Carbon sequestration potential of Eucalyptus and Acacia plantation in central areas of Iran

Seyed Armin Hashemi[1]

[1]Department of Forestry, Lahijan Branch, Islamic Azad University,Lahijan, Iran.
hashemi@liau.ac.ir

Abstract: Carbon sequestration potential of *Eucalyptus camaldulensis Dehnh* and *Acacia salicina Lindl* planted in 1980 was studied at the age of 30 years in the elevation plain areas of Iran. Two station of this plantation in province were selected the sample plots and the diameter at breast height of all trees was measured. At least, there trees from each diameter class were randomly selected and cut and different parts of the trees including, trunks, branches and leaves were separately weighed. The main roots of one tree from each diameter class were also nine collected and weighed. To estimate the man weight of litter per hectare, 40 sample plots of one square meter were randomly chosen and the amount of litter was determined. The percent of organic carbon in leaves and litter was also calculated in the laboratory. The amount of carbon sequestrated in the soil of plantation area was calculated and compared with control. This study showed that the amount of carbon sequestrated by *E.camaldulensis* in the productive site and poor site was about 8.2 and 1.73 ton $ha^{-1}year^{-1}$, respectively. On the other hand , for *Acacia salicina* in the poor site of this figure was 2.1 ton/ha in year. The highest the amount of sequestrated carbon in *E.camaldulensis* was in 30 centimeter diameter class. This figure for *Acacia* was in 25 centimeter diameter class. The amount of carbon sequestrated in different parts of the tree showed a significant difference at 0.01 also in *E.camaldulensis* , there was a significant difference in the amount of carbon sequestration between the suitable and poor sites. This study showed that there is a great potential of plantations in Fars province and similar areas of the country. This plantation will maintain suitable green areas and belts and produce wood materials for consumption in several ways. Forever planting trees will lead to the reduction of co_2 in atmosphere which reduces the greenhouse effect , a program which is university promoted and partially sponsored by united nations and some industrialized countries .

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1.Introduction

Researchers generally believe that the main factor of increasing the temperature of earth is Co_2 (Korner *etal*.,2003). From the time of beginning industrial revolution in 19 th century , the viscosity of carbon dioxide in atmosphere has reached from 280 to 365 section in million and its considered that in 21th century it would be reached to 600 section in million which this cause increasing medium annual temperature of the earth at the rate of 1C° to 4C°(Korner *etal*.,2003).However main part of carbon is holed by oceans and is kept as reserves , but studies show that the source of oceans are not so big that can reserve additional carbon in themselves and its residue should be reserved in land (Kenneth *etal.*, 2000). The main resources for reserving carbon are plants particularly forests .Forest ecosystems of the world in case of activity in order to reserve carbon, can hold about 2.3 gig ton carbon annually(Thampson *etal*.,1989). It's estimated that average rate of distributed co_2 from fossil fuels and change of the use of farms during 1980 by now is about7.6 milliard ton in a year(Dixon *etal*.,1994). Refining carbon by artificial methods such as filtration and etc include a lot of charges so that this expense in America has been measured about 100 to 300 $ for each ton carbon (Finer,1996). In this direction, industrial countries, have predicated prolonged programs in order to decrease the viscosity of carbon dioxide that in Kyoto conference, this problem was pronounced seriously and countries were obliged to reserve carbon by using particularly natural and artificial forests.

In this case of using plants and planting trees in the form of plantation we can not only create green place and produce wood or use other benefits of forest, but also can obtain the aim of reserving carbon. In most countries, considerable researches have been done for measuring the potential of fixing carbon and different methods for doing this in natural and planting forests and its continuing (Cannel *etal*.,1992 ;Dixon *etal*.,1994).

By accessed to the potential of reserving carbon in plantations of eucalyptus and acacia planted in this area , it will be provided a good background for developing plantation.

2. Materials and Methods

This study has been done in growing places of basin 21 from dividing the auriferous basins of center area of country .With due attention to ambrotermic curve of beginning and end moisture period is 20 Nov. and 15 Feb. respectively. Minimal absolute temperature is -2 Cº and maximum temperature is 45 Cº. There are two research stations of adaptation tests of different eucalyptus and acacia species have placed in the area of planting place were considered as sample plots.

