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Assessing Carbon Storage and Biomass in Moroccan Cork Oak Forests

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ABSTRACT

The present study was conducted in monospecific stand of Cork oak (*Quercus suber* L.) in the Oulmes Central Plateau (Case of Zitchouene Forest), with the following objectives: determination of the organic carbon stock in the different compartments of the forest ecosystem, namely: the soil, the above-ground and below-ground biomass. To achieve these objectives, the biomass of the cork oak tree in the study area was researched using direct dry weight measurements on 30 sample trees. Furthermore, the volume of standing trees was estimated using a volume tariff based on direct measurements of circumference at 1.30 and total tree height, all of which allowed estimating the biomass expansion and conversion factor (BECF) specific to the Oulmes Central Plateau cork oak. As a result, the volume and above-ground biomass were estimated at 55.74 m^3/ha and 20.13 t/ha of dry matter respectively. Soil organic carbon stock and biomass (above and below ground) were estimated at 43.02 t/ha and 16.60 t/ha, respectively. BECF, determined by the ratio between volume and biomass, was 0.59, which approaches the minimum value recorded under the same productivity conditions estimated by IPCC (0.6–1.4).

Keywords: cork oak, central plateau, organic carbon, biomass expansion and conversion factor, biomass, Morroco.

INTRODUCTION

It is becoming clear that the increase of greenhouse gases (GHGs) in the atmosphere and the resulting climate change are already having major effects. Indeed, this change has altered marine, terrestrial and freshwater ecosystems worldwide (Pörtner et al., 2022), and the link with human activities is no longer debated (Hansen, Sato 2004). As a consequence, these changes could be seen in the rise in sea level, increased frequency of extreme weather events, and rise in terrestrial temperature (Boer et al., 2000).In the same way that there are mechanisms that emit GHGs into the atmosphere, notably through the combustion of fossil fuels, there are natural mechanisms that absorb these GHGs and store them outside the atmosphere – wood, soils, oceans – and which are qualified as carbon sinks. Indeed, in the framework of the application of the Kyoto Protocol (1997), taking into account these carbon sinks would lighten the efforts to reduce industrial pollution and greenhouse gas emissions. Moreover, today and more than ever, these carbon sinks are in demand because, since the Paris Agreements (2015), the main world organizations have committed themselves to achieving zero net emissions by 2050. The estimation of forest carbon stocks has increased in relevance in recent years due to the function of forests in mitigating global climate change through carbon storage (Ruiz-Peinado et al., 2012). Indeed, natural ecosystems, in this case forests and soils, are among the carbon reservoirs in the biosphere that, through carbon sequestration, would contribute to the mitigation of environmental disruption (Oubrahim 2015). Pan et al. (2011) attempted to quantify forest carbon sinks globally and estimated that 45% of the total carbon stock is stored at the soil level (at a depth of 1 m), 42% in above and below ground biomass, 8% in dead wood, and 5% in litter. These results have been confirmed by several other studies that have estimated that forests (vegetation and soil) store 60% of global terrestrial carbon (Iturbide et al. 2020).

In Morocco, forests occupy a remarkable place among the ecosystems of the Mediterranean basin, due to their high biodiversity as well as the ecological and environmental services they offer (El Mderssa 2019). On the other hand, national socioeconomic choices are strongly linked to climate and its fluctuations; the national economy is very dependent on water, tourism and the coast, agriculture and forests, sectors directly exposed to the risks of climate change (MEMEE 2009).

The cork oak (*Quercus suber* L.) is an endemic species of the Mediterranean basin and has been present in the western Mediterranean for over 60 million years (Oubrahim 2015). The cork oak forests in Morocco are representative of sub-humid and humid wooded ecosystems, often suffering from overexploitation. Its range has considerably decreased due to large variations in climatic conditions over this long period, but mainly due to human activities (De Sousa et al., 2008).

