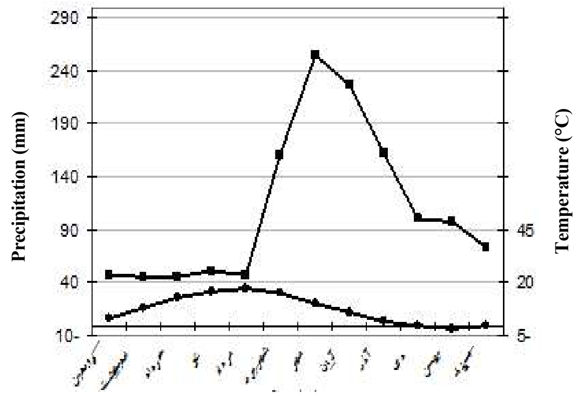

Fig. 1: Ambrothermic curve of study area using a thermal gradient and Statistics Noshahr stations (1365-1381)

Pedological Properties of Area

The Botanical Characteristics of Area: Forest type of under study section is Beech Forest.

Other species of tree and area shrubs can be cited in Ilex and *Rubus* SP and *Carpinus betulus* and *Alnus subcordata*.

Characteristics of the Studied Species: Beech tree, *Fagus orientalis Lipsky* incidence in the Alborz Mountains and can be seen in highlands of Astara and Deylaman to Kelardasht and Noor and Kojur and Gorgan. It can be rise from 80 meters height to 2200 meters above sea level in Palang Chaal Noshahr.

Table 1: Pedological properties of area based on sampling and testing are in the below table.

Characteristic	A horizon	B horizon	C horizon
Depth (cm)	10	10-45	>45
Saturation percent	76	40	40
Electrical conductivity(mz/s)	0/57	0/23	0/21
Total saturation acidity (pH)	5/65	5/53	5/61
Percentage of neutral respondents %T.N.V	0	0	0
Gypsum (Caso4) m.e/100	0	0	0
Organic Carbon Percent	2/25	0/3	0/1
Total Nitrogen Percent	0/2	0/2	0/009
Absorbable Phosphorous p.p.m	25	3/6	0/8
Absorbable Potassium p .p .m	380	110	170
Sand Percent	48/16	54/16	44/16
Silt Percent	34	24	24
Clay Percent	17/84	19/84	31/84
Texture Type	Loam	Loamy Sandy Clay	Clay Loam

Beech is tall tree and reaches a height of 35 meters and even trees with 50 meters are named. Its crown is oval or cylindrical and its trunk skin is smooth and the color of the Philippines. The egg-shaped buds are drawn and sharp golden spindle length is 2 cm.

Methods: In the present research project method consists of three stage including field operations, laboratory operations and analysis that detail is given below:

Field Operation

Select Study Area: To select the region do this is that with circulation forests, the mass of the species is chosen that have typical and representative base of their community. Then, 80-10 leg for such different age rash masses was selected.

At this stage, the plot area in different age ecosystems is considered about 50 AR.

Leg Selection: Selected legs would in different diametric groups.

- Diametric groups selection for same age mass:(minimum tree diameter is assumed 10 cm) First step) maximum diameter found with measuring and named it X.
- Second step) Changes range or D will count from D=X-10relation.
- Third step) since for same age mass worked on 4 tree,obtain the Y=D/4.
- Forth step) range of each category was calculated according to below table.
- Fifth step) from each diametric category, using systematic random method, one tree was selected.

Note: if the diameter of selected tree is closer to median of category that is in, our selection is better and more accurate.

Pedological Studies: Pedological characteristics of area were determined based on sampling and test.

Plant Community: In this step, rather than forest type determining, floristic list (tree, shrub and herbs separately), reproduction status, estimated mass age, density and rate of mass mixing was determined.

