ISSN: 0976-3104
REGULAR ISSUE
Askari et al.

THE IIOAB JOURNAL

ARTICLE OPEN ACCESS

COMPARISON BETWEEN ABOVE- AND BELOW-GROUND BIOMASS AND CARBON STOCKS OF *QUERCUS BRANTII* IN CENTRAL AND SOUTH ZAGROSIAN FORESTS

Yousef Askari[1], Ali Soltani[2], Reza Akhavan[3], Pejman Tahmasebi Kohyani[2]

[1]*Faculty of Natural Resources and earth Science, University of Shahrekord, Shahrekord, IRAN*
[2]*Faculty of Natural Resources and earth Science, University of Shahrekord, Shahrekord, IRAN*
[3]*Research Institute of Forests and Rangelands, Tehran, IRAN*

ABSTRACT

In this study, we analyzed the above- and below-ground biomass and carbon storage data for 36 trees with diameter ≥5 cm from central and south Zagrosian Forest in Iran. The aim of this research was to estimate the carbon stocks of above- and below-ground biomass in the Zagrosian forest of west Iran. Although Persian oak (Quercus brantii Lindl.) comprises more that 90% of the Zagrosian forests and similarly a major chunk of its woody biomass storage, however the scientific papers about the extent of its above- and below-ground biomass storage per tree and stand are rare. The current study examined proportion of biomass and carbon sequestration quantity in the scale of individual tree, stand and the growing forms, which were: coppice and high-forest. The methodology of harvesting was used to measure the carbon stock of this natural forests. Amount of biomass stored by above- and below-ground per tree which were 252.77, 181.36 for high forest trees and 217.7, 191.02 kg for coppice respectively in central Zagrosian forests (CZF). But this ratio which were 227.77, 170.45 for high forest trees and 197.99, 167.24 kg for coppice respectively in south Zagrosian forests (SZF). Also, the results of this study showed that the average carbon stock in CZF was 26.85 tonnes C /ha for sum above- and below-ground biomass and 21.08 tonnes C /ha for SZF respectively.

.

Received on: 10th-March-2016
Revised on: 18th-April-2016
Accepted on: 26th–April-2016
Published on: 8th –May-2016

KEY WORDS

phalograph (Biomass, Carbon stocks, Quercus brantii, Zagrosian forests

***Corresponding author: Email:** askari.yousef@yahoo.com; **Tel.:** +98-9175432639

INTRODUCTION

In recent years, the estimation of forest carbon stocks has gained prominence due to the role of forests in the mitigation of global climate change through carbon storage in biomass and soil. Estimates of carbon (C) stocks and stock changes in tree biomass (above- and belowground) are required for reporting to the United Nations Framework Convention on Climate Change (UNFCCC) and will be required for Kyoto Protocol (KP) reporting. The Intergovernmental Panel for Climate Change has recently published Good Practice Guidance (IPCC GPG) for the reporting of land use, land use change and forestry activities [1].

This guidance highlights the importance of nationally specific information, regarding a country's forest resources, in order to increase the transparency and verifiability of national C inventories. For countries which have significant amounts of afforestation, deforestation and reforestation, nationally specific information that can be used in the development of C stock and stock change estimates will greatly enhance the quality of greenhouse gas (GHG) reporting to the UNFCCC and its KP. Human activities for reducing atmospheric CO_2 were started when the effects of global warming were specified. After ratification of the Kyoto Protocol, two different actions have been taken for reducing CO_2 emissions: reducing human activities related to greenhouse gas emission; creating and improving carbon sinks in the biosphere by tree plantation [2, 3]. Trees play an important role in reducing CO_2 by absorbing and accumulating it in their leaves, branches, stems and roots as biomass [4]. Biomass has been widely used for carbon cycle studies because it is an important indicator of vegetation growth and dynamic [5]. Forest managers are interested in increasing the productivity of the planted forests and the timber production which accordingly can increase the carbon sequestration rates [6, 7].

THE IIOAB JOURNAL
ISSN: 0976-3104

The estimation of aboveground biomass (AGB) is necessary for studying productivity, carbon cycles, nutrient allocation, and fuel accumulation in terrestrial ecosystems [8]. Biomass estimates take into account the differences in wood density, upper stem dimensions and crown morphology [9].