The forest of the Oulmes plateaus is estimated at about 125 000 ha, of which 85 000 ha are cork oak forests. In addition to their ecological value, these cork oak forests have an economic potential that is manifested, in addition to the forage units, by the production of cork with an average of 10.400 steers. Thus, and by the functions insinuated in these massifs, the exploration of their virtues in terms of the CO_2 capture in organic carbon form at different levels (soil, above-ground and under-ground biomass), the quantification of the carbon stock in this natural ecosystem, as well as determination of the biomass expansion and conversion factor (BECF) value are of high importance. The aim is to provide managers with tangible planning and programming tools that supply information on the potential for carbon storage by this ecosystem, in order to make an optimal choice between species adapted to the same ecological conditions as those of the cork oak during reforestation programs, and that store more organic carbon, thus contributing to the absorption of greenhouse gases. In this perspective, the present study which took place at the level of the cork oak monospecific plots of the Zitchouene forest belonging to the Central Plateau of Oulmes, sets as objectives (i) physico-chemical characterization and evaluation of the stock of carbon in soil, (ii) dendrometric characterization of the trees of cork oak in the zone of study, (iii) evaluation of the stock of carbon in the biomass (above and underground) of cork oak, and, (vi) determination of biomass expansion and conversion factor (BECF).

MATERIAL AND METHODS

Study area

The study was conducted on mature natural monospecific cork oak stand plots in Zitchouene forest located in the ‘Haut Pays’ of the Central Plateau (Beaudet 1969) (Figure 1). The studied area is located in the South-East of the Oulmes territorial commune (Latitude: 33°28’09” – 33°15’00”N, longitude: 6°11’15” – 5°54’22.5”E) and is characterized by rugged relief. The hilly character of the relief of the forest studied is explained by the presence of an important hydrographic network that is very branched, composed of large wadis and ravines. The main wadis crossing the forest are Oued Boulhmayel, Oued Ksisksou, Oued Zoubyya, Oued Tajourrout and Oued Afçale. The investigated sites’ geological bedrock is schist, which is almost everywhere (Aherdan 1994) and quartzite deposits at the level of the summits.

The precipitation annual average ranges from 550 mm to 750 mm, maximum temperatures range from 20.5 to 38.1 °C and minimum temperatures range from -1.4 to 6.1 °C. The seasonal regime is of the HPAE type, reflecting the Mediterranean character of the study area. The region is recognized for the frequent occurrence of white frost, particularly in winter. According to the Work Center (WC) and the Arbor Oulmes station, the average number of frosts is 15 to 20 days per year. The climate of the region is Mediterranean, with a subhumid bioclimate and cool winters.

The forest in question contains in addition to forest formations based on cork oak, other ecosystems namely the holm oak and thuja. The said forest is an integral part of the future

