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ORIGINAL ARTICLE

The Study of Vegetation Effects on Organic Carbon Storage and Soil Features, (case study: Gilan, Safrabesteh)

P. Shahsavari[1], A. Golchin[2] and A. Mousavi Coper[3]
[1]MSc. Student, Zanjan University, Iran
[2]Department of Soil Science, University of Zanjan
[3]Academic Research Center Poplar Safrabasteh Threshold, Iran

ABSTRACT
The type of vegetation may have an impact on the change of the amount of carbon to soil organic carbon storage and soil quality. Due to investigating the effect of vegetation on soil organic carbon storage and soil features, a region with four different vegetation types in the Snobar Research Station has been chosen. In the mentioned region, In addition to the existence of two types of ethnic vegetations, Taxodium distichum and Populus caspica, we had two imported vegetations in the name of Snobar, Populus deltoides M. 77/5 and Populus x euramericana (Dode) Guinier cv. I - 214 which has been replaced by ethnic vegetation for the period of 20 years, were studied. Soil under different vegetation to a depth of one meter and three replicates were sampled and organic carbon storage and soil properties at different depths were studied. The results of a factorial experiment in a randomized complete block design were analyzed. Results showed that the bulk density, electrical conductivity, reactivity and amount of soil organic carbon in different coverage of ethnic forest have got significant difference at the range of one percent level. But there was no significant difference in the amount of lime in the different overages. The maximum amount of soil organic carbon at depth zero to one meter in the coverage of Populus deltoides M, 77/5 was observed, but the maximum amount of organic carbon at a depth of zero to twenty centimeters of the soil covered of Taxodium distichum, 3/59% has been measured. The amount of carbon sequestration in soil in the coverage of Populus deltoides M. 77/5, was 71/85 tons per hectare, which was more than any other coverage.The least amount of carbon sequestration equivalent to 29/73 tons per hectare in the depth of Taxodium distichum coverage was calculated. Then the greatest amount of organic soil fractions of sand equivalent 38/54 tons per acre of soil in Populus deltoides M. 77/5 was calculated.
***Keywords**: Organic carbon, Fractionation of organic, Safrabasteh, Nitrogen*

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INTRODUCTION

Carbon dioxide is one of the most important greenhouse gasses, therefore, has a very important role in absorbing the output reflection from the earth and includes almost half of greenhouse gasses around the earth [1]. Due to increasing industrial and population development in cities and high consumption of energy and fossil fuels, a high amount of carbon dioxide daily enters the atmosphere along with other greenhouse gasses [2]. These factors have caused carbon dioxide cycle imbalanced and the amount of carbon dioxide has increased in the atmosphere. If the balance of carbon dioxide won't be corrected at the proper time, climate changes [3], increase in the earth temperature and unpredictable occurrence may occur in the atmosphere [4]. What is clear is, the available technologies are not able to reduce carbon dioxide in the air, and the industrial countries are looking for not only producing lower carbon dioxide, but also reducing the carbon dioxide existing in the air [5]. Carbon dioxide absorption by plants and restoring it as humus in the soil or carbon sequestration is an appropriate strategy to reduce the impacts of greenhouse gasses [6].

Kyoto Protocol (1997) considers soils as a reservoir to reduce CO_2 and recommends increasing carbon sequestration in them [7]. Carbon sequestration is to convert carbon dioxide as organic carbon by plants and capture if for a certain time in the soil and pant body [8]. In other words, carbon sequestration in soil

is to increase density or organic carbon storage in soil [9]. Doing management practices for carbon sequestration not only requires fundamental changes in land management, but also, by increasing the organic matter, leaves direct and dramatic impacts on soil status, agricultural qualities, environmental and biodiversity which result in appropriate increase infertility and productivity to make a suitable strategy in order to establish food safety and reduction in negative impacts of global warming [10].

By increasing the potential dry matter production sin different plant species in different habitats and fields, carbon storage becomes higher in soil, plant litter and body. On the other hand, by decreasing the speed of carbon decomposition and losing from soil and plant litter and body, the stored carbon in ecosystem and soil increases as well as the amount of carbon sequestration [11]. The amount of carbon storage per time unit depends on the characteristics of plant species growth, management methods, land use changes, type of reducing operations, soil physical and biological conditions and former carbon storage [12]. Baldock *et al*. [13] believe that, organic carbon accumulation in various depths of the soil depends on the amount of humus, canopy area and the current plant species.