Measuring after Recision: After recision, for sampling, operation is performed on sample that includes inside forest operations and laboratory studies and the following:

Operation Related to Trunk:

- We divide trunks to one meters parts and dice it.
- All parts are numbered and weighted.
- Median diameter of each piece was found.
- Calculate the volume of each piece.
- From end of each segment, a disc with thickness of 5 cm apart and we numbered. (We specify that each disc is related to which one meter piece)
- Discs fresh weight in forest was calculated.
- Discs bring to laboratory.

Operations Related to Branches:

- Initial diameter of all branches was determined.
- From crown bottom to up, we numbered each branch (Figure 1)
- Calculate the diameters mean. Also we find the minimum and maximum diameters, according to tree selection, choose three branches. We supposed that minimum diameter is 2.5 cm.

Then we choose a branch from each category. We also note the number of selected branches.

- In each selected branch, we separately, separate the head branches (branches flexible).
- In forest, separately weight the branches.
- Tree branches are bringing to laboratory.

Live Branches: Branches That in Vegetative Season Have Both Flexible Branches and Leaves:

Dead Branches: Branches that in vegetative season have non flexible branches and no leaves.

Table 2: Category

Category no.	1	2	n	10
Category range	10 _ 10+Y	10+Y _ 10+2Y	10+(n-1)Y _10+nY	10+9Y_ 10+10Y
Category median	(20+Y)/2	(20+3Y)/2	(20+(2n-1)Y)/2	(20+18Y)/2

Table 3: Category

Category no.	1	2	3
Category range	2.5 _ 2.5+Y	2.5+Y _ 2.5+2Y	2.5+2Y _ 2.5+3Y
Category median	(5+Y)/2	(5+3Y)/2	(5+5Y)/2

Dormant Branches: Branches that in vegetative season have flexible branches but no leaves.

Laboratory Operations

Trunk Dry Weight Measures: After the disc of each piece (which was numbered in the forest) was transferred to the laboratory, following the steps to form No. 5 complete was done.

- Disc fresh weight before it is placed in the oven is precisely measured with scale.
- Disks to be dried with a temperature of 85 degrees for 48 hours in the oven and then weighed.
- On each disc in two directions perpendicular (small and large diameter) disk diameter with skin and without skin is measured with a ruler.
- Disc thickness in four directions perpendicular is measured with VERNIEH
- From point on disc that its thickness is equal to the mean thickness, a piece of 10 cm removed from disc skin and Then from proportional relationship between dry weight of the 10 cm piece of disc skin with disc perimeter, skin total dry weight was calculated
- The dry weight of wood is obtained from fractionation of skin dry weight from disc dry weight.
- Diametric growth of the last 5 years measured with VERNIEH and then be averaged.

Analysis and Calculations: After quantitative and qualitative measuring in forest and also performing laboratory operations, according to the results, analysis of crude data was performed. In order to do accurate work, it is necessary to follow procedures and calculations are performed step by step.

Trunk Dry Weight of Tree Calculations: First, using the following relationship, estimate the dry weight of each body parts.

$$Wdb = (wdc. Hb) / Tc$$

Wbd[1] : One meter part dry weight (kg)
Wdc[2] : disc dry weight (kg)
Hb[3] : Precise part length (cm)
Tc[4] : Precise disc thickness (cm)

Branch Dry Weight Estimation and Calculation: Given that we assumed three dead branches, three live branches and three dormant branches as indicator, we should obtain three regression equations (for the dead, living and dormant) between branch diameter and branch dry weight.

For example, in indicator branches of trees (a total of 12 branches), using SPSS and Excel software, we find the appropriate regression equation to estimate the dry weight of other branches using their diameter. Thus, we can estimate the dry weight of each category by using this equation and the initial diameter. When we obtained the dry weight of each branch, together them and calculated the dry weight of branches and perform with following tables.

Regression equation obtained between diameter (X) and branches dry weight (Y)

*First three branches, are measured branches (indicator) that diameter characteristics and dry weight of them previously is obtained. Using the formula calculate the dry weight of other branches.