Oak is a dominant tree species in various types of forest including temperate, subtropical and tropical as well as in some areas of chaparral and scrubland [10]. Persian oak (Quercus brantii Lindl.) covers most of the Zagrosian forests throughout three countries. Its versatile growing forms allow it to be seen in both high-forest and coppice forms in a single site [11]. Trees affected by anthropic activities, trend to grow in coppice form, which comprises more than 80 percent of these forests. This phenotypic plasticity gives in situ observers an opportunity to compare the root-shoot ratio between two growing forms of the Persian oak trees in different tree ages and sizes.

The potential of oak species to reproduce vegetatively, the fact that they frequently have been cut and harvested for many years, and the particular ecological and edaphic conditions in these ecosystems, are the main causes for the domination of coppice stands in the zagros zone.

In this research, we aimed to compare the biomass and carbon storage potential in the above- and below-ground parts of *Quercus brantii* in the two Persian oak growing forms located in central and south Zagrosian forest in west of Iran.

MATERIALS AND METHODS

The study was conducted at a forest in Basht city, Kohgiluyeh and Boyer-Ahmad Province, in south-western of Iran. We selected one of the least disturbed southest Zagrosian forest stands, with the local name of Dahak mountain (30°21'-30°50'N, 50°25'-51°20'E). With an average altitude of 835 m, annual temperature of 26°C and precipitation of 634 mm, the site is categorized as a semi-dry temperate region based on the bioclimatic Emberger's method. The oak forest is located on a silty clay deep brown forest soil with pH 7.87. Persian oak (*Quercus brantii* Lindl.) with almost 90% forest cover is the dominant tree species, creating a vast park-like landscape. Several hawthorn and wild almond species are the companion shrubs and trees. For second area, we selected one of the least disturbed central Zagrosian forest stands, located at the head of the Karoon River, with the local name of Balootboland (31°20'-31°50'N, 49°25'-50°20'W). With an average altitude of 1641 m, annual temperature of 24°C and precipitation of 694 mm, the site is categorized as a semi-dry temperate region based on the bioclimatic Emberger's method. The oak forest is located on a silty clay deep brown forest soil with pH 8.1.

In late spring 2015, and at the same altitude and facing slope, For each area eighteen healthy Persian oak trees were chosen (9 trees of each high-forest and coppice growing forms), in a way that each diameter at breast height (DBH) class for high-forest trees, and crown width (CW) class for coppice trees, had a representative in our selection. The selected trees were cut down and their trunk were detached. In a coppice tree, trunk was limited to the lower part of the tree crown; and in a high-forest tree, it extended across the crown until it couldn't be distinguished [**Figure– 1**]. 30 circular plots were systematically placed at each study site to measure diameter at ground level. The size of sample plots were limited to either 1500 m^2 (radius: 21.85) for measured trees per hectare.

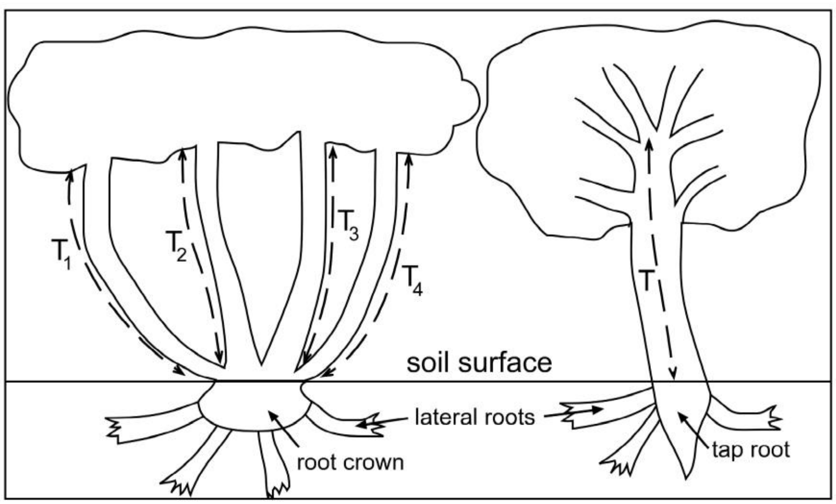

Fig:1. Differences between two Persian oak growing forms. Having several shoots or trunks (T1-T4 in this case) and existence of a major root crown are the characteristic features of a coppice tree (left), and standing on a single trunk (T) as well as a prominent tap root are associated with a high-forest tree. Refer to the text for further details about the meaning of the trunk in this study.

