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PROTECTED CARBON AND NITROGEN STOICHIOMETRY IN SOILS UNDER RED PINE AND OAK FORESTS

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ABSTRACT

Carbon and nitrogen are stoichiometrically linked in soil organic matter to influence ecosystem services. The objective of our study was to determine the impact of Red pine (Pinus brutia Ten.) and Oak (Quercus coccifera) forest vegetation on soil aggregate protected carbon and nitrogen stoichiometry in the Göksu catchment of Turkey. Soils were collected form two randomly selected composite sampling sites under the cover of about 100 years old Red pine (RP1, RP2) and Oak (Ok1, Ok2) natural forests. Soils were air-dried, fractionated into different aggregate sizes (>2 mm, <2 mm, and 2 to 0.25 to 0.25 to 0.05 mm separately), and analysed for total organic C (SOC) and N (TN) contents. The highest SOC and TN content was determined in the Ah horizons of profile RP1, RP2 and Ok1 and the A1 horizon of profile Ok2. The <2 mm aggregates contain higher SOC and TN contents than the >2 mm aggregates in the Bw horizons of all the four soil profiles. The 0.25 to 0.05 mm aggregates had higher contents of SOC and TN than that of the 2 to 0.25 mm aggregates in the Bw horizon of all the soil profiles.

KEYWORDS:
Natural forest, soil aggregates, Ah and Bw horizons, Turkey

INTRODUCTION

The soil organic carbon (SOC) pool, is one of the most important carbon stocks on earth [1]. Carbon sequestration in the Mediterranean forest ecosystems refers to the sequestration of atmospheric CO2 in organic compounds which is responsible for the increase in the pools of organic C in forest soils [2,3].

The forest trees, with long life cycles, improve nutrient cycling within the soil horizons, provide environmental protection, thus creating the forest biomass and the major C input positively changing soil properties [3-11].

Soil aggregates are the pools of SOC, the basis of soil quality that control the dynamics of SOM (soil organic matter) and nutrient cycling [11-18]. SOC is protected from microbial decomposition by the physical occlusion within the aggregates [19-23] and adsorption of the clay particle surfaces [22-25]. The ability of aggregates to physically protect SOC varies among aggregate sizes and by the binding agent between SOC and aggregates [26]. The dynamics of SOC sequestration in soil aggregates have also been studied widely by [18,27,28].

Conceptually, aggregates are generally classified into macro-aggregates (>0.25 mm) and micro-aggregates (0.053 – 0.25 mm) [29,30] where the most important mechanism of stabilization of SOM is the encapsulation into the latter [3,31,32].The C functional group composition of the micro-aggregates are complex at the nano and micrometer scale [33]. Carbon in micro-aggregates would be physically or chemically excluded from microbial attack or enzymatic reactions within the soil environment by aggregation. Macro-aggregates are sensitive to changes in land use and cultivation practices [34], whereas micro-aggregates are less sensitive [35,36]. In addition, the soil aggregates larger than 2 mm may contain a considerable amount of organic C depending on the nature of the parent material and on its resistance to the weathering processes as reported by [37,38]. But Mao et al. [39],Li et al. [40],Wang et al. [41] suggested that microaggregates contain higher contents of SOC and TN in comparison to the macroaggregates.

There is evidence that certain SOC fractions are more important in maintaining soil fertility [42] and are, therefore, more sensitive indicators of the effects of management practices than the total SOC [43]. An approach based on the SOC fractions concerns the measurement of its smaller and more active fractions essential to identify the changes in SOC quality that is affected by soil management practices.

The Göksu catchment, one of the major forest areas of Turkey, is within the Mediterranean climatic

region of the country. The catchment is highly productive in agriculture [44]. The Turkish red pine and oak are well adapted to the Mediterranean-type of climate via several physiological and morphological characteristics and are the main species in the forests of this eco-region [45].

Earlier studies have mostly focused primarily on farmland, grassland and planted forest SOC and TN contents, whereas few studies have focused on the SOC and TN protected in soil aggregates in natural forests. In this context, this study primarily is aimed to reveal the variety of SOC and TN distributions in the different soil aggregates of natural (undisturbed) red pine and oak tree rhizospheres.