Plot and Mass Biomass Estimation: After that biomass of each tree was determined, by using regression, we could estimateother trees dry weight only with their diameter at breast. Then collect dry weight of trees in the plot. And we could evaluate biomass stock with very good estimation.

Estimate the Biomass in Each of the past 5 Years: By using the diameter of trees in each of 5 years (counting and measuring the growth of diameter of vegetative circles by VERNIEH) and also selected formula in the above, we can accurately guess how much of the biomass of trees we have been in the last 5 years.

RESULTS

After the eight trees were selected, their quantitative and qualitative profile including diameter at breast, crown diameter, collar diameter, age, height, quality of the trunk, the trunk branched, the location of the crown, the symmetry status of the crown, crown amplitude and health were examined.

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[1] Wbd : dry Weight of bole
[2] Wdc : dry Weight of bole
[3] Hb : Height of bole
[4] Tc : thickness of cookie

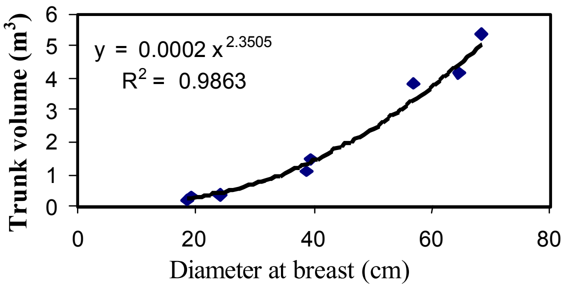

Fig. 2: Evaluation of relationship between trunk volumes with diameter at breast

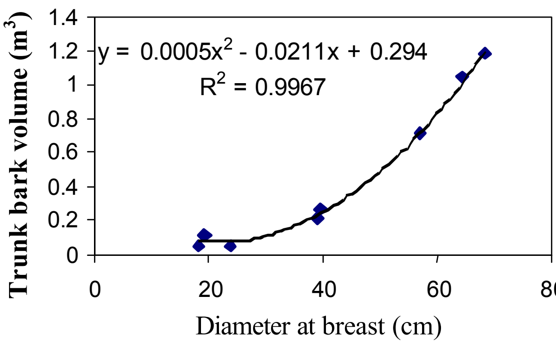

Fig. 3: Evaluation of relationship between trunk bark volumes with diameter at breast

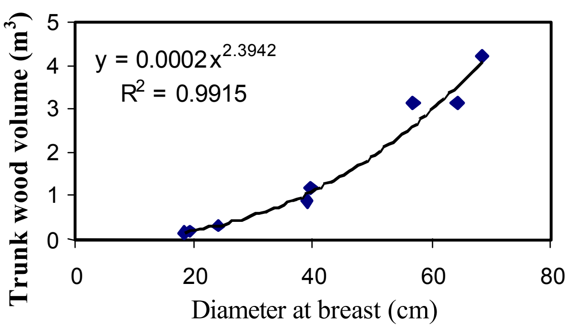

Fig. 4: Evaluation of relationship between trunk wood volumes with diameter at breast

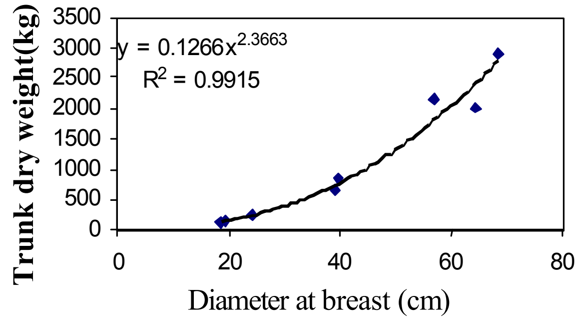

Fig. 5: Evaluation of relationship between trunk dry weights with diameter at breast height