THE IIOAB JOURNAL
ISSN: 0976-3104

Tree crown defoliated manually (foliage) and trunks and major branches were debarked. Small branches with leaf scar (twigs) were also dissected. A CAT excavator was used to create a hole as wide as tree crown peripheral. Stump and all attached underground woody organs (roots) were exhumed and cleaned. The biomass for stump was added to the trunk biomass.

Fresh weight of roots, foliage, twigs, branches (big and small together) and trunks were measured using a battery-powered bascule at the tree location. An appropriate sample size from each above mentioned tree components were stored in a sealed container. These samples were later dried to constant weight at 80°C in lab. The moisture content percentages were then used to calculate the biomass weight for each tree part. A considerable portion from each tree part was also moved to the lab and its total organic carbon was analyzed using the combustion method [12].

One-way analysis of variances was used to test the significant differences in biomass and carbon concentration between different tree parts. A Tukey test were applied to identify significant differences ($P < 0.05$).

RESULTS

Central Zagrosian forests

Figure– 2 shows the amount of the ecosystem trees per hectar from two growing forms of the Dehdez stands. The number of trees per hectar in high forest form which were 66.88 and 62.88 for coppice respectively.

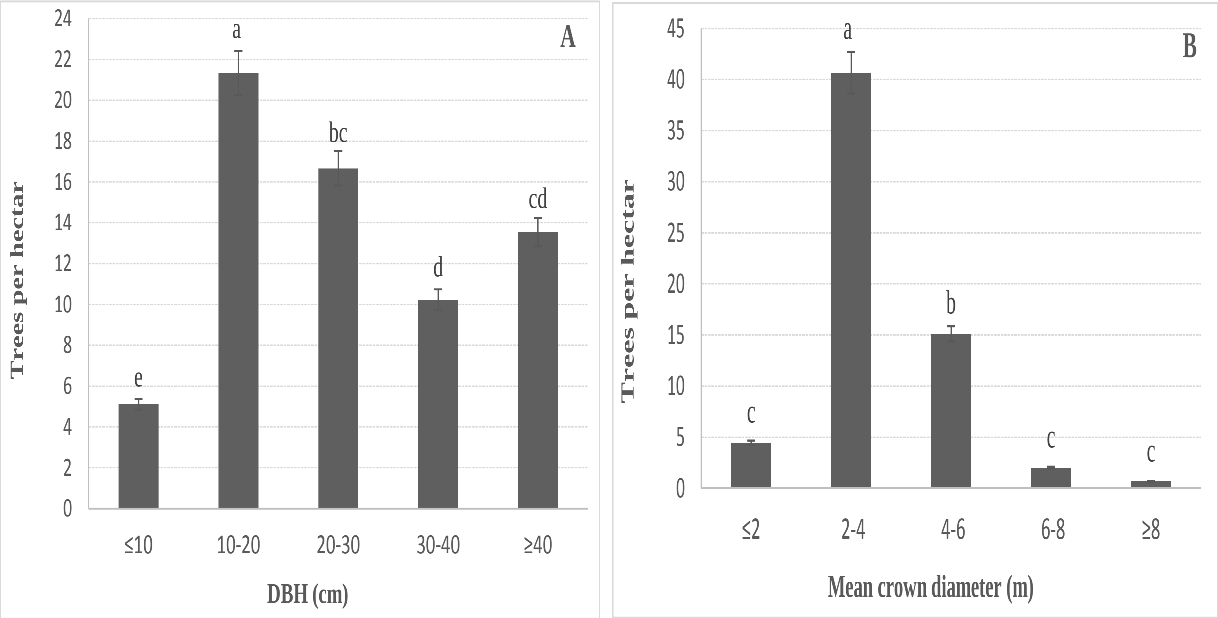

Fig: 2. The average number of trees per hectare in different diameter classes; high forest (A) and coppice (B) trees

Figure– 3 shows the amount of the ecosystem biomass in the trees of the two growing forms. In this study, the ecosystem biomass included the above- and below-ground tree components. The maximum biomass value was found in the above-ground of high forest form (252.77).

