CARBON SEQUESTRATION IN SOILS AFFECTED BY DOUGLAS FIR REFORESTATION IN APENNINES (NORTHERN ITALY)

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Abstract

Douglas fir reforestation plays an important role in Italian forest because no indigenous conifer has similar characteristics of productivity and timber quality. Few studies on physicochemical properties of soils under Douglas fire are noticeable. The aim of this work is to evaluate the organic C stock into soils under Douglas fir plantation in different selected areas. The areas of study are located in the North Apennine (Italy); Corno alle Scale (COR), Vallombrosa (VAL), Mulino Mengoni (MEN), respectively are chosen for the presence of Douglas fir reforestation of 60 years old. Two soil profiles for each area have been open and described. The pH value decreased along the profile depth. The organic C amount in organic layers was higher in Val and Men pedons than that determined in COR one. Higher amount of organic C were detected in organo-mineral horizons of Co pedons, highlighting a rapid turnover of soil organic matter. The C stock calculated in the first 30 cm of soil showed that the higher C amount is stored in highest altitudes profiles (COR6 and VAL6) than the other. The soil are classified as Lithic Dystrudepts in the highest altitudes (COR 6, 7 and VAL 6, 7, respectively) while as Humic Dystrudepts in MEN (4 and 5) pedons. We conclude that no dangerous effects on soil quality of Douglas fir were investigated and they seem to be similar to those of native tree species, even if other different aspects should be investigated.

Keywords: *Douglas fir, North Apennine, Dystrudepts, C sequestration*

Introduction

Douglas fir (*Pseudotsuga menziesii* [Mirb.] Franco) is a forest species naturally occurring in the North America and one of the premier timber trees. It is common in many temperate regions of Australia, New Zealand and South America, while it has been introduced in Europe (Hermann and Lavender, 1999), suggesting a continue spreading due to climate change. In Europe, in the second half of 1900, the production of high-quality wood has led to a major forests exploitation in which the native deciduous species were replaced with monospecific conifer plantations, often of exotic origin, characterized by high productivity (Lejon et al., 2005). From an ecological point of view, cultivation of Douglas fir in Europe is likely to have a significant impacts on forest ecosystems, particularly in case of stands of pure Douglas fir and with high density of this species over large areas (Schmid et al., 2014). A concern has been raised when Douglas fir replace species-rich and

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threatened ecosystems such as forest glades and heathlands (Fagúndez, 2013). Several cases have been shown that exotic and invasive organisms can alter ecosystems, landscapes and ecosystem services (Schmid et al., 2014). The increasing productivity of forest plantations is often achieved by nitrogen fertilization and it accelerated carbon sequestration into forest wood (Barclay and Brix, 1985, Johnson and Kern, 1990, Smith et al., 1993, Adams et al., 2005 and Magnani et al., 2007). Forest ecosystems are diverse and complex and the forest floor constituents play a very important role in the productivity of forest soils. The forest floor acts as a system of nutrient input-output. The differences from broadleaved and conifers are associated with changes in forest floor and mineral soil properties (Vittori Antisari et al., 2011; 2013). Douglas-fir plays an important role in Italian plantation forestry because, within its optimal vegetation zone ranged from 600 to 1000 m a.s.l., no indigenous conifer has similar characteristics of productivity and timber quality (Corona et al., 1998). The forest management in many areas of the Apennines is failed with the consequent abandonment, no-renewal and degradation of forests (Vittori Antisari et al., 2015). In this framework, the aim of this work was to evaluate the C sequestration of soil affected by Douglas fir abandoned reforestation. The Douglas fir stands are selected in different areas of North Apennine (Italy) and at the same age class (60 year old).

Materials and methods

Study area location

Three different areas in the North Apennines are chosen on sandstone and the 6 distinct pedons were studied. The study areas have quote at 900- 1200 m a.s.l. and they are located between Castanetum and Fagetum phytoclimatic zone. Two different soil profiles (MEN 4 and MEN 5) have been studied and this area is at 925–935 m above sea level (a.s.l.).