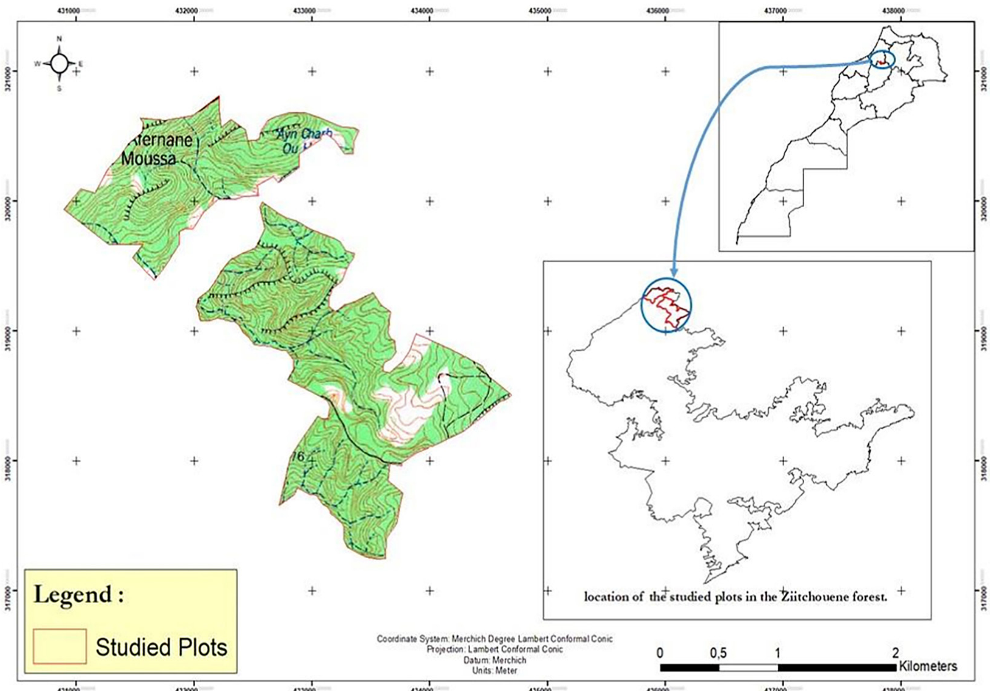

Figure 1. Studied area location

Natural Park of the Central Plateau the studies of which are being finalized by the ministerial department concerned, it occupies an area of 25% of the entire park.

Physico-chemical characterization and soil carbon stock assessment

For the physico-chemical characterization of the studied area soil, samples, randomly distributed on the plots of monospecific cork oak stand, taken with the pedological auger, from the upper organo-mineral layer the depth of which is less than 30 cm, were sieved through a 2 mm mesh and were subsequently subjected to analysis for the determination of:

- pH of the soil solution: measured in a soil: water suspension using a pH meter;
- Total nitrogen: realized via the Kjeldahl and Wilke (2005) distillation method;
- Organic carbon and organic matter: the organic carbon analysis of the soil was carried out via the Walkley and Black method (1934) and the value of the organic matter value deduced from the formula of Soltner (1988);
- Exchangeable bases (Na, K, Ca and Mg): the technique used for the characterization of these elements is the inductively coupled plasma mass spectrometry (ICP-MS). The soil samples mineralization was carried out with aqua regia;
- Bulk density: consists in a calculation of the soil mass in relation to its fresh volume according to the following formula:

$$DA = P/V \text{ (g/cm}^3\text{)} \quad (1)$$

where: P – the dry weight of the sample and V: the volume of the sample taken and dried;

- Granulometry: this consists of the percentage determination of the soil constituents, namely clays, silts and sands, using the Bouyoucos hydrometer method (1962);
- Soil carbon stock is calculated based on the following formula: (Boulmane 2014, Oubrahim 2015, El Mderssa 2019):

$$q(ji) = 0.1 \times Ei \times da(i) \times C(ji) \quad (2)$$

where: $q(i)$ – content of element (j) in soil layer (i) ($t \cdot ha^{-1}$); 0,1 – conversion coefficient; Ei – thickness of the layer (i) (cm); $da(i)$ – apparent density of the fine fraction, < 2 mm, in layer (i) in ($g \cdot cm^{-3}$); $C(ji)$ – concentration of the element (j) in the soil layer (i) ($g \cdot kg^{-1}$).

Assessment of biomass carbon stock

In order to estimate the cork oak trees carbon stock in the studied area, whether above or below ground (roots), it is essential to explore their biomass (Ruiz-Peinado et al. 2012).

In this sense, knowledge of the structure of the cork oak stand in the studied plots is essential. For this purpose, an exhaustive inventory of the circumferences at 1.30 m from the ground of all the trees inside circular sample plots, systematically distributed, of 5 ares (with a radius of 12.5 m) each in the studied area, was carried out.

On the basis of on the structure of the stand determined in this way, a number of 30 sample trees, weighted by circumference classes, felled during the opening and maintenance of tracks in the area, were chosen to calculate their individual biomass, on which the following measurements were made:

- The total weight of the trunk until the cut of 5 cm of the circumference using a spring scale (poket balance) with an accuracy of 1 kg;
- The total weight of the branches by a spring scale (poket balance) with a precision of 1 kg;
- The total weight of the leaves using an electronic scale with a precision of one gram (1 g);
- The total height/length of the sample tree.
- Subsequently, samples of disks of wood were taken for the purpose of measuring the humidity and the organic carbon fraction of the wood. This is true for each tree:
- Three disks of 5 cm from the trunk, one at the base, another at mid-height and the third at the cut of 5 cm;
- A 3 cm slice of the middle branch of the tree;
- Two handles of the tree leaves after stirring.