The evaluation of the carbon sequestration potential requires careful consideration of the amount of carbon in the tree tissues, which, in most studies, was considered as 50% of the weight of the tree biomass [13]. The present study showed that the carbon concentration is different in the tissues for the two growing forms. **Table– 1** shows Different average biomass and carbon stocks (t C /ha) of above-and below-ground in two growing forms.

THE IIOAB JOURNAL
ISSN: 0976-3104

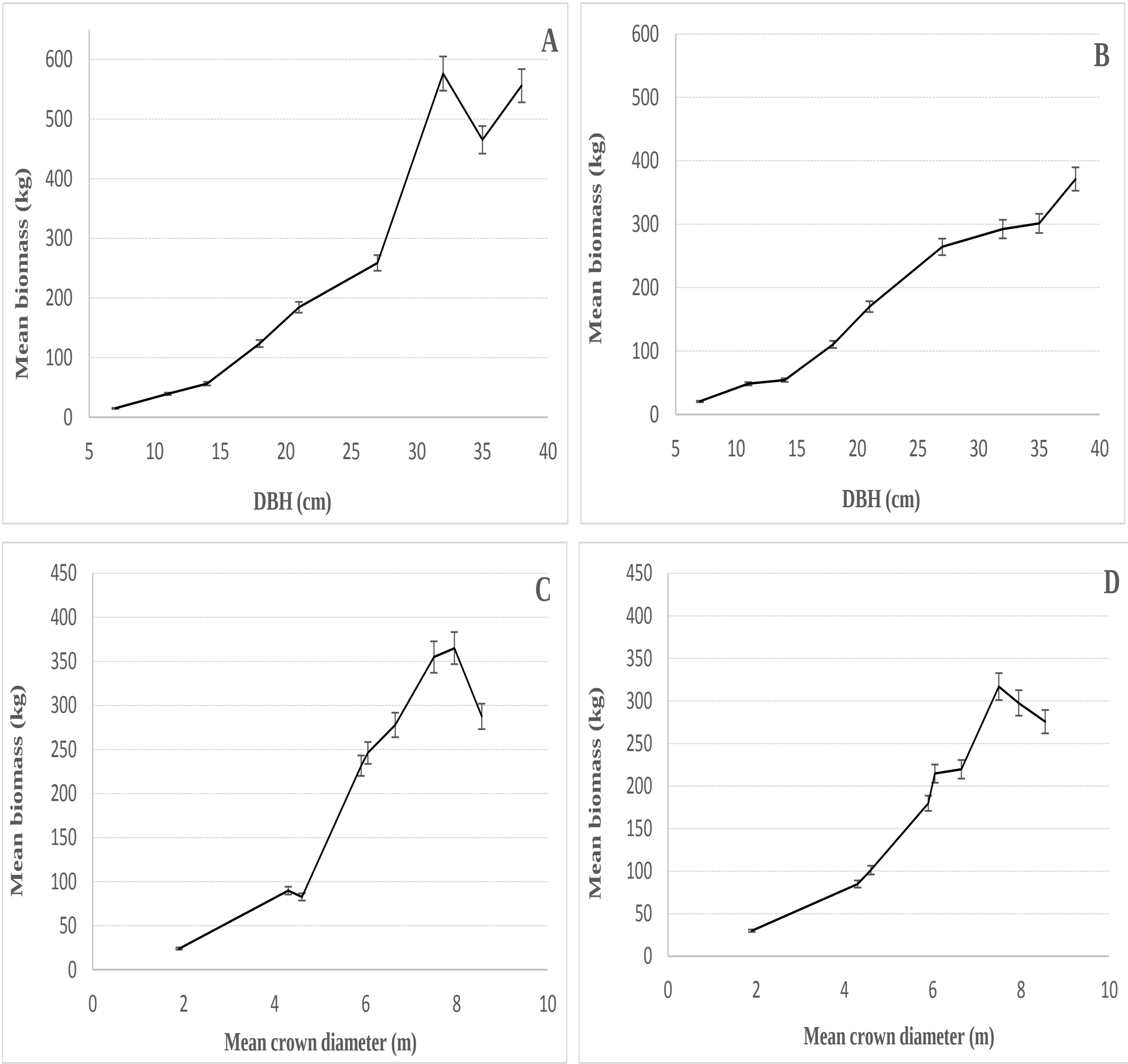

Fig: 3. Average biomass weight (kg) in trees of the two growing forms; High forest (A , B) and coppice (C , D) of above (A , C) and below-ground (B , D).