By investigating the effect of various tree species and specially hardwood species on the amount of organic carbon and nitrogen in temperate forests it was found that, the tree species significantly affect the amount of organic matter and its decomposition and destruction particularly in surface layers of the soil [14]. Carbon storage till the depth of 40 cm in managed forests, forests with conventional management and rangelands will be 335, 145 and 46 tons/ha respectively [15]. Dung *et al*. [16] compared carbon sequestration of hardwood and softwood forest masses and concluded that, hardwood carbon sequestration potential is higher than softwoods. Varamesh *et al.* [17] conducted a study on locust and ash masses in Chitgar forest park in Karaj city. They showed that, the total sequestrated carbon per area unit was 78.19 and 48 tons/ha respectively for locust and ash while this value was 10.8 tons/ha for the control pasture. The amount of soil organic carbon under the mentioned coverage at the depth of 15 cm was higher than the depth of 15-30 cm. Results of a study conducted by Diaze *et al.* [18] in six regions of Spain under two tree covers of Poplar and Oak showed that, the soils covered by Poplar had higher amount of organic carbon compared to oak. Also, the maximum carbon storage was observed at the surface layer of 0-5 cm. The ratio of C/N and total nitrogen at the layer of 30-50 cm was significantly higher in the soil covered by Poplar.

Land use change, different management practices and planting various plants instead of native covers have caused to change the fate of organic carbon in soil. Mejaliwa *et al.* [19] reported that, cultivation and working in forest lands caused to waste soil carbon in the early years of land use change and then, the amount of mineralized nitrogen was reduced. Hu *et al*. [20] studied the effect of forestation by pine and poplar in the grasslands and concluded that, forestation n grasslands led to increase of carbon sequestration.

Nowadays, fractionation and isolation of primary particles and soil organic matter have been carried out in order to accurate study and higher understanding of soil organic matter traits, importance of carbon sequestration in soil and behavior of behavior of organic - mineral complexes created by organic matter [21]. Despite chemical separation of organic matter, minerals are not eliminated in physical separation, and some information are given about the position of organic matter in the soil mineral context [22]. Also, in the physical method, lower destructive impacts enter the soil organic matter [23]. Theory of physical fractionation of organic matter based on the particles' size is that, primary articles of sand, silt and clay are composed from different minerals with different mineralogy [24]. Hence, the organic matter composed with these particles have different chemical compound and dynamic. Accordingly, the organic matter complexes with these particles are divided into three parts of sand, silt and clay. In the present research, it has been attempted to study the impact of vegetation cover type on organic matter storage and physical and chemical traits of the soil by investigating the qualitative traits of soil and organic matter storage in various depths of soil and calculating their carbon sequestration.

MATERIALS AND METHODS

The studied area is located in poplar research station of Safrabasteh in geographical position of 49^0 57' to $49^0$69' of eastern longitude and $37^0$22' of northern latitude. Mean annual precipitation was 1186.6 mm, mean temperature was 17.7 ^{0}C and it was 12.5 m above sea level. The region soil had been formed by alluvial sediments with fine texture which has been deposited by overflow and its gentle flow. Soil moisture and temperature regimes were iodic and Mesozoic. The studied vegetation cover and land uses included three types of poplar forestations (*Populus caspica, Populus deltoides* M. 77/5, *Populus x euramericana* (Dode) Guinier cv. I – 214) and one species of softwood named *Taxodium distichum*.

In order to study the effect of vegetation cover and soil depth on organic carbon storage and physical and chemical characteristics of soil, a factorial test was performed as randomized complete blocks layout with

three replications and 20 treatments. Soil samples were taken and sieved from various soil depths (0-20, 20-40, 40-60, 60-80 and 80-100 cm).