Phytoclimatic Zone *(Vegetation)*	Profile	Geographical coordinates WGS84 UTM-32T reference system		Elevation m asl
Fagetum zone, warm subzone *(Douglas fir reforestation)*	COR6	645388 E(m)	4889537 N(m)	1231
	VAL6	700657 E(m)	4845233 N(m)	1152
	VAL7	700651 E(m)	4845218 N(m)	1100
	COR8	653544 E(m)	4889473 N(m)	1038
	MEN5	683446 E(m)	4894510 N(m)	926
	MEN4	683431 E(m)	4894583 N(m)	925

Table 1 *Localization of soil profiles.*

They are formed and developed on the Monghidoro sandstone formation. The other four soil profiles are formed and developed on Mt Cervarola sandstone formation, two were sampled in Vallombrosa Forest (VAL6 and VAL7). The Vallombrosa Forest is a State Natural Reserve Biogenetic, entered the Official List of protected areas in accordance with Law 394/91 at the same time, is part of the Natura 2000 network being included within the Site of Community Importance "Vallombrosa Forest” and St. Anthony (code IT5140012), also classified as a Site of Regional Importance (SIR). The other two were sampled at Corno alle Scale mountain (COR

6 and COR 8), which is located in the northern Emilia-Tuscany Apennines (Italy). The soil profiles location and their elevation are shown in Table 1.

Soil analyses

Measurement and estimation of bulk density. From the undisturbed soil core the bulk density (BD) of the fine earth (<2 mm) of each fixed-depth mineral layer (0-5, 5-10 and 10-20 cm) was quantified from the mass of the oven-dry soil (105° C) divided by the volume of the soil cores (Blake and Hartge, 1986).

Physicochemical analysis. All the samples obtained by the genetic horizons were air-dried and sieved (<2 mm), and the soil analyses were carried out on the obtained fine earth fraction. The pH was determined potentiometrically in a 1:2.5 soil:deionised water suspension. The texture was obtained by the pipette method after dispersion of the sample with a sodium hexametaphosphate solution (Gee and Bauder 1986). Total organic C and total N content was determined by dry combustion (EA-1110 Thermo Scientific Lab). The cation exchange capacity (CEC) was determined after exchange with 0.05 N cobalthexamine chloride solution (Orsini and Rèmy, 1976, modified by Ciesielski and Sterckeman, 1997). The exchange acidity was determined in KCl 1M. The total element concentrations (Fe, Al and Ca) were measured by Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES, Ametek, Spectro) after HNO_3:HCl (1:3 v:v, suprapure Merck) microwave digestion of samples (Vittori Antisari et al., 2011). The total extractable carbon (TEC) and the fractions of humic acids (CHA) and fulvic acids (CFA) were determined by wet oxidation at 160 °C with $K_2Cr_2O_7$ 1/3 M , according to the method Springer and Klee (1954). The total extractable C (TEC) was extracted with a solution of NaOH 0.1 M and 0.1 M $Na_4P_2O_7$ at 65 °C for 24 h. The HA fraction was separated from the FA by precipitation at pH < 2 of total extract; the FA was separated from the non-humified organic material by chromatography with solid resin of polyvinilpyrrolidone (PVP) according Ciavatta et al. (1990).

C sequestration. The SOC stock was calculated for each horizon of the profiles according to Eq. 1 (Boone et al. 1999):

$$y = a * b * c * d \qquad [1]$$

where y is the SOC stock per unit area (kg C m^{-2}),a is the C concentration in the sample (kg Ckg-1), b is the soil bulk density (kg soil m^{-3}), c is the depth of the horizon (cm) and d is the percent in mass of rock fragments [1-(% rock volume/100)].
All the SOC stocks were calculated for the mineral soil only, since information about the organic horizons were unfortunately missing. This obviously has to be considered since organic horizons contain a considerable amount of C.

Results and discussion

Soil pedons are commonly differentiated into a succession of horizons based on observable differences in soil color, texture, structure, or other characteristics, which are essentially associated with or determined by the chemical composition of soil

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materials. The representative soil profiles were opened and described (Table 2) according to Schoeneberger et al. (2012).
The soils showed a limited thickness with a lithic contact within 50 cm of the mineral soil surface and the Bw horizons were developed between 13 to 20 cm (Figure 1). The higher deepening of sum of A horizons was observed in Val6 pedon.