Table: 1. Different average biomass and carbon stocks (t C /ha) of above-and below-ground in two growing forms

Form growth	Component	N*hectar	Mean tree biomass (kg)	Biomass (T/ha)	Carbon storage (T/ha)
High forest	Above-ground	66.88	252.77	16.905	8.279
	below-ground		181.36	12.129	5.969
Coppice	Above ground	62.88	217.70	13.688	6.690
	below-ground		191.02	12.011	5.913
Sum		129.76		54.73±.987	26.85±.477

This study shows that, the carbon stock is higher in above-ground biomass with 14.969 t c/ha compared to below-ground biomass with 11.882 t c/ha.

ENERGY

THE IIOAB JOURNAL
ISSN: 0976-3104

Southern Zagrosian forests

Figure– 4 shows the amount of the ecosystem trees per hectare from two growing forms of the Basht stands. Number of trees per hectare in high forest form which were 60.33 and 52.22 for coppice respectively.

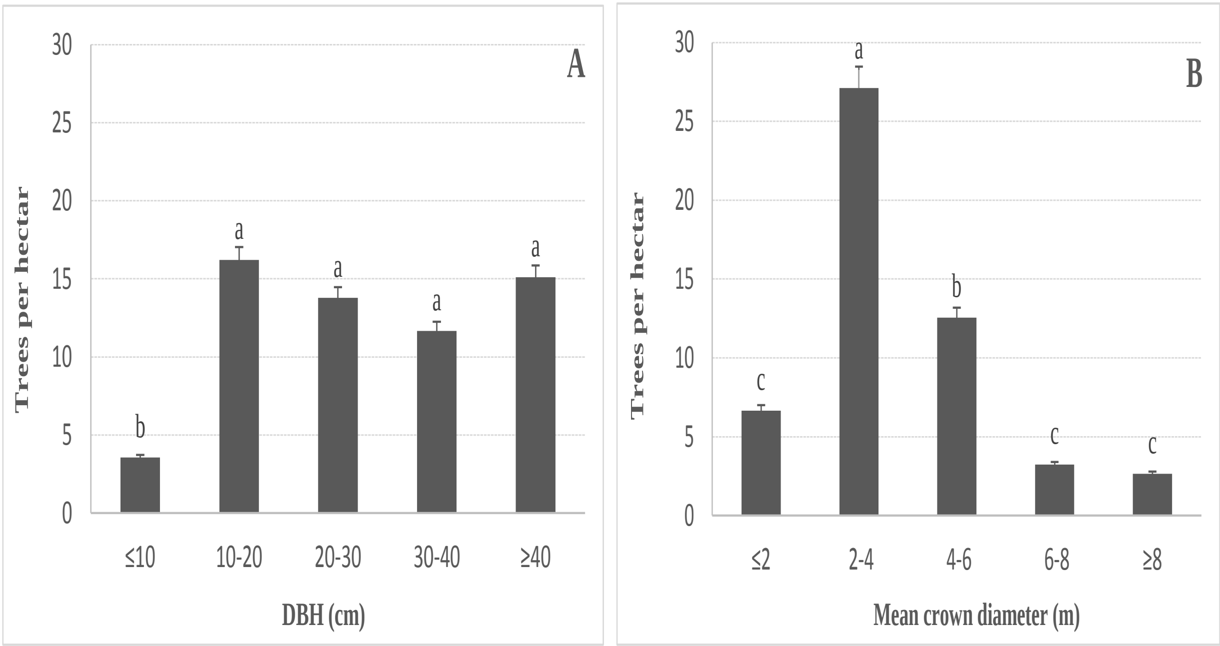

Fig: 4. The average number of trees per hectare in different diameter classes; high forest (A) and Coppice (B) trees

Figure–5 shows the amount of the ecosystem biomass in the trees of the two growing forms. In this study, the ecosystem biomass included the above- and below-ground tree components. The maximum biomass value was found in the above-ground of high forest form (227.76). The present study showed that the carbon concentration is different in the tissues for the two growing forms. **Table– 2** shows Different average biomass and carbon stocks (t C /ha) of above-and below-ground in two growing forms.