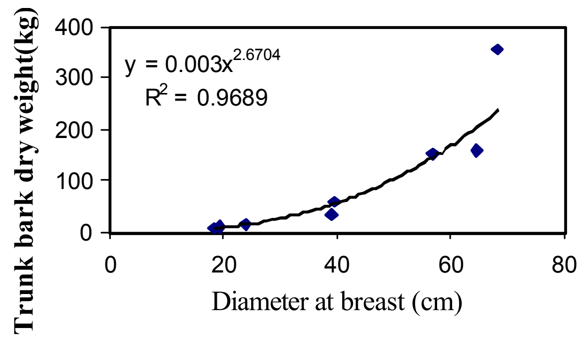

Fig. 6: Evaluation of relationship between dry weights of trunk bark with diameter at breast

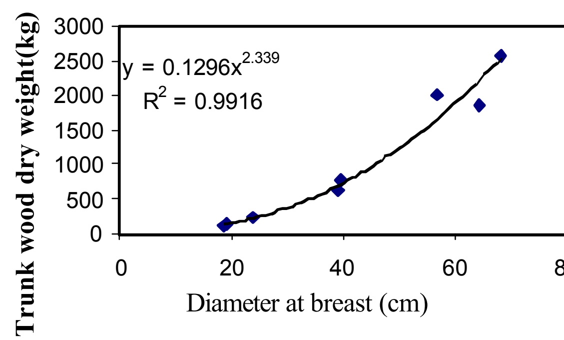

Fig. 7: Evaluation of relationship between dry weights of trunk wood with diameter at breast

Calculation and Evaluation of Trunk Dry Weight: After the trunks was divided into a meter parts and cutting them, all parts have been number and weighed. The middle diameter of each piece in each tree was determined and then calculate the size of each piece and from the end of each piece, we separate a disc with 5 cm thickness and numbered it to drive the information related to discs dry weight that we could extrapolate them to whole body of trunks.

Calculation and Estimation of Branches Dry Weight: According to what was described in the previous chapter three branches of each tree were selected and weighed. This means that data for 24 branches was obtained. Using the data of the 24 branches, regression relationship between branch dry weight and initial diameter of branch to estimate the dry weight of the all other branches were fitted.

By using above equation, dry weight estimation of other trees in the plot could be obtained accurately. Considering that the plot of the area is 50 aar, using a proportional relationship, we obtain the dry weight in hectare of studied area in terms of kilogram in hectare.

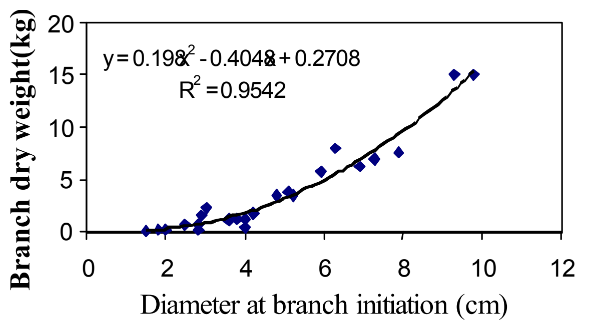

Fig. 8: Evaluation of relationship between branch dry weights with diameter at branch initiation Using the above regression equation dry weight of the other branches could be estimated.

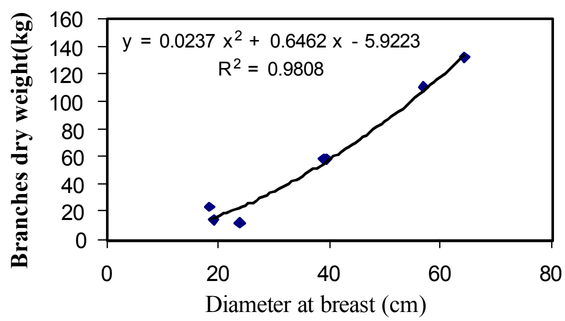

Fig. 9: Estimation the relationshipbetween tree branches dry weight with its diameter at breast

