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THE INFLUENCE OF FOREST MANAGEMENT ON THE AMOUNT OF LITTER ORGANIC CARBON, IN BEECH FORESTS

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Abstract: *This study aims at presenting the tests results regarding the influence of forest management on the amount of litter organic carbon in beech forests. The samples for analysis were collected from beech forests in Southern Romania. The results have shown a high variability as regards the organic carbon stock of litter, by stand age and forest management. The values calculated for the stock of organic carbon ranged from 3.4 to 8.1 t / ha. The analysis for the two types of forest management has yielded values from 5.1 to 6.7 t / ha. However, it is premature to assess the impact of forest management on organic carbon stock from litter, because of the limited data.*

Key words: *organic carbon, litter, forest management.*

1. Introduction

Forests cover about 31% of the European land area and the extent to which forest practices influence the budget carbon is little known [12]. Soil organic carbon is an important component of ecosystems [14]. Globally, soils contain three times more carbon than the atmosphere and four and a half times more than worlds' biota [11], which means more than the atmosphere and plants together [9]. The mitigation of climate change depends on the distribution and control inputs and outputs of organic carbon in the soil. The increase of carbon storage in soil was often proposed as a technique meant to reduce CO_2 emissions [11]. The litter layer is a link between the aboveground and underground carbon [10]. There is a strong link between the net primary productivity, the carbon inputs from litter accumulation [11] and the decomposition of organic matter is an important process in the global carbon cycle [4]. The amount of soil organic carbon is strongly linked to a number of factors, such as temperature, humidity, soil type, and also vegetation type [16]. The inputs resulted from litter decomposition (leaves, fruit, dead wood) and fine roots will determine the quantity and quality of soil organic matter [13], which is essential to carbon stocks [1], as well as to tree growth rates [7]. The purpose of this study is to quantify the organic carbon in litter hill beech forests, within a site representative for southern Romania, as well as to evaluate the impact of forest management on the organic carbon, for stands with a history covering over 50 years. Of course, the representativity of the species and of the management types was also an important criterion, which was equally fulfilled by choosing beech stands

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to establish the forest management. Indeed, beech is Romani's first species in terms of the volume, and it occupies around 30% of the entire cover (over 2M ha). Most of the beech stands (69%) in Romania are even-aged [19]. We tested the hypothesis that inputs of organic carbon from litter were affected by the forest management.

2. Material and methods

The experiment was performed in 2014, in nine beech forest stands. The stand age varied from 30 to 180 years and the stands underwent different forest-management practices.

2.1 Study area

The study was conducted in the Experimental Forest District Mihăeşti, situated in Argeş, Romania (45° 6' 8" N, 25° 0' 39 "E). The average altitude of the site is 520 m, the average annual temperature is 9,0^{o} C and the average annual precipitation is 715 mm [5]. The soil is eutricambosol, well structured, with forest mull humus type, moderately acid, with undifferentiated texture profile, with degree of base saturation of more than 55%, rich in nutrients and with high water-capacity output [17]. The climate in combination with the conditions of fertile soil provides optimum growing conditions for beech forests.

2.2. Description of plot stands

The plots were established in stands that have been under the same type of management for the last 50 years. Likewise, the species occupying the largest area was the common beech (*Fagus sylvatica* L) according to the management plan (2014). However, the variability and stability of forest managements in time, the uniformity and good accessibility were the essential criteria for the choice to conduct this study. The experimental plots were chosen to be the most representative stands possible, for the forest management. Furthermore, there were samples of litter for a stand where the intensity of intervention was different, as compared to the control plot. The data upon the characteristics of the stand were recorded from the Forest Management Plan of the Experimental Forest District Mihăesti, (Table 1). The gradient put in place covered a wide range of forest management practices: from even aged (30) to uneven aged (selection system, 180). Also, the composition homogeneity is quite good. The plot collection is constituted of 5 high forest stands (even aged) with varying thinning intensities and 4 uneven aged. According to Table 1, the number of trees per ha ranges from 168 (180 years aged) to 1385 (30 years aged), the basal area from 13 m^2/ha to 38 m^2/ha in high forest stand. Yet, overall, there are no clear differences in terms of management on the basal area. The volume ranges from 210 m^3/ha to over 620 m^3/ha in the even aged stands.

2.3 Data collection

In this study, we investigated the variability of the amount of litter organic C stock in nine beech stands with different management regimes. In order to reduce the temporal variations, the sampling was carried out during the biological activity in low ground [2]. For each stand, we collected litter from 20 x 20 cm square subplots, located in five dice - shape frames. The subplots were located in the centre and the cardinal directions corners (Centre, NE, NW, SE and SW), each of them at three meters from the centre of the plot. Mineral residue, stone and living plants were removed from the frame using a metal knife.