Table: 2. Different average biomass and carbon stocks (t C /ha) of above-and below-ground in two growing forms

Form growth	Component	N*hectar	Mean tree biomass (kg)	Biomass (T/ha)	Carbon storage (T/Ha)
High forest	Above ground	60.33	227.77	13.739	6.725
	below-ground		170.45	10.283	5.035
Coppice	Above ground	52.22	197.99	10.339	5.054
	below-ground		167.24	8.733	4.270
Sum		112.55		43.09±.457	21.08±.224

This study shows that, the carbon stock is higher in above-ground biomass with 11.76 t c/ha compared to below-ground biomass with 9.324 t c/ha.

In total, the average of carbon stock in Dehdez ecosystem located in central Zagrosian forest with 26.85 t c/ha is higher to Basht ecosystem located in south zagrosian forest with 21.08 t c/ha **[Table– 1 and 2]**.

THE IIOAB JOURNAL
ISSN: 0976-3104

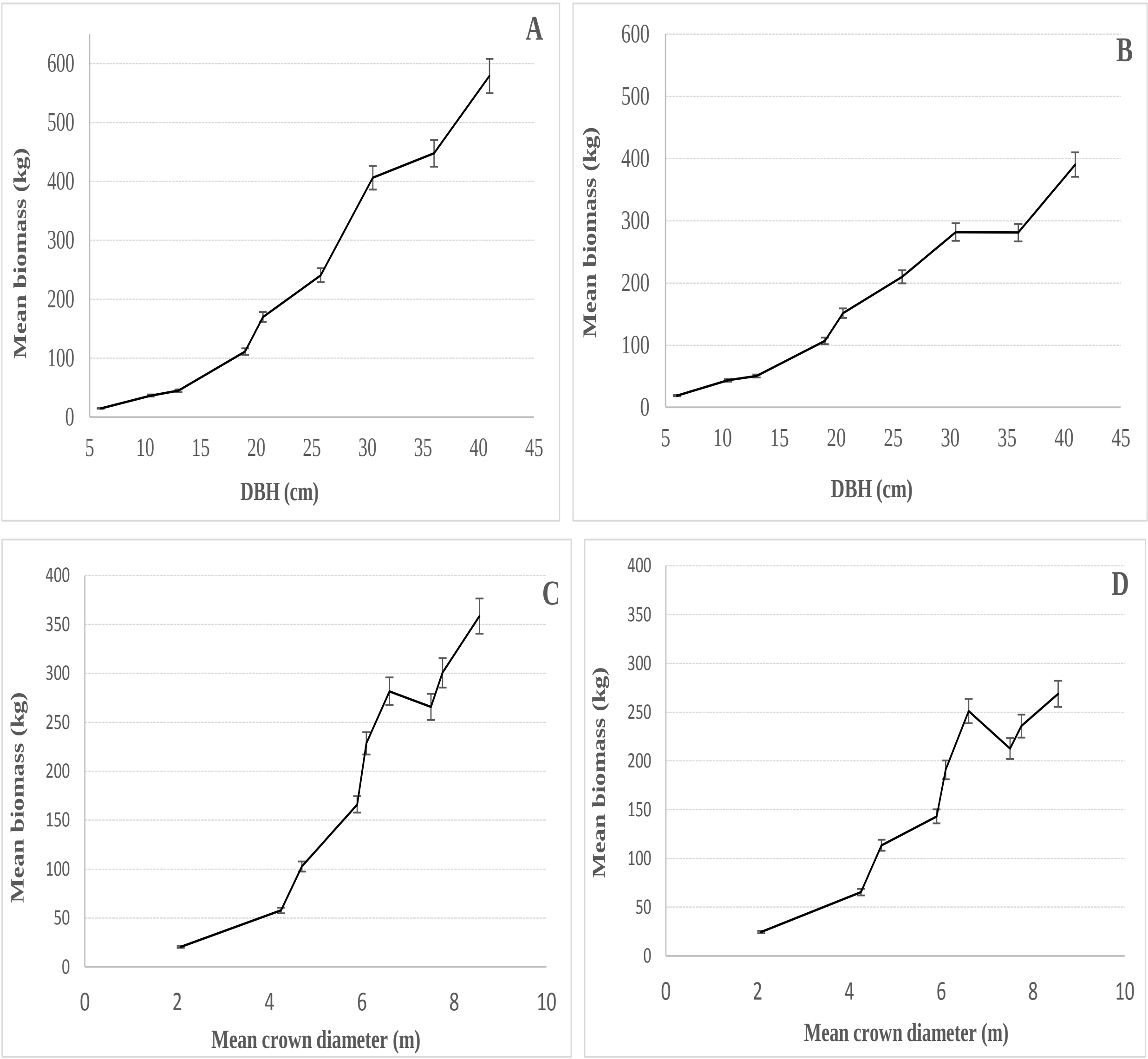

Fig: 3. Average biomass weight (kg) in trees of the two growing forms; High forest (A , B) and coppice (C , D) of above (A , C) and below-ground (B , D).

DISCUSSION

In the west of Iran in Zagrosian forests (with an area of 5 million hectares), oak manna trees (*Quercus brantii* var. *persica*) are the dominant species in 1000-2300 m above sea level. This forest has the most extensive habitat among oak species in Iran [14].

The Zagrosian forests have always been within easy reach of farmers, nomads, traders, and armies crossing the Zagros mountains on their way between Mesopotamia and central Persia. Archaeological evidence shows that these forests have been exploited economically for millennia. Human interference, in combination with climatic and other ecological factors (soils, topography), must therefore be considered as decisive for the distinctly different character of this forest type.

This study allowed us to estimate the carbon stock of above-ground biomass (AGB) and below-ground biomass (BGB) in central and south Zagrosian forests. The results of central Zagrosian forests shows that, total average

THE IIOAB JOURNAL
ISSN: 0976-3104

biomass in two growing forms approximately 54.73 and 26.85 for carbon stocks, respectively. In the stand, the average biomass of high forest growing form 29.034 and 25.699 t/ha for coppice trees. And the average carbon stocks of high forest growing form 14.248 and 12.603 t c/ha for coppice trees. For southern Zagrosian forest, results showed that, total average biomass in two growing forms approximately 43.09 and 21.08 for carbon stocks, respectively. In the stand, the average biomass of high forest growing form 24.022 and 19.072 t/ha for coppice trees. And the average carbon stocks of high forest growing form 11.760 and 9.324 t c/ha for coppice trees.