Sample plots

For species eucalyptus according to adaptation of this species in all conditions of planting place , sample plots were selected in two planting place of weak and relatively fertile and *A.Salicina* due to the lack of planting in different planting place , forcefully was selected in a planting place of sample plots.

Measurement of biomass

In other to determine the situation of planted mass in selected sample plots from diameter at breast to accuracy of centimeter were measured hundred per cent , and all aggregated statistics were analyzed by using the soft wares Minitab and Excel and drawing the curve of number in diameter classes and height was done. According to the dispersion of number in diameter classes of existing trees , in each mass , minimal 3 trees from each diameter class were selected randomly within existing trees and marked with dye and after the cutting of different organs , were weighed with accuracy of gram. In order to estimate the existing litter under trees, 40 sample plots of one square meter under sample trees were chosen and existing litter were weighed with accuracy of gram. From each diameter class, one sample selected and all roots with the diameter more than 1mm were collected until the depth of 2 meter and were weighed. After generalizing obtained numbers to all existing trees, the weight of existing biomass weighed in each sample plots.

Determining conversion coefficient

From different organs of trees and litters of different mass, three samples delivered to laboratory and then in order to samples were placed into kiln after completely conversion to ash, these . These samples were weighed again. By determining the weight of ash and having initial weight and the ratio of organic carbon to organic materials, the amounts of organic carbon in each tree organs were calculated separately. Finally by having initial weight and percentage of organic carbon for each organ separately, conversion coefficient was calculated.

3. Results

Results of measuring different organs

The results of statistical analysis at the basis organs of cutter sample trees in the station number one as relatively fertile planting place and the station number two as a weak planting place have been presented in terms of ton in hectare in year in table 1. A: Eucalyptus relatively fertile growing place, B: Eucalyptus weak growing place.

Table 1 – Results about the production of biomass in different aerial organ in ton in hectare in year

aerial organ	total	Weight of litter	weight of root	Wet weight of leaf	Wet weight of lops	Wet weight of trunk
A	15.906	1.578	3.050	0.406	1.562	13.938
B	3.813	0.268	0.284	0.156	0.483	3.813
Acacia	3.981	0.205	0.066	0.146	0.508	3.327

Table 2-concersion coefficient of different organs to organic carbon (%)

Organ	trunk	lops	leaf	root	litter
species					
E.Camaldulensis	28.4	24.5	21.34	52.7	46.65
A.Salicia	34.25	28.59	16.85	53.36	47.99

Table 3-percent rates of organic carbon in different growing places (%)

Species	Growing place		Soil depth
	Weak	Relatively	
E.Camaldulensis	0.321	6.709	0-30
A.Salicia	0.175	-	0-30

Results of determining conversion coefficient of biomass to organic carbon

The results of the experiments about determination of conversion coefficient of wet weight of different organs of tree species to organic carbon in this project have been shown in table 2.It is necessary to note that between the obtained numbers for repeating the samples, meaningful difference was not observed.

Results of determining the amounts of reserved carbon in soil (*E. camaldulensis*)

By doing the experiment, of determining the amounts of organic carbon of harvested soil from different planting place and comparing with control

samples, the amounts of percentage of organic carbon in different growing places have been presented in table 3.

Results of the amounts of annual carbon sequestration

The results from the measurements and generalization of conversion coefficient in the region of the project at the basis of ton in hectare in year have been presented in table 4.

Table 4 the amounts of carbon sequestration (ton) in different parts of studied species

species	total	soil	litter	Root	leaf	lops	trunk
A	8.407	0.353	0.836	1.710	0.97	0.483	4.158
B	1.734	0.119	0.228	0.132	0.111	0.143	1.001
Acacia	2.1019	0.20	0.104	0.109	0.104	0.245	1.239

A: Eucalyptus relatively fertile growing place ,B: Eucalyptus weak growing place

Statistical analysis of *E. camaldulensis* in fertile growing place

The results from comparing between average carbon sequestrations in different organs of *E.camaldulensis* in this growing place shows that there is a meaningful percentage of difference between carbon sequestrations in different organs at level 1%. According to Danken test, the average amounts of carbon sequestration in different organs are placed in three classes. Average weight of sequestrated carbon in trunk with 164 kg is maximum rate and is placed in class A and sequestrated carbon in root with 75 kg is placed in class B and the weight of carbon in lops and leaf don't have any difference in one percent together and are placed in class C. The details of statistical analysis have been presented in tables 5 and table6.