After measuring the weights of these disks in the field, they were placed into paper bags prepared for this purpose. These paper bags were then placed in a plastic bag for each given tree and they were quickly brought back to the laboratory where they were reweighed, dried at 105 °C for the trunk and branch disks and at 65 °C for the leaves (Picard et al., 2012) until they reached a constant weight and then reweighed. The humidity was calculated using the formula of de Aleon (1984) shown below:

$$H\% = \frac{(FW - DW)}{DW} \times 100 \quad (3)$$

where: *FW* is the fresh weight of the sample and *DW* is its dry weight.

Biomass model development and determination of the carbon fraction: Knowing the biomass of each compartment of the sample tree, their summation informs that of the total tree, so its extrapolation to the scale of the studied plots, while using the direct measurements of C1.30 and total height, requires the development of model called the biomass model. The authors proceeded to the modeling by using allometric and polynomial equations expressing the relationship between the dimensions (C1.30 and height) and the total biomass of the cork oak trees. Also, from the length/height measurements of the felled sample trees, the relationship between the height and the C1.30 was established.

The most commonly used biomass models, tested in this study (El Mderssa et al., 2022), aimed at estimating biomass from direct dendrometric measurements, are summarized below:

$$BS = a(C^2H)^b \quad (4)$$

$$BS = aC^b H^d \quad (5)$$

where: *a* and *b* – regression coefficient to be estimated, *C* = circumference at 1.30 (m); *H* = tree height (m). As well, the determination the carbon fraction was estimated according to the method described by (Ikraoun et al., 2022, Soltner 1988).

Biomass expansion and conversion factor

Biomass expansion and conversion factors (BECF) expand the dry weight of the commercial volume of growing stock, net annual increment, or wood extraction to account for the non-commercial components of the tree, stand, and forest (El Mderssa 2019). These factors allow this volume to be transformed directly into above-ground biomass. The BECF values are more practical, because they can be applied directly to volume-based forest inventory data and activity censuses, without the need for basic wood density (DB) (IPCC 2006).

Determination of this factor for a given plant species requires the quantification of the standing wood volume and the aerial biomass. Thus its calculation is illustrated by the following formula, called the general formula of the above-ground biomass calculation:

$$BA = V \times FECB \quad (6)$$

where: *BA* the above-ground biomass in t/ha, and *V* the volume in m^3.

For assessing the volume of the cork oak stand in the studied plots, the construction of a cubing rate was used while serving the simple and easy to measure dendrometric characteristics, in this case C1.30 and total height of the tree.

In this context, the following measurements on felled trees were performed (El Mderssa et al. 2021), namely:

- circumference measurement at 1.30 m from the ground of the standing tree using a tape measure;
- measurement of the large and small circumferences of the bolts of 1 m in length each, from the base of the tree to the cut of the strong wood (20 cm in circumference) of the felled tree, using a tape measure;
- the overall length of the fallen tree was determined using a tape measure.

The volume of successive bolts of stems was estimated by the Smalian formula:

$$V = [(B2 + b2)/2] \times L\ x\ \pi/4 \quad (7)$$

where: B is the large diameter, b is the small diameter and L is the bolt length (1 m).

Thus, the total volume of the tree is the sum of the volumes of the different bolts of the tree.

Statistical analysis

Statistical analyses and adjustments were performed using RStudio software. The choice of models for biomass, height-girth relationship and cubing rate was based on the following parameters: coefficient of determination (R2), residual standard deviation (Sy.x), Akaike information criterion (AIC) and root mean square error (RMSE).

RESULTS AND DISCUSSION

Physico-chemical characterization and soil carbon stock

The different physicochemical characteristics of the soil at the level of the studied plots are listed in Tables 1 and 2.

According to the investigation of soil physicochemical characteristics, the area being studied is on slightly acidic soil. Despite the fact that the substratum is schist, these pH values can be explained by the presence of vegetation represented by leafy species in the natural state, particularly the cork oak. The range of organic carbon content, with a mean value of roughly 1.48%, remains very variable between replicates, with a coefficient of variation approaching 30%.