There might be reason for the observed characteristics of the biomass ratios **[Figure– 2 and Figure– 4]**. First regarding to the stands characteristics **[Figure– 2 and Figure– 4]** the plantation sites differed from the diameter classes ecosystem. The Dehdez ecosystem had a higher variation of diameter classes compared to the Basht ecosystem. However, it was not possible to harvest all diameter classes.

As mentioned above, the difference is caused mainly by stand density, age and sometimes by different ecotypes or subspecies (including hybrids). The altitudinal range of Dehdez ecosystem is higher than Basht ecosystem. There might be reason for the observed of the biomass and carbon stocks ratios.

As a rule of the thumb, precipitation mainly occurs in winter and averages around 400-800 mm, so that approximately 70 % of it, falls in the second half of the year [15]. Maybe is another reason for the rise in this ratio the comparable studied sites, In the Dehdez ecosystem mean precipitation in higher than Basht ecosystem. Carbon concentrations differed with tree forms and tree components. Carbon content of tree componenets varied **[Table– 1 and Table– 2]**. The average carbon accumulation including all tree parts was higher in high-forest followed by coppice. The mean carbon concentration was found very close to the 50 percent value often used for estimation of carbon storage from dry biomass. Kraenzel et al [6] reported the range of 45.2 to 50.4 percent carbon in different tree components, which is tru in present study also [7].

ACKNOWLEDGEMENT

None.

CONFLICT OF INTEREST

There is no any form of conflict of interested.

FINANCIAL DISCLOSURE

No financial support was received for this work.

REFERENCES

[1] Penman J, Gytarsky M, Hiraishi T. [2004] IPCC good practice guidance for land use, land use change and forestry. *Institute for Global Environmental Strategies (IGES)*, Hayama, Kanagawa, Japan.

[2] Aguirre-Salado CA, Treviño-Garza EJ, Aguirre-Calderón OA, et al. [2014] Mapping aboveground biomass by integrating geospatial and forest inventory data through a k-nearest neighbor strategy in North Central Mexico. *Journal of Arid Land*, 6(1): 80–96.