MATERIALS AND METHODS

Study area. The study area is located in the Göksu catchment (36°14'20" to 37°13'21"N latitudes and 32°06'29" to 34°04'39" W longitudes) of the Mediterranean region of the southern Turkey (Figure 1). The studied soils were Calcaric Cambisols [46]. Selected regarding the overlying widespread tree populations, canopy vegetation, bedrocks, slopes and aspects. Selected soil properties were presented in Table 1. The Turkish red pine (Pinus brutia Ten.) and oak (Quercus coccifera) are the most dominant vegetation types in the forests of this ecoregion. This trees naturally distributed mainly in the Mediterranean and Aegean regions and have economically important multi-purpose forest tree species in the Turkey. The 4 soil profiles studied in this paper were under the canopies of red pine and oak trees of two different areas (100 km apart from one another) in the Göksu catchment



FIGURE 1
The location of the study area and the sampling sites in the Göksu catchment, Turkey.

TABLE 1
The physical and chemical properties of the horizons under red pine and oak canopies

Profile	Horizonon.	Depth	ECEC	Sand	Silt	Clay	Tex
		(cm)	(cmol	--------- %--------			
RP_1	Ah	5-10	93.7	53.5	39	7.7	L
	A_2	10-19	38.3	37.9	44	18	L
	Bw	19-28	28.2	40.5	39	20	L
	Bk/C	28-45	22.8	41.2	40	20	L
RP_2	Ah	8-16	157	43	33	24	CL
	Bw	16-30	45	18	49	33	C
Ok_1	Ah	3-6	49.7	48	36	16	L
	Bw	6-15	34.3	27	38	35	CL
	Bk/C	15-32	27	29.9	38	32	CL
Ok_2	A_1	0-7	52.4	18	25	57	C
	A_2	7-13	51.8	22	24	54	C
	Bw	13-27	40.7	18	20	62	C

(RP1 and RP2= Soil samples collected from the rhizospheres under the red pine in the first and second sampling sites). (Ok1 and Ok2 = Soil samples collected from the rhizospheres under the oak in the first and second sampling sites).

Soil sampling and analysis. Composite soils were randomly collected from 100 years old red pine (RP) and oak (Ok) forests in June 2013. While soil samples at RP1 profile were collected from Ah (5-10 cm depth), A2 (10-19 cm depth), Bw (19-28 cm depth), and Bk/C horizons (28-45 cm depth), the soil samples at RP2 profile were collected from Ah (8-16 cm depth) and Bw (16-30 cm depth) horizons, respectively. Similarly, soil samples at Ok1 profile were collected from Ah (3-6 cm depth), Bw (6-15 cm depth), and Bk/C (15-32 cm depth) horizons and at Ok2 profile from A1 (0-7 cm depth), A2 (7-13 cm depth), and Bw (13-27 cm depth) horizons, respectively. The field-moist soils were collected in selable plastic bags, air-dried for 15 days under shade at room temperature (~250C), ground, and 2-mm sieved prior to analysis. However, 4.8 cm aggregates were used for aggregate size distribution and aggregate-associated SOC and TN analysis.

Soil pH was measured by using glass electrode method. Particle size distribution (sand, silt and clay) was determined by the hydrometer method [47]. The exchangeable cations were extracted by using 1-M ammonium acetate extraction method [48] and determined by atomic absorption spectrophotometer. The cations were summed to calculate for effective cation exchange capacity (ECEC). The physical and chemical properties of the horizons under red pine and oak canopies of the study area are shown in Table 1.

A 20 g sample of 4.8 mm air-dried soil aggregates was separated into two fractions, namely to >2, 2-0.25 and <0.25-0.05 mm sizes by wet sieving (Kemper and Rosenau 1986). The aggregates were collected, oven-dried, ground and analysed for SOC and TN contents, using FLASH 2000 NC analyser, after removing the inorganic carbon (carbonates) by 5% HCl solution with heating.

Statistical analyses. Statistical analyses were conducted on the separated size fractions of 2 - 0.25 and 0.25 - 0.05 mm as well as the >2 mm and <2 mm. The analysis of variance of the data was carried out, using MSTATC and SPSS software and one-way ANOVA followed by the Duncan's Multiple Range Test that was used to determine the mean comparability.