Table 1 - vegetation cover in the study, age and symptoms in

Mark covers	Age of cover	Type of vegetation
A	20 years	*Populus x euramericana* (Dode) Guinier cv. I – 214
B	20 years	*Populus deltoides* M. 77/5
C	More than a hundred years	Populus caspica
D	More than a hundred years	*Taxodium distichum*

Organic carbon by Walky and Black method, nitrogen by Kjeldahl method, equivalent calcium carbonate by back-titration method of hydrochloric acid with sodium hydroxide, saturated clay soil reaction, electrical conductivity and bulk density in the soil extracts using a small lump were measured [25].For fractionation of organic matter, 50 gr of so was taken from 0-20 and 20-40 cm and was thrown in a balloon along with 200 ml distilled water. Then, the soil was dispersed using ultrasonic device so that, the amount of achieved clay was as much as the clay measured from the soil texture [26]. Then, the dispersed soil was sieved by a 0.05 sieve to remain sand particles. After that, the sand particles were washed, dried and weighted. The remained silt and clay were thrown in a one-liter scaled cylinder and theses particles were separated according to Stokes' law and siphoning off the upper10 cm of the cylinder. Data analysis and mean comparison of the effect of various vegetation cover types on soil qualitative traits in different soil depths was conducted using SPSS software Version 19, and statistical test of data significance was carried out using Duncan test at probability levels of 1% and 5%.

RESULTS AND DISCUSSION

According to the morphological observations, the soils covered by poplar were categorized as in ceptisolsunder iodic class due to having iodic moisture regime and the lack of subsurface identification horizons and thick malic. Surface horizons had the characteristics of malic horizon except of adequate thickness and were classified in the big group of Humudepts, and they were paced under Typic Humudepts group due to the lack of vitric, volcanic material, aotuic and other characteristics. Intrinsic properties of the soil in the studied area including soil texture class were same and loam.

Table 2 - Analysis of variance vegetation type and soil depth effects on some physical and chemical characteristics of soil

Source	df	Mean Square				
		OC (%)	$CaCO_3$ (%)	pH	EC (dS/m)	pb (gr/c m^3)
Vegetation	3	1.83**	61.18 ns	0.15**	3.12**	0.07**
Soil depth	4	8.56**	6.20*	0.29**	0.18*	0.46**
Vegetation* Soil depth	12	0.28**	4.66*	0.02	0.17*	0.02 ns
Error	38	0.056	1.20	0.02	0.06	0.01
CV	-	12.62	8.20	2.06	13.73	6.25

* And ** respectively significant at the 1%, 5% and ¬ ns means not significant differences

As the table of data variance analysis shows, organic carbon percentage in the soil covered by different soils has a significant difference at probability level of 1% (Table 2). Also, the difference of various depths was significant in terms of organic carbon which was resulted from interaction of various forest covers and soil and the power of creating different conditions of decomposition and storage of organic matter in the mentioned soils. Pouladi *et al.* [27] conducted a study in on alder and poplar cover in Safrabasteh region in Gilan province and showed that, the amount of organic carbon measured in surface horizons of the soil covered by alder was higher than poplar but, this difference was not significant statistically. They stated that, the type of forest cover had no direct impact on the amount of organic carbon. The most irritant factors affecting the amount of organic matter of the soil in forest region have reported as the dominant tree species in the area, the culture history of the area, soil properties and soil microbial activity indicators. Correlations showed that, the tree species was more effective on this trait than the other factors. The results showed that, bulk density, electrical conductivity and soil reaction in different

vegetative covers and soil depths had a significant difference at probability level of 1%. Difference in the values of bulk density and soil reaction is probability due to the difference in the amount of soil organic matter. These results were consistent with Onweremadu *et al.* [28]. Despite these traits, the values of calcium carbonate had no significant difference in various covers.

Estimation of carbon storage

Table 3 Interaction of forest cover and soil type on the concentration of organic carbon storage

Vegetation	Soil depth (cm)	OC (%)	carbon storage (ton/ha)	
A	0- 20	2.40d	81.49bcd	243.18c
	20- 40	1.59e	54.99efg	
	40- 60	0.75f	30.25h	
	60- 80	0.76f	30.69h	
	80- 100	0.78f	34.21gh	
B	0- 20	2.94ab	91.87abc	375.55a
	20- 40	2.77c	94.22ab	
	40- 60	1.77e	64.79def	
	60- 80	1.61e	62.98def	
	80- 100	1.03f	45.42fgh	
C	0- 20	3.15b	103.12ab	360.64a
	20- 40	2.30d	81.63bcd	
	40- 60	1.84e	69.41cde	
	60- 80	1.64e	62.45def	
	80- 100	0.87f	34.78gh	
D	0- 20	3.59a	111.71a	304.48b
	20- 40	1.76e	55.14efg	
	40- 60	1.50e	49.09efg	
	60- 80	1.06f	41.39fgh	
	80- 100	0.73f	29.73h	