Table 5 variance analysis of carbon sequestration in different organs of eucalyptus in relatively fertile growing place

Resources of change	Amount of F	Degree of freedom	Average square	Total squares
Organs	75.366**	3	190489.743	571469.230
Error		161	2703.292	400087.71
Total		164		971556.411

**Significant level 0.01

Table 6-Danken test, average carbon sequestration in different organ of eucalyptus

Organ	Class	**Average** weight of sequestrated carbon
The weight of carbon in trunk	A	29.4671
The weight of carbon in trunk	b	3.8846
The weight of carbon in leaf	C	1.0941
The weight of carbon in root	B	4.8933

Weak growing place

The results of comparing between the average carbon sequestrations in different organs of *E.camaldulensis* in this growing place shows that there is a meaningful percentage of difference between carbon sequestrations in different organs at level 1%. According to Danken test, average amounts of carbon sequestration in different organs are placed in three classes.

Average weight of sequestration carbon in trunk with 30.34is maximum rate and is placed in class A and sequestrated carbon in lops and root is placed in class B and don't have meaningful difference together in level 1 percent. Average weight of carbon in leaf with 1.1 is placed in class C. The details of statistical analysis have been presented in table 7 and table 8.

Table 7 variance analysis of carbon sequestration in

Resources of change	Amount of F	Degree of freedom	Average square	Total squares
Organs	532.955**	3	52521.824	147565.472
Mistake		1188	98.548	127075.478
total		1191		274640.950

different organs of eucalyptus in weak growing place

**Significant level 0.01

Table 8 Dankan test, average carbon sequestration in different organs of eucalyptus in weak growing place

Organ	Class	Average weight of sequestrated carbon
The weight of carbon in trunk	A	30.47
The weight of carbon in trunk	B	3.55
The weight of carbon in leaf	C	1.1
The weight of carbon in root	B	4.6

The species *A. Salicina*

The table of variance analysis between the weights of sequestrated carbon in different organs of *A. Salicina* planted in the region show that there is a difference at the level of 1 percent between the weights of different organs. According to Danken test , average amounts of carbon sequestration of different organs are placed in 3 class. Average weight of sequestrated carbon in trunk with 45.9 is maximum rate and is placed in class A and sequestrated carbon in lops with 6.3 is placed in class B and with the weight of root. At level 1, it doesn't have meaningful percentage of difference. Average weight of the carbon in leaf with 1.579 is placed in class C. Average weight of sequestrated carbon in root with 4.34 is placed in class B C and doesn't show a meaningful percentage of difference at level 1% with leaf and lops. The details of statistical analysis have been presented in tables 9 and table 10.

Table 9 – variance analysis of the amounts of sequestered carbon in different organs of acacia in

Resources of change	Total squares	Degree of freedom	Average square	Amount of F
Organs	124724.397	3	4154.799	109.337**
Error	389370.845	1024	380.245	
total	514095.242	1027		

**Significant level 0.01

Table 10- Dankan test, carbon sequestration in different organs of acacia

Organ	Class	Average weight of sequestrated carbon
The weight of carbon in trunk	A	45.9
The weight of carbon in trunk	b	6.3
The weight of carbon in leaf	C	1.579
The weight of carbon in root	B	4.34

Discussion

The results of this research showed that species *Eucalyptus camaldulensis Dehnh* and *Acacia Salicina Lind* I can thoroughly located in rigid regions and play an efficient role in relation to carbon sequestration. Analyzing collected information and statistics in relation to studied species in this research show that *E.Camaldulensis* in the station which due to suitable depth of soil and coming up of underground waters , is as a relatively fertile growing place which after so years could produce the amounts of 20.534 ton biomass that by considering the litter poured under trees and the amounts of carbon added to soil as compared with control region could reserve the amount of 8.2 ton organic carbon in hectare in year.