The C/N ratio considered by Lafond et al. (1992) and Akselsson et al. (2005) as a good indicator to evaluate carbon sequestration in soils takes a rather high value (61.38) showing a low carbon decomposition rate. The soil texture in the study area is a significant parameter, since its nature has a significant influence on plant productivity (Kendra, 2006) and soil microbial activity. It was determined with reference to the particle size analysis of the soil and the textural diagram "the soil taxonomy triangle" (Web1, 2021), (Figure 2). Thus, the texture of the soil in question is loam, with a total sand content exceeds 36% on average, indicating low cohesion between soil particles and the presence of silt with an average rate of 39%, testifying to permeability to water and air. For the exchangeable bases, namely calcium, magnesium, potassium and sodium, magnesium is indeed the

Table 1. Physico-chemical characterization of the soil in the studied area

Value	% N	% C	C/N	%OM	BD	pH-H_2O	pH-Kcl	SOCS (t/ha)	Ca (mg/L)	K (mg/L)	Na (mg/L)	Mg (mg/L)	SEB (mg/L)
Mean	0.024	1.48	61.378	2.556	0.962	6.196	5.162	43.018	20.64	11.346	1.337	19.58	52.903
SD	0.009	0.312	4.718	0.539	0.070	0.407	0.518	9.265	6.648	3.683	0.738	4.064	10.526

Note. N: nitrogen, C: carbon, OM: organic matter, BD: bulk density, SOCS: soil oganic carbon Stock, Ca: calcium, K: potassium, Na: sodium, Mg: magnesium, SEB: sum of exchangeable bases, SD: standard deviation.

Table 2. Granulometric characterization of the soil in the studied area

Value	Clay %	Silt %		Sand %	
		Thin	Coarse	Thin	Coarse
Mean	24.14	26.02	13.2	17.38	19.28
SD	5.128	3.584	2.320	5.024	5.944

Note: SD: standard deviation.

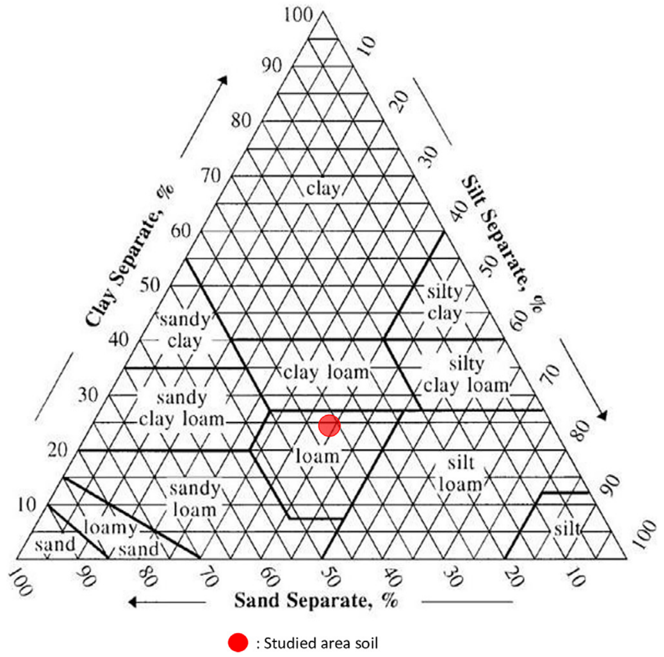

Figure 2. Textural diagram of the soils studied (Web1, 2021)