RESULTS

Soil organic carbon and total nitrogen distribution in different aggregates. The SOC and TN contents of the horizons and aggregate sizes were significant in the aggregates of >2 mm and <2 mm in profile RP1 ($P \leq 0.0001$). The highest content of SOC% was obtained from the aggregates of less than 2 mm (16.26%) in the Ah horizon of the soils of profile RP1 (Table 2). While the lowest contents of SOC were determined in the aggregates larger than 2 mm (0.91%) in the A2 horizon of the soils of this profile (Table 2). The SOC content of the aggregates <2 mm decreased with depth in the horizons of the same profile (Table 2). The highest TN content was obtained from the aggregates less than 2 mm (1.99%) in the A2 horizon of the soils of profile RP1 (Table 2). The lowest TN (0.09%) was determined in the aggregates larger than 2 mm in the A2, Bw and Bk/C horizons of the soils of the same profile (Table 2). In profile RP2, high significant differences ($P \leq 0.0001$) were obtained for the SOC content of the Ah and Bw horizons (Table 2). The SOC content of Ah in both aggregate fractions was obtained higher than the Bw horizon. The aggregates larger than 2 mm showed significantly ($P \leq 0.03$) highest SOC (20.88%) content in the Ah horizon of RP2 (Table 2). The SOC content was also high in the aggregates less than 2 mm (19.18%) in the soils of the Ah horizon of the same profile. In profile RP2 the highest TN (3.6%) was obtained from the aggregates less than 2 mm in the Ah horizon (Table 2). In profile Ok1 the accumulation of SOC was significant ($P \leq 0.0001$) for the highest level (6.75%) in horizon Ah (Table 2). The soil TN concentration (1.01%) was also significantly highest ($P \leq 0.0008$) in the aggregates less than 2 mm in the Bw horizon of the same profile (Table 2). This shows that the aggregates less than 2 mm contain higher SOC and TN than the aggregates larger than 2 mm as was determined in soils of profile RP1. In relation to this outcome, the distribution of TN in different aggregate fractions showed the same trend as the SOC under the forest cover. In the soils of profile Ok2, there were no significant differences between the SOC ($P \leq 0.145$) and TN ($P \leq 0.1798$) contents in the aggregates less and larger than 2 mm in the different horizons. However, significantly ($P \leq 0.0001$) higher contents of SOC (≥4%) and TN (≥0.3%) were observed in the A1 and A2 horizons in the same profile (Table 2).

The SOC concentration (10.27%) was observed significantly more ($P \leq 0.01$) in the aggregates from 0.25 to 0.05 mm in the Ah horizon of the soils of profile RP1 (Table 3). For the TN mean, the presence in the aggregates were ranged from 0.06-0.55% in the aggregates from 2-0.25 mm in the Bk/C horizon to the aggregates 0.25-0.05 mm in the Ah horizon of the soils of profile RP1 (Table 3), whereas the TN content of the same profile significantly ($P \leq 0.0001$) decreased in the horizons with depth (table 3).

The interaction of the SOC and TN (%) to the aggregate fractions from 2 to 0.25 and 0.25 to 0.05 mm of Profile RP2 were not significant. The highest SOC contents were obtained in the aggregate fraction from 2 to 0.25 mm (5.1%) of the Ah horizon, whereas the lowest were obtained in the aggregate fraction from 0.25 to 0.05 mm (1.23%) of the Bk/C horizon of profile Ok1. The highest TN (0.34%) was obtained from the aggregate fraction of 2 to 0.25 mm in the Ah horizon and the lowest (0.1%) in the aggregates from of 0.25 to 0.05 mm in the Bk/C horizon

of the same profile. In general, the TN content was high in the aggregates from 0.25 to 0.05 mm in all the horizons of profile Ok1. The highest SOC (4.99%) and TN contents (0.45%) of profile Ok2 were obtained from the aggregates of 0.25-0.05 mm in the A2 horizon.

Comparison of the SOC and TN contents in the Bw horizons of the soils. SOC and TN in the aggregate fractions of >2 mm and <2 mm. The difficulty in employing the statistical analysis for all the horizons of all 4 profiles which was bound to the high variability of the data led us to select only the Bw horizons for comparison due to their more developed and stable character, i.e. the uniformity in the physical, chemical and mineralogical properties. The statistical results revealed that there were significant differences in the SOC and TN contents of the profiles ($P \leq 0.0059$). The interaction of the profiles × the aggregates >2 mm and <2 mm for SOC% and TN% was also significant ($P \leq 0.0146$). The highest and lowest SOC % were obtained from the aggregates less than 2 mm (3.98%) in the Bw horizon of profile RP2 and the aggregates larger than 2 mm (1.43%) in the Bw horizon of profile RP1 (Table 4). The highest TN content also was obtained from the aggregates of less than 2 mm (1.28%) in the Bw horizon of profile RP1 and the lowest TN content was determined in the aggregates larger than 2 mm (0.11%) in the Bw horizon of profile RP1 (Table 4).