Means that a common word , there was no statistically significant difference

As it is seen in Table 3. The maximum amount of organic matter was measured at the depth of 1 m in *P. deltoides M. 77/5* poplar cover. While, the maximum value of organic carbon at the depth of 0-20 cm was 3.59% in the soil covered by cedar which had a significant difference to the other soils. This value is due to the existence of high values of fine and very fine roots in the surface horizons, as well as the lack development in underside parts [27]. In all the soils, more than 50% of organic carbons are at the first two depths (40 cm of the surface soil) which are due to the existence of particle organic matter and new and semi-decomposed organic matter which include microbial straw litter and foliage. Onweremadu *et al*. [28] indicated that, the amount of carbon and nitrogen was higher at the depth of 20 cm from soil surface than the underside grains. Sinoga *et al.* [29] studied two depths of soil (0-5 and 10-15 cm) in the south of Spain and they observed that, the amount of organic carbon at the depth 0-5 cm was higher than 10-15 cm in all the studied areas but, the opposite state was observed in arid lands [17].

The estimated carbon storage in the soil covered by deltoides M. 77/5 poplar with mean value by 71.85 was higher than the others but, it had no significant difference tocaspca alder. The maximum amount of carbon storage in all covers was for the first soil depth covered by *Taxodium cedar* by 111.71 tons/ha which had a significant difference to the other soils. Also, the minimum value of soil organic carbon was calculated by 29.73 tons/ha at the last soil depth of Taxodium cedar. Pouladi *et al.* [27] studied two pure masses of *Taxodium distichum* and a blend of poplar and alder in research station of Safrabasteh in Gilan province. They showed that, weight mean of the grains' diameter, bulk density and hydraulic conductivity of the soils in two sections had a significant difference at probability level of 1%. The amount of carbon stored in organic and mineral layers of poplar-alder mass was measured by 112.5 and 85.73 tons/ha and this value was 123.07 tons/ha in *Taxodium distichum*.

Carbon storage was dramatically decreased from surface toward higher depths in the soil under all covers. This reduction is due to the decrease of organic carbon in deeper points which is much more than the increase of bulk density. Caspica spruce cover is related to the native spruces of the region with over hundred years old; therefore, they have had enough time to store organic carbon in the soil, and carbon storage in the soil has been conducted at the soil depths. Beside it, deltoides M. 77/5 poplar cover had a considerable amount of organic carbon at various soil depths due to greater ability of shoots and roots in carbon uptake [30]. The investigations showed that, hardwood forests have greater ability for carbon

dioxide absorption and organic carbon storage in the soil, and changing softwood forests to hardwood forests can enhance carbon absorption [31].

Table 4 - Analysis of variance on the effects of vegetation and soil organic carbon, nitrogen, carbon to nitrogen ratio and carbon content of the different fractions

Source	df	Mean Square											
		Sand				Silt				Clay			
		Organic carbon (%)	Total nitrogen (%)	C/N	Organic carbon in the Sand fraction (ton / ha)	Organic carbon (%)	Total nitrogen (%)	C/N	Organic carbon in the Silt fraction (ton / ha)	Organic carbon (%)	Total nitrogen (%)	C/N	Organic carbon in the Clay fraction (ton / ha)
Vegetation	3	0.24**	0.001**	74.26**	64.80*	0.53**	0.01ns	11.24ns	299.82**	1.54**	0.01ns	8.36**	346.41**
Soil depth	1	5.1**	0.006**	1.59ns	737.04**	3.69**	0.03*	25.67ns	91.57*	4.80**	0.06**	0.07ns	311.11**
Vegetation* Soil depth	3	0.19**	0.01**	7.99ns	41.36ns	0.04ns	0.01ns	20.00ns	35.11ns	0.13*	ns01/0	1.04ns	15.20ns
Error	14	0.01	0.001	3.70	14.45	0.02	0.01	12.13	9.08	0.03	0.001	0.60	25.96
CV	-	2.54	8.33	9.91	10.71	7.84	12.14	11.49	10.46	6.64	9.88	9.64	12.18