most represented element in the studied soils. In decreasing order, the authors found calcium, then magnesium and potassium. The variation of exchangeable base values between sites is important, ranging from 29% for magnesium to 68% for sodium, which presents the highest variation. The soil organic carbon stock (SOCS) varies from 23.95 to 66.18 t/ha with an average value of 43.02 t/ha. A comparison of this value with those found in the central Moroccan plateau by Zaher et al. (2019) and Ikraoun et al. (2022) summarized in Table 3, reveals that the soil carbon stock at the studied sites under cork oak, with the exception of the SCOS of the site under Green oak in the Harcha forest (109.14 t/ha), is higher than those found under cork oak and thuja in the previously cited works, which can be explained by the floristic procession developing an important organic matter. In addition, the SCOS in the studied area is also higher than the average value recorded by Sabir et al. (2020) at the Morocco level within deciduous forests (24.2 T/ha) and higher than that recorded in the Maamora forest under different forest covers (Malki et al., 2022, Oubrahim et al., 2015, Nininahazwe 2017) (Table 4) due to the Mediterranean climate conditions, which are not favorable to the accumulation of organic matter at the Maamora forest (Benjelloun et al., 1997). Nevertheless, these values remain lower than those recorded at the level of the Middle Atlas and the Rif Maroccan (Boulemane et al., 2014, El Mderssa et al., 2019, L'bahy, 2015). A similar finding in the study by Eglin (2005) and Lecointe et al. (2005) in British forests estimated a SOCS in the organic layer (Depth < 30 cm) of 136 and 153 t/ha respectively, which remains higher than the SOCS found in the studied area. In the East of the country, and specifically in Algeria, values almost close to those obtained in this study have been found in the soils of the mountains of Tessala, ranging from 18 to 64 t/ha (Merabtene et al., 2021).

Dendrometric characterization, height-circumference relationship and stand cubing tariff

The analysis of the curves relating to the distribution of the forest stands of cork oak stems gives an idea of the general tendency of the structure of this species. It also allows the planner to support the orientations in terms of forest management to adopt and the mode of conduct to establish. Indeed, the curve relating to the structure of the stands is of normal tendency (Fig. 3), It is generally a simple coppice, and the class of 60 cm contains the maximum number of strands. It is noted that more than 65% of the strands have a circumference 1.30 m lower than 60 cm. Also, the main dendrometric characteristics of the studied stand harvested from the field

Table 3: Soil carbon stock values in the central Moroccan plateau

Studied area	Author	Specie	Mother rock	Depth	SOCS (T/ha)
Ait Ichou East forest (Oulmes area)	Zaher et al. (2019)	G.O	shale	30	40.83
Harcha forest (Oulmes area)	Zaher et al. (2019)	C.O	shale	30	109.14
Zicthouene (Oulmes area)	Ikraoun et al. (2022)	T.A	shale	30	47.91
Zicthouene (Oulmes area)	Ikraoun et al. (2022)	G.O	shale	30	40.07

Note: G.O: green oak; C.O: cork oak; T.A; tetraclinis articulate.

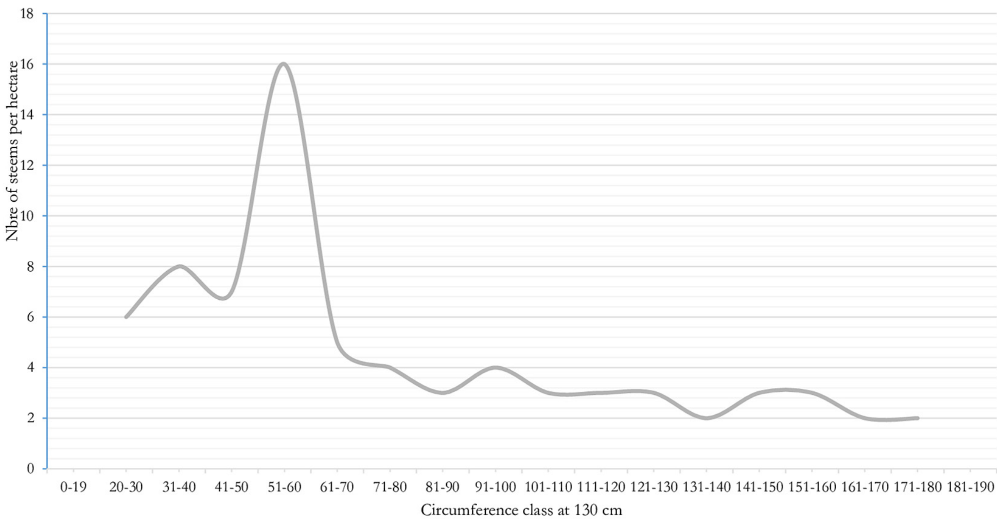

Figure 3. Cork oak stand structure in the studied area

inventories are summarized in Table 5. Regarding the relationship between circumference 1.30 m and height, an equation considered necessary and practical for estimating the height of the cork oak tree from its circumference (1.30 m), the model considered most relevant is illustrated in Table 6. With respect to the cubing rate, the model that showed the most relevant characteristics is summarized in Table 7.