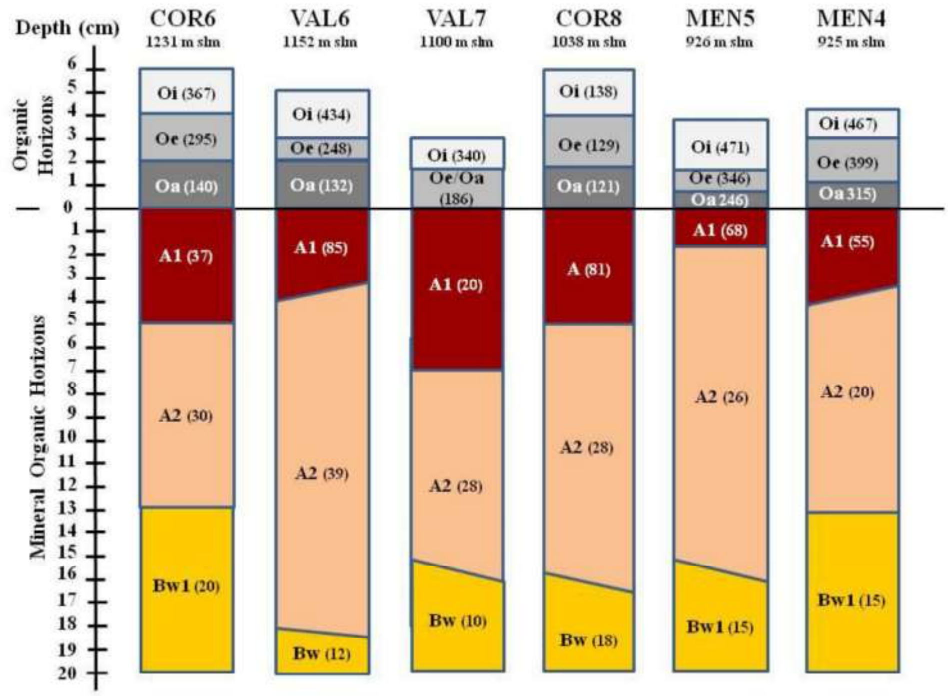

Figure 1. *Description of soil profiles according to elevation. Valeurs de TOC entre parenthèses*

The physicochemical properties of selected soil profiles were very similar (Table 3), they are characterized by high sand content and low pH (from 4.7 to 6.2). The pH value of organic horizons was ranged between 5.1 to 5.6, while in the epipedon an average low value in MEN and VAL was detected (4.8 and 4.7, respectively) comparing with COR (5.6).
No difference was found in the endopedon where the values were around 5.1. The organic layers of COR profiles showed lower average content of organic C (173 g kg^{-1}) than the other location (267 and 324 g kg^{-1} for VAL and MEN, respectively).
This trend was completely reverse in the epipedon where the sequence was following: COR (59 g kg^{-1})>VAL (47 g kg^{-1})>MEN (32 g kg^{-1}); in the epipedon, low OC content was detected in MEN (7 g kg^{-1}).

Table 2. *Morphological description of investigated soil profiles. Codes according to Schoeneberger et al. (2012)*