* and ** respectively significant at the 1%, 5% and ns means not significant differences

Fractionation of organic matter (based on particle size)

Fractionation of organic matter is an effective step in determination of organic-mineral complexes behavior. The table of data variance analysis (Table 4) shows that, organic carbon percentage in fractions of sand, silt and clay and various covers and depths has a significant difference at probability level of 1%. But, carbon to nitrogen had a significant difference at probability level of 1%. In fraction of sand and clay. Organic carbon in fractions of sand, silt and clay had a significant difference in different forest covers.

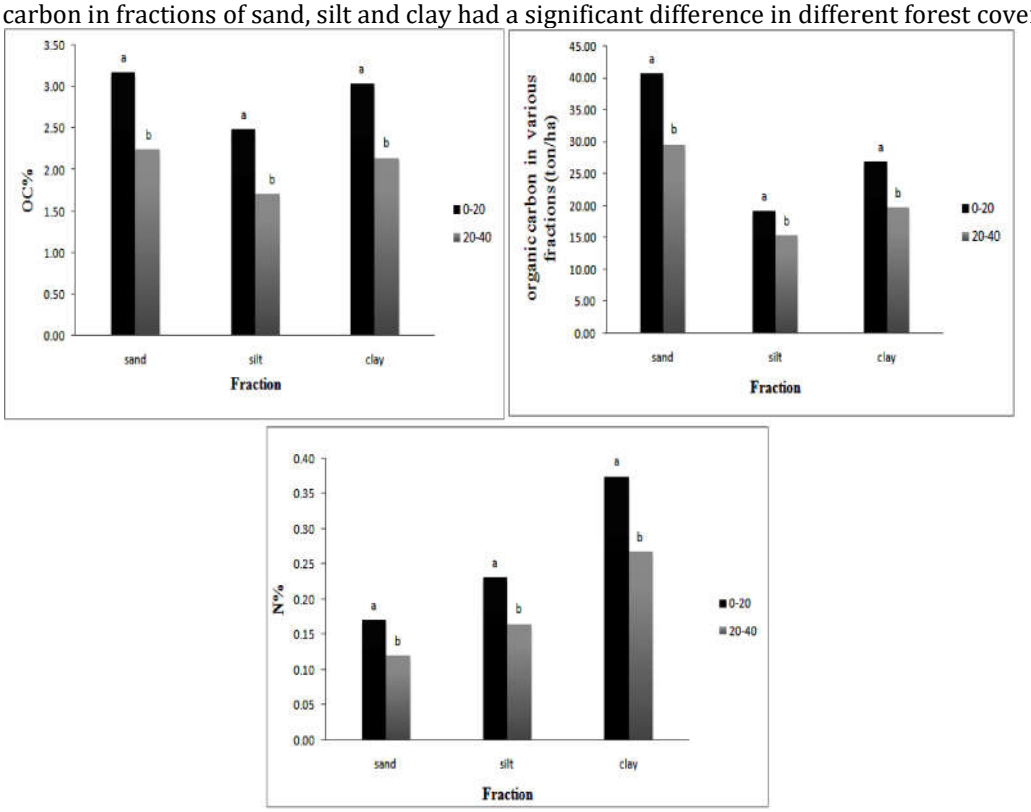

Fig 1. Mean comparison of organic carbon percentage, total nitrogen and the amount of organic carbon in various fractions (ton/ha) and at the depths of 0-20 and 20-40 cm (means comparison is based on Duncan test).

As it is seen in Fig. 1, the values of organic carbon at the depth of 0-20 cm are higher than 20-40 cm in all the fractions. Organic carbon in sand part at the depth of 0-20 cm had the highest value (40.76 tons/ha) compared to silt and clay. This amount of carbon in sand part is probably due to the existence of free and

semi-decomposed particle organic matter. These particles are separated along with this fraction due to being as big as sand [32]. The maximum amount of nitrogen at the depth of 0-20 cm is equal to 37% of clay fraction which is has a 20% reduction in sand fraction.