The estimated total volume of cork oak stands at the studied plots, in application of the above mentioned tariff, amounts to an average of 55.47 m^3/ha for the formations based on monospecific cork oak stand. This average value is considered low compared to that recorded in cork oak stands in Chefchaouen (115.97 to 127.74 m^3/ha) (El Makhloufi et al., 2008). This great production potential of cork oak by hectar in Chefchoauen can be explained the high density in the studied plots (797 to 932 stems per hectare). Nevertheless, lower values were noted by reforestation based on Eucalyptus (20.4 m^3/ha) and pine (23.8 m^3/ha), at the level of the forest of Maâmora (HCEFLCD 2014). It can be attributed

Table 4. Soil organic carbon stock (SOCS) values in Morocco

Studied area	Author	Specie	Depth	SOCS (T/ha)
Maamora	Malki et al. (2022)	Cork Oak	30	40.12
		eucalyptus plantation	30	33.04
		pine plantation	30	28.84
		acacia plantation	30	30.17
Western Maamora	Ourahim et al. (2015)	Cork Oak at medium density	40	46.4
Western Maamora	Nininahazwe (2017)	Cork Oak	40	39.76

Table 5. Dendrometric characteristics of pure cork oak stands in the studied are

Average density per hectare	Average circumference per hectare (cm)	Average basal area (m^2/ha)
151	78	9

Table 6. Statistical characteristics of the selected height-conference model

Model	R^2	D	RMSE	AIC
$H = 5{,}349 + 2{,}658 \times C^2$	84.8	2.576	0.659	58.35

to explained by the high longevity of cork oak compared to these species.

Biomass tariff and biomass carbon stock assessment: For the elaboration of the cork oak tree biomass rate in the studied plots, the biomass of each tree sample compartment, namely: trunk, branches and leaves, was summed up, after which an estimation rate of the aboveground biomass was adjusted. The characteristics of the selected biomass model are summarized in Table 8.

The quantification of the weighted aerial biomass of cork oak in the studied plots, based on the selected biomass model, is estimated at 20.13 tDM/ha (tDM = tonne of dry matter).

The biomass in the root part of cork oak trees was evaluated using the IPCC (2006) generic data. Thus the root biomass of cork oak trees is estimated at 9.26 tDM/ha.

The total aboveground and root biomass is estimated at 29.39 tDM//ha. Indeed, for cork oak forests, values of 89.5 tDM/ha were noted for the western subera of the Maamora (Oubrahim et al., 2015), 240.59 to 411.30 tDM/ha, respectively, for young and adult stand in Bellif forest, northwestern Tunisia (Zribi et al., 2016), and 42.2 t/ha in Italy (Léonardi et al., 1992). The clearly low value recorded in the studied area can be explained by the dominance of subjects of small dendrometric dimensions, as it is related in the structure of the stand marked by the predominance of subjects of small circumference at 1.30 m of 78 cm order.

The result of the carbon fraction estimation contained in the cork oak trees in the studied area is evaluated at 0.5648 t (C)/tMS. On this basis, the quantification of the carbon contained in the cork oak stands, based on the estimated total biomass and on the measured carbon fraction for this species, was evaluated at 16.60 t (C)/ha. In fact, this value is considered low compared to those recorded in other ecosystems summarized in Table 9, which can be explained by the low density per hectare, which agrees with the finding of Le Clec'h et al. (2013) who concluded that the highest carbon stocks are located in the most forested areas (dense forests).