N Site	Horizon Master	Horizon Depth cm	Boundary D/T	Matrix Color (Munsell) dry	moist	Structure G/S/T	Tex.	Consistence P/S	Roots Q/S	Rock fragment S/ V%/R
CCOR6 (1231)	Oi	6-4	A/S							
	Oe	4-2	C/W	10YR 3/3	10YR 3/2					
	Oa	2-0	G/W	10YR 3/3	10YR 3/3					
	A1	0–5	C/W	10YR 4/3	10YR 3/3	1/vf/gr	sl	(w)po/(w)ss	2/fm	fgr12/2
	A2	5-13	C/W	10YR 4/4	10YR 3/4	1/f/gr	sl	(w)po/(w)so	3/mco	mgr/13/1
	Bw1	13-26	G/W	10YR 5/6	10YR 4/4	1/m/abk	ls	(w)po/(w)ss	1/m	mgr/15/2
	Bw2	26-40	D/I	10YR 5/4	10YR 4/3	0/m/sg	ls	(w)po/(w)ss	0	mgr/23/2
	C/R	40 +	U	Moderately weathered sandstone (Cervarola formation)						
VAL6 (1152)	Oi	5 - 3	A/S							
	Oe	3–2	C/W							
	Oa	2-0	A/S	10YR 2/2	10YR 2/1	1/f/gr		(w)po/(w) so		
	A1	0-4	A/W	10YR 4/3	10YR 2/2	1/m/sbk		(w)ps/(w) so	2/f	
	A2	4–20	C/W	10YR 4/4	10YR 3/3	1/f/sbk		(w) p/(w) ss	1/f	fgr/1/2
	Bw	20-28	A/S	10YR 5/4	10YR 4/4	0/m/sg		(w)po/(w) so	0/f	mgr/3/2
	C	28-35	G/I	10YR 6/4	10YR 5/6	1/f/gr		(w)po/(w) so	1/f/m	mgr/15/2
	C/R	35+	U	Moderarely weathered sandstone (Falterona formation)						
VAL7 (1100)	Oi	3 -1,5	A/S							
	Oe/Oa	1,5- 0	A/W	10YR 4/2	10YR 3/2					
	A1	0 - 7	C/W	10YR 4/3	10YR 3/3	1/m/sbk		(w)ps/(w) so	1/f/m	fgr/1/2
	A2	7–20	C/W	10YR 4/4	10YR 4/3	1/m/abk		(w)ps/(w) so	0/m	fgr/2/2
	Bw	20-40	D/I	10YR 5/4	7.5YR 4/3	1/f/abk		(w) p/(w) ss	0/m	mgr/10/1
	C	40-48	D/I	10YR 6/4	10YR 5/6	1/m/pl		(w)ps/(w) so	0/m	mgr/15/1
	C/R	48+	U	Moderarely weathered sandstone (Falterona formation)						
COR8 (1038)	Oi	6-4	A/S							
	Oe	4-2	A/S	10YR 4/4	7.5YR 3/2					
	Oa	2-0	C/W	7.5YR 2/2	7.5YR 2/1					
	A1	0 - 5	G/I	7.5YR 4/3	7.5YR 3/2	1/f/gr	sl	(w)po/(w)so	1/f	fgr/11/1
	A2	5–21	G/I	7.5YR 4/4	7.5YR 3/4	1/f/sbk	sl	(w)ps/(w)ss	1/fm/	mgr/12/1
	Bw	21-32	D/I	7.5YR 5/6	7.5YR 4/4	2/f/sbk	sil	(w)p/(w)s	1/m/	fgr/14/3
	C	32-37	D/I	7.5YR 5/8	7.5YR 5/4	0/m/sg	sl	(w)ps/(w)ss	1/m/	mgr/22/3
	C/R	37+	U	Moderately weathered sandstone (Cervarola formation)						
MEN5 (926)	Oi	3.5-1.5	A/S							
	Oe	1.5-0.5	A/S	10YR 4/3	10YR 3/2					
	Oa	0.5-0	A/S	10YR 2/3	10YR 2/2					
	A1	0-1.5	A/W	10YR 4/3	10YR 3/3	1/f/gr	ls	(w)po/(w)so	3/f	0
	A2	1.5-18	C/S	10YR 4/4	10YR 3/3	2/m/abk	sl	(w)ps/ (w)so	2/m	0
	Bw1	18-36	C/S	10YR 5/4	10YR 3/3	2/m/abk	sl	(w)p / (w)so	1/f	mgr/3/1
	Bw2	36-80	C/S	10YR 5/4	10YR 4/4	1/m/abk	sl	(w)ps/ (w)ss	0	mgr/3/1
	CB	80-100	D/I	10YR 6/4	10YR 4/4	0	sl	(w)ps/ (w)ss	0	mgr/7/1
	C/R	100+	U	Moderately weathered sandstone (Monghidoro formation)						
MEN4 (925)	Oi	6-3.5	A/S							
	Oe	3.5-1	A/S	10YR 3/3	10YR 3/2					
	Oa	1-0	A/S	10YR 2/2	10YR 2/1					
	A1	0-2/4	A/W	10YR 4/3	10YR 3/3	2/f/sbk	ls	(w)po/(w)so	3/m	0
	A2	2/4-12	C/S	10YR 5/3	10YR 5/4	3/f/abk	ls	(w)po/(w)so	2/m	FGR/3/1
	Bw1	12-32	C/S	10YR 6/4	10YR 4/3	3/f/abk	sl	(w)p / (w)ss	1/m	FGR/2/1
	Bw2	32-60	C/S	10YR 6/4	10YR 5/4	3/m/abk	sl	(w)ps/ (w)so	1/f	MGR/3/1
	CB	60-70	D/I	10YR 7/4	10YR 5/4	0	sl	(w)p / (w)ss	1/f	MGR/5/1
	C/R	70+	U	Moderately weathered sandstone (Monghidoro formation)						