In the station due to stony soil and coming down of underground waters , as a result of lower fertility as compared with the station as a weak growing place, planted eucalypts has relatively weak growing condition so that after 30 years could produce amounts of 4.4 ton biomass. By considering the litter and existing carbon in soil , these samples have reserved totally 1.1 ton organic carbon in hectare in year. The acacia, after 30 years could produce amounts of 4.253 ton biomass. By considering the litter and existing carbon in soil, totally these samples have reserved 1.5019 ton organic carbon in hectare in year.

From the view of the share of each organs in carbon sequestration 50% of the production of biomass has been allocated to trunk wood that in this research in eucalyptus in both growing place is also close to 50 but acacia biomass with 75% relative to announced numbers in references , has meaningful difference which is considered that the reason being the decrease of the production of leaf , root and lops , like wise being pure in mass and being low the plants under floor can be also major reasons(Watson *etal*.,,2000) . The amounts of sequestrated carbon by soil of two studied species in eucalyptus biomass are 0.227 and 0.131 ton in hectare in year respectively and in acacia biomass is 0.90 ton in hectare in year which there is a meaningful difference in comparing between two species. In relation to high difference between the amounts of sequestrated carbon in soil, of acacia and eucalyptus and being low in it , it seems that the availability of higher nitrogen in under floor soil of acacia as a result of high speed in mineralizing organic carbon cause the amounts of sequestered carbon relative to available soil under floor of eucalyptus be low. In relation to the amounts of produced litter under floor of studied species, it seems that according to the ability of fertility in studied growing place and species combination of studied biomass, acceptable rates have been estimated.

The amounts of produces litter depends on major factors like type of species , climate , fertility of growing place and ability of production so that for different species in different growing places , different numbers have been presented(Watson *etal*.,2000).

In relation to obtained coefficients in order to convert wet weight of biomass to carbon at the basis of previous researches , conversion coefficient was considered 21% for needle – leaf trees and 24% for wide – leaf trees (Thampson *etal.*,1989). Also in another research , total conversion coefficient of the weight of dry wood to carbon has been considered

50% and certain weight of needle – leaf trees has been estimated 350 kg /m3 and for wide – leaf trees 550 kg/ m3 (Kilbride *etal.*,1999).

In this study also at the basis of measurements, different numbers were obtained for different organs. Table 2 which minimum percentage is related to leaves and maximum percentage is related to roots which is seems that the decrease of conversion coefficient in leaves is due to the amounts of minerals in leaves are high. The reason that conversion coefficient is high in acacia is probably low amounts of water in roots. Generally , conversion coefficient of produced biomass in all above organs and underground of eucalyptus has been calculated 34% and for acacia this amounts are 35.6% which is more than announced average in references.

By considering aerial organs singly, conversion coefficient for eucalyptus is 27.6% and for acacia is 30.7 which it seems that the reason of its increase rather than announced rates, in references, is dryness of studied regions and being low of moisture of produced organs (Finer ,1996).

In relation to the amounts of root production , we should say that because of good permeability of soil in studied area , the volume of produced root specially in eucalyptus is very well which according to the limit of studied depth with considering available roots in lower depth , the volume of real production of root is more than calculated numbers. In relation to the amounts of total carbon sequestration in different forest masses, we should say that there is a direct relationship between sequestered carbon with the type of species, fertility of growing place, cultivating operations and forestology which is done during life period of trees (Dewar *etal.*,1992). In the studied region because of the lack of doing cultivating operations in planted biomass and near distance of trees, we can increase the growing of trees.

Generally , according to complex subjects in natural ecosystems and problems such as mineralizing organic materials , impact of climatic factors and other factors on absorption of Co_2 in trees , wider researches in this era seems necessary .

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Corresponding Author:
Dr. Seyed ArminHashemi
Department of Forestry
LahijanBranch
Islamic Azad University
Kashef Street, Postal Code:1616, Iran
E-mail: hashemi@liau.ac.ir

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