Thus, the estimated carbon stock for the strata of the cork oak monospecific stand resulting from that at the soil and biomass levels is estimated at 59.72 t/ha. This value remains low compared to others recorded in the Middle Atlas (El Mderssa 2019) for other species, namely zeen oak (214.75 to 303.25 t/ha), atlas cedar (201.3 to 277.49 t/ha) and maritime pine (143.9 t/ha). Also, the same thing is found for the cork oak at the level of the forest of Maamora, where the study conducted by Oubrahim et al. (2015) recorded a higher value which is 121 t/ha. The difference between with these studies can be explained, probably, by the nature of the soils in our study area, based on shale that stores low values of organic carbon and the structure of the stand in the area studied, which marked the dominance of subjects with a small circumference to 1.30 m about 60 cm. In addition, values close to those recorded in the authors' case, were noted for the green oak at the forest of Zitchouene by Ikraoun et al. (2022) (85.42 t (C)/ha).

Table 7. Tested equation models for wood estimation

Model	R^2	D	RMSE	Error	Application interval
$V = 0.077 \times C^{1.552} \times H^{0.84}$	94.1	1.817	0.155	0.148	20–180 cm

Table 8. Statistical characteristics of the biomass model

Adjusted model	R2	RMSE	AIC	D
Ln(BS-T) = 3.620 + 0.710·Ln(CH)	91.1	0.110	-33.9	1.465

Table 9: Biomass carbon stock (BCOS) values of other ecosystems in Morocco

Studied area	Author	Specie	BCOS (t (C)/ha)
Middle Atlas	El Mderssa (2022)	Altlas cedar	78.75
Western Maâmora	Oubrahim (2015)	Cork Oak	40.84 – 77.70
Middle Atlas (Reggada)	Boulmane (2013)	Green oak	58
Middle Atlas (Tafchna)	Boulmane (2013)	Green oak	64
Oulmes Central Plateau (Zitchouene)	Ikraoun (2022)	Green oak	45.35
Middle Atlas (Jaaba)	El Mderssa (2019)	Zeen Oak	70.53
Middle Atlas (Azrou)	El Mderssa (2019)	Zeen Oak	51.71

Biomass expansion and conversion factors (BECF)

The value of the BECF for Cork oak within the studied area is 0.59. In the absence of specific values at national level, and compared with the 2006 IPCC generic value which ranges from 0.6 to 1.4 with an average of 0.8 used to date for carbon quantification in Morocco, there is not a significant difference between this IPCC (2006) generic value, adopted for the entire Mediterranean, dry tropical and subtropical forest climatic zone, and that specific to the cork oak of the Oulmes Central Plateau (OCP). The ratio between the two FECB values (FECB-OCP /FECB-GIEC) is 74%. It can be attributed to the high average age of the studied stands, which exceeds 100 years, where the BECF tends to decrease with the age of the stand as the density of the growing stock increases (IPCC 2006).

CONCLUSIONS

The present study aimed to estimate the dendrometric parameters, above-ground and below-ground biomass, the biomass expansion and conversion factor (BECF), the carbon fraction (CF) and the organic carbon stock contained in the cork oak ecosystem in the Oulmes Central Plateau. It also aimed to compare the values obtained with the generic IPCC values currently used for carbon estimates at the Moroccan national level.

The results obtained show that the above and under-ground weighted biomass of the cork oak of the Oulmes Central Plateau in the studied area amounts to 29.39 tDM/ha, a value that is explained by the low basal density of the wood of the species in question.

The resulting BECF value is 0.59 tDM /m^3. This is too close to the generic value proposed in the 2006 IPCC tables, which is 0.8 tDM /m^3; the ratio of the two values is 74%. For the carbon fraction, the value measured in the oak grove of the plots studied is 0.5648 tC/tMS. This is higher than the generic value proposed in the IPCC (2006) tables, which is 0.48 tC/tMS.

The forest ecosystem based on monospecific cork oak stands contributes its part to mitigating the effects of global warming, although the amount of organic carbon stored at this level remains low (59.72 t/ha) compared to other forest ecosystems.

The above-mentioned values, in spite of their differences with those recorded by the IPCC (2006), are very important, since they reflect more precise cases and will allow a more reliable assessment of the cork oak plant material at the level of other mountain ecosystems as well as of their carbon sequestration potential. Nevertheless, similar studies should be performed on other forest species in other national ecosystems.

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