Horizon Boundary. (**D**) Distinctness: A = abrupt, C = clear, G = gradual, D = diffuse (**T**) Topography: S = smooth, W = wavy, I = irregular, U = unknown ### **Structure.** (**G**) Grade: 0 = structureless, 1 = weak , 2 = moderate, 3=strong (**S**) Size: vf = very fine, f = fine, m = medium – co = coarse (**T**) Type: gr = granular, abk = angular blocky, sbk = subangular blocky, sg = single grain ### **Texture.** Field estimation: s = sand, ls = loamy sand, l = loam, sil = silt loam, sl = sandy loam ### **Consistence.** (**P**) Plasticity: (w) po = non-plastic, (w) ps = slightly plastic, (w)p = moderately plastic - (**S**) Stickiness: (w) so = non-sticky, (w) ss = slightly sticky, (w) s = moderately sticky ### **Roots.** (**Q**) Quantity: 0 = very few, 1 = few, 2= common, 3 = many – (**S**) Size: vf = very fine, f = fine, m = medium, co = coarse ### **Rock fragments.** (**S**) Size: FGR = fine gravely, MGR=medium gravely; CGR=coarse gravely; VGR=very gravely; XGR=extremely gravely - (**V%**) Fragment content % by volume – (**R**) Roundness: 1 = angular, 2 = subangular, 3 = subrounded

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Table 2. *Main physicochemical characteristics of selected soil profiles*