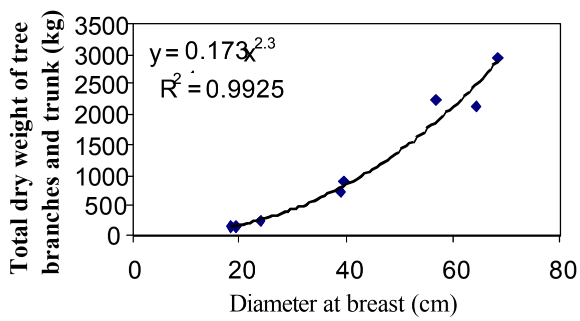

Fig. 10: Estimation the reationship between total dry weight of tree branches and trunk with diameter at breast

Relations Obtained in this Study Are as Follows:

- The relationship between diameter at breast with trunk bark volume is y = 0.0005x2 - 0.0211x + 0.294 with R^2 = 0.9967.
- The relationship between diameter at breast with trunk wood volume is y=0.0002x2.3942 with R^2=0.9915.
- The relationship between diameter at breast with total trunk volume is y=0.0002x2.3505 with R2 = 0.9863.
- The relationship between diameter at breast with trunk bark dry weight is y = 0.003x2.6704 with R^2=0.9689.
- The relationship between diameter at breast with trunk wood dry weight is y = 0.1296x2.339 with R^2=0.9916.
- The relationship between diameter at breast with total dry weight of trunk is y=0.1266x2.3663 with R^2=0.9915.
- The relationship between diameter at breast with branches dry weight is y = 0.0237x2 + 0.6462x- 5.9223 with R^2=0.9808.
- The relationship between diameter at breast with total dry weight of branches and trunk is y = 0.1731x2.3 with R^2=0.9925.

DISCUSSION

Harrington, Fownes (1992) [13] carried out the allometry of 4 multipurpose tropical species including *Eucaliptus camaldulensis*, *Acaisa auriculiformis*, *Coliricidiasepium*, *Leucaena.divercifolia*. So that by measuring the diameter, other data calculated from regression equations and is easily measured.

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Son Y (2001) [14], by the knowledge of allometry, compared the biomass of *Pinus koraiensis* in natural forests with its biomass in seven age classes of forest planting and found that biomass of *Pinus koraiensis* in natural forest 118 ton/ ha and in forest plantation is in the range from 52.3 ton/ha for 11-20 years old stands to 317.9 ton/ha for 71-80 years old masses.

Zianis and Mencuccini (2002) [8] investigated the above ground biomass of *Fagus moesiaca* in northern Greece and finally analyzed the accuracy of equations for biomass estimating for *Fagus* sp.

In Iran, research on allometry of few tree species in northern forest ecosystems including eastern beech *Fagus orientalis* is being done.

The relationships obtained in the last section of chapter estimated results for total beech trees trunk bar volume is almost 30.14 cubic meters per hectare, the total volume of trunks wood is 119.05 cubic meters per hectare, total volume of the trunks 149.19 cubic meters per hectare, dry weight of trunks barks is 5.85 tons per hectare, dry weight of trunks wood 61.1 tone/ha and total dry weight of branches is 2.33 tons per hectare.

Accordingly, the ground biomass of beech species in Golband forests can be estimated 69.34 tone/ha.

The average diametric growth of stand from 1380 to 1384 (5 years) 1.41 cm, which on using equation 8, we can get the above ground biomass in the 1380 equivalent to 65.7 tone/ha that to 1384 (5 years) enhanced 3.6 tons per hectare and an average of last 5 years is 0.7 tons per hectare in the above ground biomass. Provided that the average diametric growth in the next year and coming years remain with the constant amount, can expect that above ground biomass of rash increases 0.7 tone/ha annually.

Equations obtained from the diameter at breast and other studied variables, stands were selected stepwise and in all obtained relationships between diameters at breast with other variables grade 2equations showed the highest correlation coefficient so that mean R^2 in these relationships are more than 0.98 that shows a very good correlation between these relationships.

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