[3] Bipal J, Mrinmo M. [2010] Impact of Climate Change on Natural Resource Management. Netherlands: Springer.

[4] McPherson EG, Simpson JR. [1999] Carbon dioxide reduction through urban forestry: Guidelines for professional and volunteer tree planters. In: USDA Forest Service, PSW General Technical Report. No. PSW-GTR-171. Albany, CA, USA.

[5] Yan F, Wu B, Wang YJ. [2013] Estimating aboveground biomass in Mu Us Sandy Land using Landsat spectral derived vegetation indices over the past 30 years. *Journal of Arid Land*, 5(4): 521–530.

[6] Kraenzel M, Castillo A, Moore T, Potvin C. [2003] Carbon storage of harvest-age teak (Tectona grandis) plantations, Panama. *Forest Ecology and Management*, 173: 213–225.

[7] Woodbury PB, Smith JE, Heath LS. [2007]. Carbon sequestration in the U. S. forest sector from 1990 to 2010. Forest Ecology and Management, 241(1–3): 14–27.

[8] Bannari A, Pacheco A, Staenz K., McNairn H, Omari K. [2006] Estimating and mapping crop residues cover on agricultural lands using hyperspectral and IKONOS data. *Remote Sensing of Environment* 104: 447–459. DOI: 10.1016/j.rse.2006.05.018

[9] Spetich M, Parker G. [1998] Distribution of Biomass in an Indiana Old-Growth Forest from 1926 to 1992. *American Midland Naturalist*, 139(1): 90–107. Published by: The University of Notre Dame.

[10] Nixon KC. [1993] The genus Quercus in Mexico. In: Ramamoorthy, TP, Bye, Robert Lot, Antonio Fa J, eds. *Biological diversity of Mexico: origins and distribution. Oxford*: Oxford University Press, 447–458.

[11] Talebi M, Sagheb-Talebi Kh, Jahanbazi H. [2006] Site demands and some quantitative and qualitative characteristics of Persian oak (Quercus brantii Lindle.) in Chaharmahal & Bakhtiari province (western Iran), *Iranian Journal of Forest and Poplar Research*, 14(1):67–79.

THE IIOAB JOURNAL
ISSN: 0976-3104

[12] MacDicken KG. [1997].A Guide to Monitoring Carbon Storage in Forestry and Agro forestry Projects. Winrock International Institute for Agricultural Development, *Forest Carbon Monitoring Program*, 91p.

[13] Thomas SC, Martin AR. [2012]. Carbon content of tree tissues: a synthesis. *Forests*, 3(2): 332–352.

[14] Sagheb-Talebi Kh., Toktam S, Pourhashemi M. [2014] Forests of Iran: A Treasure from the Past, a Hope for the Future (Plant and Vegetation), *Springer*, 157pp.

[15] Matinizadeh M. Korori, SAA Teimouri M and Praznik W. [2008] Enzyme Activities in Undisturbed and Disturbed Forest Soils Under Oak (Quercus brantii var. persica) as Affected by Soil Depth and Seasonal Variation. *Asian Journal of Plant Sciences*, 7: 368–374

[16] Lemus R, Lal R. [2005] Bioenergy crops and carbon sequestration. *Critical Reviews in Plant Sciences*, 24(1): 1–21.

ABOUT AUTHORS

Yousef Askari *is Ph.D. Student of Forestry, Faculty of Natural Resources and earth Science, University of Shahrekord. Research fields of interest; Forest inventory and Biometry, Spatial point pattern and Carbon Sequestration.*

Dr. Ali Soltani *is working an Associate Professor in the Faculty of Natural Resources and earth Science, University of Shahrekord. Research fields of interest; Forest Ecology, Silvicultural and Seed Sciences.*

Dr. Reza Akhavan *is working an Associate Professor in the Research Institute of Forests and Rangelands, Tehran. Research fields of interest; Forest inventory & Biometry; Geostatistics; Spatial point pattern and Forest Modeling.*

Dr. Pejman Tahmasebi kohyani *is working an Associate Professor in the Faculty of Natural Resources and earth Science, University of Shahrekord. PhD Graduated in the field of Rangeland Ecology from Department of Biology, Gent University Belgium.*

ENERGY