N Site	Horizon	Depth	pH	Texture (g/kg)			TOC	TN	TOC /TN	TEC	TEC/ TOC	HA	FA	NH
		cm	H_2O	S	L	A	g/kg			g/kg	%		g/kg	
COR6 (1231)	Oi	6-4	5.2	nd	nd	nd	366.5	10.9	33.6	nd	nd	nd	nd	nd
	Oe	4-2	5.3	nd	nd	nd	294.6	13.5	21.8	83,9	22.9	57.9	5.2	20.8
	Oa	2-0	5.0	nd	nd	nd	139.8	7.8	17.9	53.3	18.1	31.1	6.6	15.6
	A1	0-5	4.9	782	213	5	37.3	2.4	15.5	20.4	14.6	8.1	4.1	8.2
	A2	5-13	5.1	840	153	7	29.8	1.9	15.7	11.4	30.6	2.2	2.2	7.0
	Bw1	13-26	5.3	663	283	54	20.0	1.3	15.4	5.9	19.8	1.2	0.9	3.8
	Bw2	26-40	5.4	666	271	63	9.3	0.9	10.3	4.3	21.5	nd	nd	nd
	C	40+	5.5	656	304	41	7.4	0,8	9.3	2.1	22.6	nd	nd	nd
VAL6 (1152)	Oi	5-3	4.6	nd	nd	nd	438.8	12.1	35.9	62.4	14.4	54.2	5.0	3.2
	Oe	3-2	4.8	nd	nd	nd	247.9	10.8	23.0	70.6	28.5	56.9	5.5	8.2
	Oa	2-0	4.8	nd	nd	nd	131.6	7.1	18.5	53.5	40.7	41.1	5.3	7.1
	A1	0-4	4.7	406	292	302	84.5	5.3	15.9	48.8	57.8	8.9	7.0	32.9
	A2	4-20	4.5	465	273	262	38.9	3.1	12.5	32.9	84.6	5.4	4.4	23.1
	Bw	20-28	4.7	626	297	77	20.7	1.0	20.7	16.4	79.2	4.5	2.8	9.1
	C	28+	5.1	613	279	108	22.5	1.8	12.5	17.4	77.3	1.4	2.2	13.8
VAL7 (1100)	Oi	3-1,5	4.9	nd	nd	nd	339.7	10.3	33.0					
	Oe/Oa	1,5-0	5.8	nd	nd	nd	186.2	8.9	20.9	76.1	40.9	45.6	4.4	26.1
	A1	0-7	5.0	571	248	181	19.5	12.7	11.5	15.3	78.5	31.6	3.4	30.3
	A2	7-20	4.7	508	295	197	28.4	2.1	13.5	12.9	45.4	11.0	2.5	1.9
	Bw	20-40	5.2	609	301	89	16.5	1.4	11.8	13.6	82.4	5.6	1.9	6.1
	C	40+	5.5	665	173	162	10.4	1.0	10.4	9.6	92.3	2.6	2.2	4.8
COR8 (1038)	Oi	6-4	6.1	nd	nd	nd	137.7	7.1	19.4	nd	nd	nd	nd	nd
	Oe	4-2	6.2	nd	nd	nd	129.3	6.9	18.7	56.3	43.5	37.1	5.3	13.9
	Oa	2-0	6.2	nd	nd	nd	120.7	6.4	18.9	57.6	47.7	36.4	6.2	15.0
	A1	0-5	6.3	755	214	31	81.3	4.9	16.6	43.7	53.8	24.8	6.5	12.4
	A2	5-21	6.3	742	242	16	27.9	2.1	13.3	18.3	65.6	11.1	2.1	5.1
	Bw	21-32	5.2	420	464	115	18.2	1.3	14.0	11.2	61.5	5.6	1.1	4.5
	C	32+	5.1	574	240	186	7.0	0.7	10.0	nd	nd	nd	nd	nd
MEN5 (926)	Oi	3.5-1.5	4.9	nd	nd	nd	471.1	11.4	41.3	34.2	7.3	28.3	4.1	1.8
	Oe	1.5-0.5	6.0	nd	nd	nd	346.2	14.4	24.1	38.4	11.1	38.7	3.4	9.6
	Oa	0.5-0	6.0	nd	nd	nd	246.3	11.8	21.3	27,8	11.3	27.2	4.1	4.5
	A1	0-1.5	4.4	731	246	23	67.6	3.8	17.9	24,5	36.2	8.6	5.5	10.4
	A2	1.5-18	4.6	612	338	50	25.9	2.4	11.0	13,8	53.2	2.8	2.3	8.7
	Bw1	18-36	5.0	651	277	72	14.7	1.3	11.1	2,5	17.0	1.2	0.5	0.8
	Bw2	36-80	5.1	653	261	86	10.2	1.3	8.0	9,3	91.4	1.2	0.3	7.8
	CB	80-100+	5.3	674	243	83	6.3	0.8	7.5	5,9	94.0	0.6	0.1	5.2
MEN4 (925)	Oi	4.5-3.5	5.0	nd	nd	nd	467.3	12.2	38.2	38.0	8.1	27.2	7.9	2.9
	Oe	3.5-1	5.9	nd	nd	nd	399.1	15.7	25.1	42.2	10.6	32.1	6.1	4.0
	Oa	1-0	5.4	nd	nd	nd	315.2	15.7	20.2	36.7	11.6	45.0	6.3	3.0
	A1	0-2/4	4.3	780	187	32	55.0	3.2	16.9	11.9	21.6	5.8	3.7	2.4
	A2	2/4-12	4.7	815	167	18	19.9	1.4	13.9	6.9	34.6	1.8	1.8	3.3
	Bw1	12-32	4.7	710	227	64	14.7	1.4	10.5	3.7	25.1	1.4	1.0	1.2
	Bw2	32-60	4.8	714	205	81	7.1	0.8	9.0	1.7	24.0	0.8	0.3	0.6
	CB	60-70+	4.8	700	234	67	4.3	0.8	5.4	1.9	44.8	0.2	0.2	1.5