Table 1

Description of plot stand and management type

Plot	Management	Age (years)	No of trees N/ha	Basal area m^2/ha	Volume m^3/ha	Treatment
P1	even aged	30	1385	25.30	316	standard*
P2	even aged	60	626	37.23	513	no thinning
P3	even aged	60	535	30.11	428	thinning17%
P4	even aged	75	612	34.31	536	standard
P5	even aged	75	589	38.90	580	standard
P6	uneven aged	170	423	13.02	210	standard
P7	uneven aged	170	504	35.12	620	standard
P8	uneven aged	180	407	34.51	595	standard
P9	uneven aged	180	168	24.61	488	standard

* *as prescribed by the technical sylvicultural norms*

Litter samples consisting in leaves, fruits, dead wood (<1 cm diameter) were dried in an oven at 65^0C high capacity and their components were weighed separately, with a high precision balance (±0.01 g). Finally, the calculation determined the organic carbon pool in litter, consisting in tonnes of carbon per hectare, by applying moisture correction. As a result of determining the factor carbon (= 0.5), it is considered that, on average, 50% of the organic matter is composed of carbon [3].

For each sample analyzed, the organic carbon was determined in leaves and wood organic carbon (fruits and dead wood). The data were grouped by age and forest management practices that characterize stands, resulting in values of organic carbon stock of litter.

3. Results and discussion

For each plot where the litter was sampled, were determined two parameters, the mean and the standard deviation (Table 2)

Table 2

The mean and standard deviation for the litter biomass

Plot	Litter (g)			
	leaves	fruits	Wood	TOTAL
P1	16.09 (7.18)	0.13 (0.30)	10.22 (5.52)	26.45 (9.94)
P2	28.16 (5.47)	0.88 (1.40)	9.02 (4.82)	38.07 (8.31)
P3	23.99 (4.35)	4.30 (3.59)	8.88 (5.64)	37.18 (9.14)
P4	28.90 (6.08)	2.72 (1.26)	12.25 (13.17)	43.88 (19.99)
P5	39.96 (4.11)	1.36 (0.74)	16.24 (8.96)	57.57 (8.89)
P6	46.65 (15.66)	5.02 (1.94)	15.79 (16.20)	67.47 (24.16)
P7	37.88 (5.81)	6.02 (4.09)	14.91 (8.13)	58.81 (14.12)
P8	37.62 (5.36)	6.89 (4.24)	11.92 (4.40)	56.43 (12.89)
P9	29.19 (9.57)	9.80 (5.49)	13.01 (8.81)	52.01 (22.20)

From the above data (table 2), it can be noticed that the minimum average amount of litter was present in the youngest stand (P1), while the maximum average amount was present in a stand of 170 years (P6). Also it was noted that, from the total mass collected, the highest percentage was given by foliar mass, the share varying from 55%

in a stand of 180 years (P9), to 74% in a stand of 60 years (P2), due to the presence of higher amounts of fruit and wood in older stands. This can also be explained by the abundant fructifications, during the previous year to the sampling, in older stands; the recorded amount of fruit representing approximately 19% of the material collected. Also there are a significant positive correlation between the stand age and the litter mass (R=0.80092, P<0.05, P-value = 0.00948). The amount of litter varies between 7.5 t/ha and 16.5 t/ha, for a coefficient of variation of 26%. The 75 year-old stand presented a high amount of litter, similar to the one observed in older stands. This may be due to the microclimate conditions existing at the time of sampling, an atypical general condition of the stand (P5). The amount of organic carbon in the litter is shown for each experimental area in t/ha; the organic carbon in leafs is combined with the organic carbon in dead wood (Table 3). For the 9 plots, the analysis was made by means of Kruskal – Wallis test, as it does not require normality and as it works on small sample sizes. It was performed (H test) in order to test if there are differences between plots (H_0 – H null hypothesis is rejected as calculated > $H_{0.05}$). Moreover, in Table 3, it can be observed the quantitative differences in organic carbon, by stand age and by litter components. As expected, the highest organic carbon stock in litter was observed in old stands (170 – 180 years) and the lowest content in the 30 years young stand. The analysis of organic carbon stock per compartment leaves, dead wood (fruit, wood) and total (litter) is shown in figure 1. We observed that the stock of litter varied from 3.5 t/ha to 8.2 t/ha.