Table 5 - Comparison of the average percentage of organic carbon, total nitrogen, carbon to nitrogen ratio and organic carbon in the sand, silt and clay fractions influence of Vegetations

Vegetation	Sand				Silt		clay	
	Organic carbon (%)	Total nitrogen (%)	C/N	Organic carbon in the sand fraction (ton / ha)	Organic carbon (%)	Organic carbon in the silt fraction (ton / ha)	Organic carbon (%)	Organic carbon in the clay fraction (ton / ha)
A	2.43c	0.10b	23.28a	29.40b	2.02b	25.68a	1.91c	16.60b
B	2.70b	0.16a	16.76b	38.54a	1.72c	20.44a	2.73b	16.90b
C	2.82ab	0.13ab	21.50a	38.51a	2.28ab	11.19b	2.61b	26.76a
D	2.88a	0.18a	16.13b	32.05ab	2.39a	11.59b	3.12a	30.06a

Means that a common word , there was no statistically significant difference

Organic carbon in sand fraction is much important in terms of structure and nutritional traits and can be mentioned as an important index in comparison of the impact of various vegetation covers on the soil nutrition and fertility and releasing various food elements for the plant [33]. The maximum amount of organic carbon (2.88%) of sand fraction was in the soil covered by *Taxodium cedar* which had no significant difference to caspica poplar (Table 5). As it was mentioned, the cause of this amount of organic carbon in this vegetation cover is the existence of much values of fine and very fine roots under this cover as well as high ability of this vegetation cover in returning organic matter to the soil. deltoides M. 77/5 poplar has stored higher amount of organic carbon in sand fraction compared to euramericana I-214 poplar. The maximum amount of organic carbon of sand fraction per hectare was observed jointly in the soils covered by deltoides M. 77/5 and caspica poplar which had no significant difference to Taxodium cedar. The maximum amount of organic carbon in cay fraction was for the soil covered by Taxodium cedar (3.12). Organic carbon in this fraction is sticking to the clay surface and is resistant against decomposition and is decomposed very slowly [32]. On the other hand, due to high specific area of clay, microbial enzymes and organic matter are absorbed by these particles and become inactive [33]. Increase of organic carbon in the fine part of the soil shows that, the soil organic matter has high humus degree in this part [34].

The maximum amount of nitrogen was in the soil covered by *Taxodium cedar* in all the three fractions (sand, silt and clay). This vegetation cover and poplar need high amounts of nitrogen but, the results of this research showed that, the ability of *Taxodium cedar* in providing nitrogen was higher than the others. The ratio of carbon to nitrogen of sand fraction in Taxodium cedar cover was 16.13 which was the minimum value among the vegetation covers. This low ratio is due to high amount of nitrogen. Low ratio of carbon to nitrogen represents the existence of high amount of new and se-composed organic matter which is an important index in the subject of organic matter decomposition and nitrogen mineralization [19].

Table 6 - interactions between forest cover and soil depth on the percentage of organic carbon and nitrogen

Vegetation	Soil depth (cm)	Sand	
		Organic carbon(%)	Total nitrogen (%)
A	0-20	2.91c	0.12bc
	20-40	1.95f	0.09c
B	0-20	3.01bc	0.18ab
	20-40	2.39d	0.14bc
C	0-20	3.17b	0.14bc
	20-40	2.47d	0.12bc
D	0-20	3.59a	0.24a
	20-40	2.18e	0.13bc

Means that a common word , there was no statistically significant difference

Results of the interaction of cover type and soil depth on organic carbon percentage and nitrogen in sand fraction showed that, the maximum value of nitrogen and organic carbon of sand fraction was for the first soil depth covered by Taxodium cedar (Table 6).

CONCLUSION

What found from this research is that, softwood and hardwood covers have different ability to store organic carbon in soil. Mostly, hardwood covers particularly poplar, have a considerable role in carbon sequestration in Iran. The soils covered by *Taxodium distichum* as a softwood, higher organic matter was stored particularly at the depth of 0-20 cm compared to some poplar covers studied in this research, which indicates high power of these trees to conduct this process. Study of organic carbon in sand, silt and clay fractions in the soils covered by various forest covers showed that, deltoides M. 77/5 poplar had a high ability to return and store organic carbon in the soil.

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