HA = humic acid – FA = fulvic acid – NH = non humic substance

This same behaviour was also noticeable for N amount in the organic horizons, *epipedon* and *endopedon*, respectively. Low C/N ratio was detected in COR organic layers (an average value of 19.5), while in the Val and Men, the C/N ratio was ranged between 26.6 and 27.2. The C/N ratio is an important indicator of ecosystem stability indicating the role of soil organic matter as carbon and nitrogen reservoir, the sensitivity of soil organic matter to environmental change (Vejre et al., 2003). In the Apennines sites a huge thickness of organic layer was observed as well as a differentiation of them (Oi, Oe and Oa). The humic acids (HA) content decreased according to the altitude, high HA amount was recognized in COR6 and VAL6. According to the Soil Taxonomy (SSS, 2014) the pedons COR (6,8) and VAL (6,7) are classified as Lithic Dystrudepts, while MEN (4,5) as Humic Eutrudepts. It is well known that Douglas fir plantation led to decrease input of carbon to the soil mineralisation rates and size of the labile C pool as effect of low quote and oceanic influence (Gauthier et al., 2010), This phenomenon can be observed at the low quote of MEN soil profiles that increased C content in the organic layers, while decreased that of epipedon (Falsone et al., 2015). No dangerous effects on soil quality of Douglas fir were investigated and they seem to be similar to those of native tree species (Schmid et al., 2014). Globally, soil organic C amounts to about 1,500 Pg C in the upper meter of soil, ranging from 3.0 kg C m^{-2} in arid climate to 80 kg C m^{-2} in organic soils of cold regions (Lal, 2004), and the most of this organic C is stored in forest soils (Dixon et al., 1994; Batjes, 1996). The relationship between soil organic carbon and site characteristics have been studied at a local and regional scale (Jenny, 1980) with the aim to understand the effects of forest management and climate change on the soil carbon stores (Turner et al., 1993). In Figure 2, the organic C stock in the selected soil under Douglas fir are reported.

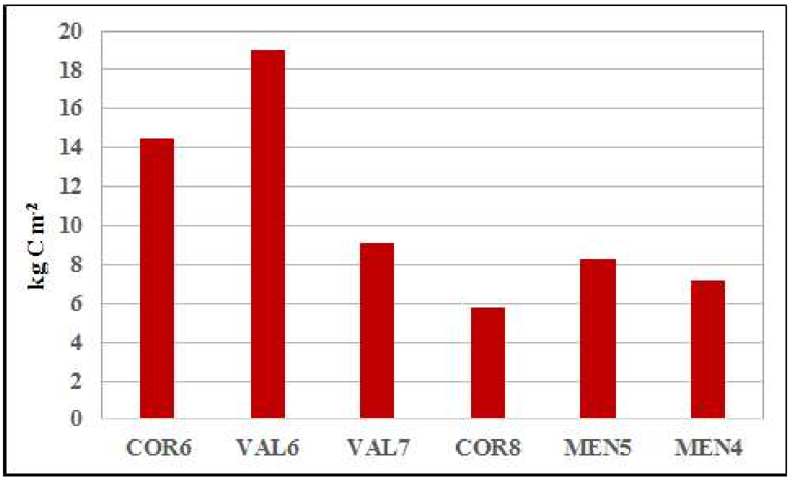

Figure 2
Organic C storage in soils under Douglas fir

It is possible to recognize a higher organic C storage in soils at highest altitude (COR6 and VAL6) than the other studied soil profiles. It must be considered that micro-climatic conditions can interfere on the soil organic C accumulation processes (e.g. mineralization, humification etch) which reduce the decomposition and a higher accumulation of soil organic matter is observed in north-facing slopes (Egli et al., 2009). It is noticed that COR8 had the lowest organic C content per unit surface area (5.8 kg C m^{-2}) and this value is correlated to low C/N ratio.

Conclusion

The mineral soils under Douglas fir store a large amount of organic C. It is important the role carried out by the organic layers in the C and nutrients storage and the mineralization processes. These horizons protect the underlying organo-mineral layers and a depth of organic C along the soil profiles is evaluated. No dangerous effects on soil quality of Douglas fir were investigated and its plantation can be encouraged.