Table 3

The analysis of organic carbon by plots

Plot	Stand age (years)	Organic C leaf (t/ha)	Organic C dead wood (t/ha)	Organic C litter (t/ha)
P1	30	2.160	1.334	3.494
P2	60	3.226	1.160	4.385
P3	60	3.731	1.164	4.895
P4	75	5.261	2.088	7.349
P5	75	3.865	1.586	5.451
P6	170	6.099	2.070	8.169
P7	170	4.975	1.939	6.914
P8	180	4.973	1.548	6.520
P9	180	3.854	1.675	5.529

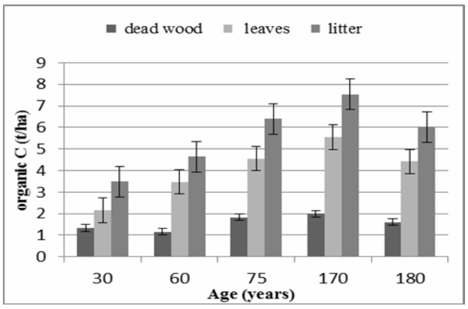

Fig.1.*The organic carbon stock by stand age*

The amount of litter depends on the intensity of the silvicultural interventions, even for beech stands of the same age. Thus, the intensity of intervention (control and 17%) It was also analyzed the organic carbon stock from the litter, by type of management (Figure 2). For this, the studied stands were divided into two groups: one group with even-aged stands and the other with uneven-aged stands.

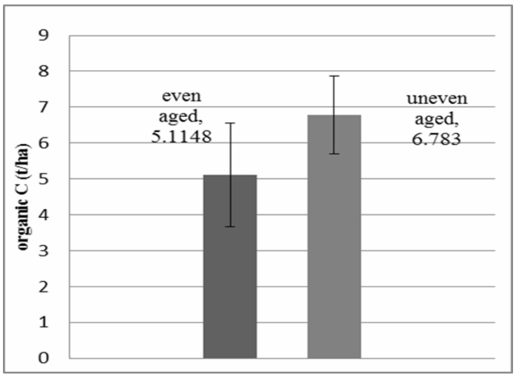

Fig.1.*The organic carbon stock by forest management*

Silvicultural systems are classified either as even- or uneven aged depending the harvest regeneration method employed. Stands containing trees of about the same age that develop under full-light conditions without significant border competition are silvicultural classified as even-aged. Stands containing trees of several ages that develop with significant interaction with surrounding trees of different ages are classified as uneven-aged [6]. Basically, the uneven aged system applications provide permanence of the forest cover [15]. For each group of stands, the mean and standard deviation was calculated. From the data presented (figure 3) the stands in the first group were stored at higher percentage with approximately 25% more organic carbon in the litter, compared to the second group. Even if the first group accumulated more organic carbon in litter, it is necessary to prove whether these forests are truly representative in time for the hill beech forests in southern Romania. Forest management can add value to stand, even if biomass is reduced, so the net effect on carbon is lost [8]. However, the role of interventions will increase the stability of stands and, more importantly, it provides a control mechanism to maintain storage of carbon in forest ecosystems.

Conclusions

Forest management can influence the quality and quantity of litter [8], hence it has an important role in soil organic carbon stocks. Our results indicate that there is a significant variability of the organic carbon stock of litter, mainly due to the age of the stands, from 3.4 t/ha to 8.1 t/ha. These values are comparable to the range of values reported in previous studies 4.4 t/ha in beech forest [13] at young acacia forest to mature Picea forest, 0.4 – 8.0 t/ha, [3]. [12] found a variability of organic carbon from litter between 0.8-2.8 t/ha, considering that the driver for this variability was the amount of fallen leaves in the previous year and basal area of the plot. Comparing the two groups of stands (uneven and even-aged) with different forest management, we found differences of approximately 26% more organic carbon from litter between them. To generalize the practice of forestry upon budget carbon beech forests and to compare the impact of different treatments is questionable in with other case studies [12]. For an objective analysis, the amount of organic carbon in litter can be determined only after long forest management practices. Thus, it becomes a challenge to quantify to the long-term effects of forest management on soil organic carbon stock, by installing and monitoring of long-term surface in natural and managed forests. In addition, the future will follow the determination of organic carbon stock using CHN analyzer, knowing that the classical method produce an overestimation of 20% [3]. Also it is still necessary to quantify organic carbon stock in litter for different ecological conditions and for the main forest species just to see how far the forest management influence the stock carbon.

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