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LE SEQUESTRE DU CARBONE DANS LES SOLS AFFECTES PAR LE REBOISEMENT A DOUGLAS DANS LES APENNINES (ITALIE DU NORD)

Résumé

Le reboisement avec sapins de Douglas jouent un rôle important dans les forêts italiennes, à la fois la productivité et la qualité du bois supérieure à d'autres conifères indigènes. Il ya quelques articles scientifiques sur les propriétés physico-chimiques des sols sous le sapin de Douglas. Le but de ce travail est d'évaluer le stock de carbone organique dans le sol sous le sapin de Douglas dans différentes zones sélectionnées des Apennins en Italie du Nord; ils ont été choisis pour la présence de boisement de 60 ans, les emplacements de Corno alle Scale (COR), Vallombrosa (VAL), Mulino Mengoni (MEN). Dans chaque domaine ont été ouverts décrit deux profils de sol. La quantité de carbone organique dans les horizons organiques (Oi, Oe, Oa) est plus élevé dans les pédons de VAL et MENG que celles déterminées par COR. Augmentation de la quantité de C organique a été détecté dans des horizons organo-minéraux de profils de COR, montrant une rotation rapide des matières organiques du sol. Le stock de C organique, calculée dans les 30 premiers centimètres du sol, a montré que la valeur plus élevée de C organique est stocké dans le sols des lieux à des altitudes plus élevées (COR6 et VAL6) que les autres sols. Ils ont été classés comme Lithic Dystrudepts des altitudes plus élevées (COR 6, 7 et VAL 6, 7, respectivement), tandis que le site Humic Dystrudepts de MEN. À la lumière de ces données, il est conclu qu'il n'y avait pas de dégradation par rapport à la qualité du sol, à une distance de 60 ans par le reboisement du sapin de Douglas et que les processus pédogénétiques semblent similaires à ceux des sites caractérisés par des espèces d'arbres indigènes. La confirmation de ces résultats seront atteints en étendant l'enquête à d'autres sites dans les Apennins.

IL SEQUESTRO DEL CARBONIO IN SUOLI INTERESSATI DA RIMBOSCHIMENTO A DOUGLASIA NELL'APPENNINO DEL NORD ITALIA

Riassunto

Le riforestazioni con Douglasia svolgono un ruolo importante nei boschi Italiani, perché nessuna conifera indigena ha caratteristiche simili per produttività e qualità del legname. Ci sono pochi lavori scientifici sulle proprietà fisico-chimiche dei suoli sotto Douglasia. Lo scopo di questo lavoro è quello di valutare lo stock di C organico nel suolo sotto Douglasia in diverse aree selezionate dell'Appennino del Nord Italia; le località di Corno alle Scale (COR), Vallombrosa (VAL), Mulino Mengoni (MEN) sono state scelte per la presenza di riforestazioni di 60 anni. Per ogni area sono stati aperti e descritti due profili di suolo. Il valore di pH diminuisce con la profondità lungo il profilo. La quantità di C organico negli orizzonti organici (Oi, Oe, Oa) è più elevata nei suoli di VAL e MEN rispetto a quella determinata nei suoli di COR. Maggiore quantità di C organico è stata rilevata negli orizzonti organo-minerali dei profili di COR, evidenziando un rapido turnover della sostanza organica del suolo. Lo stock di C organico, calcolato nei primi 30 cm di suolo, ha evidenziato come il valore superiore di C organico venga immagazzinato nei suoli posti a quote più elevate (COR6 e Val6) rispetto agli altri suoli. Sono stati classificati come Lithic Dystrudepts i suoli delle quote più alte (COR 6, 7 e VAL 6, 7 rispettivamente) e come Humic Dystrudepts quelli del sito MEN. Alla luce di tali dati si può concludere che non sono stati riscontrati fenomeni di degrado relativamente alla qualità del suolo a distanza di sessanta anni dai rimboschimenti a Douglasia e che le condizioni pedogenetiche sembrano simili a quelle instauratesi in siti interessati da specie arboree autoctone. Una conferma di tali risultati si potrà ottenere estendendo l'indagine ad altri siti dell'Appennino.

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