SOC and TN in the aggregate fractions from 2 to 0.25 mm and from 0.25 to 0.05 mm. The SOC and TN contents (%) of the profiles and aggregate sizes were significant ($P \leq 0.0001$) in the aggregate fractions from 2 to 0.25 mm and from 0.25 to 0.05 mm. The highest SOC (5.07%) and TN contents (0.37%) were obtained from the aggregates from 0.25 to 0.05 mm in the Bw horizon of profile Ok1 (Table 5). The lowest SOC and TN contents were obtained from both sizes of aggregates in RP1 and the aggregates from 0.25 to 0.05 mm in the Bw horizon of profile RP2 (Table 5).

TABLE 2
The distribution of SOC and TN in the aggregates >2 mm and <2 mm

Soil profile	Soil horizon	Size (mm)	SOC (%)	TN (%)
RP_1	**Ah**	**>2**	12.6 ±0.278 b	0.64 ±0.006 e
		<2	16.26 ±0.297 a	1.42 ±0.076 b
	A_2	**>2**	0.91 ±0.535 f	0.09 ±0.050 f
		<2	5.037 ±0.261 c	1.99 ±0.096 a
	Bw	**>2**	1.43 ±0.172 ef	0.11 ±0.012 f
		<2	3.14 ±0.569 d	1.28 ±0.010 c
	Bk/C	**>2**	1.96 ±0.773 e	0.13 ±0.015 f
		<2	1.97 ±0.612 e	0.83 ±0.091 d
RP_2	**Ah**	**>2**	20.88 ±1.034 a	1.24 ±0.021 b
		<2	19.18 ±0.739 b	3.6 ±0.257 a
	Bw	**>2**	3.08 ±0.045 c	0.21 ±0.010 c
		<2	3.74 ±0.075 c	0.24 ±0.012 c
Ok_1	**Ah**	**>2**	2.99 ±0.080 c	0.25 ±0.006 d
		<2	6.75 ±0.460 a	0.88 ±0.045 b
	Bw	**>2**	1.72 ±0.046 d	0.16 ±0.006 d
		<2	3.98 ±1.011 b	1.01 ±0.105 a
	Bk/C	**>2**	2.02 ±0.123 d	0.18 ±0.015 d
		<2	1.94 ±0.114 d	0.74 ±0.032 c
Ok_2	**A_1**	**>2**	4.63 ±0.010 a	0.43 ±0.012 a
		<2	4.65 ±0.070 a	0.4 ±0.000 a
	A_2	**>2**	4.29 ±0.006 a	0.39 ±0.006 a
		<2	4.46 ±0.407 a	0.36 ±0.036 a
	Bw	**>2**	2.44 ±0.110 a	0.24 ±0.006 a
		<2	3.03 ±0.329 a	0.25 ±0.023 a

(D: aggregate diameters).
(RP1 and RP2: Soil samples collected from the rhizospheres under the red pine in the first and second sampling sites). (Ok1 and Ok2: Soil samples collected from the rhizospheres under the oak in the first and second sampling sites).
(The data are the mean of replicates and ± is the standard deviation).
(Means in each column followed by similar letter (s) are not significantly different at 5% probability level, using Duncan's Multiple Range Test).

TABLE 3
The distribution of SOC and TN in the aggregates from 2 to 0.25 mm and 0.25 to 0.05 mm

Soil profile	Soil horizon	Size (mm)	SOC (%)	TN (%)
RP_1	**Ah**	**2-0.25**	8.75 ±1.289 b	0.43 ±0.067 b
		0.25-0.05	10.27 ±0.415 a	0.55 ±0.006 a
	A_2	**2-0.25**	1.83 ±0.015 cd	0.12 ±0.006 de
		0.25-0.05	2.82 ±0.181 cd	0.2 ±0.015 c
	Bw	**2-0.25**	1.83 ±0.734 cd	0.1 ±0.006 de
		0.25-0.05	1.78 ±0.092 cd	0.13 ±0.006 de
	Bk/C	**2-0.25**	2.36 ±1.195 cd	0.06 ±0.006 e
		0.25-0.05	1.06 ±0.067 d	0.08 ±0.010 de
RP_2	**Ah**	**2-0.25**	16.36 ±0.190 a	1.02 ±0.006 a
		0.25-0.05	17.79 ±0.376 a	1.17 ±0.025 a
	Bw	**2-0.25**	3.403 ±0.118 a	0.23 ±0.006 a
		0.25-0.05	5.067 ±0.081 a	0.37 ±0.006 a
Ok_1	**Ah**	**2-0.25**	5.1 ±0.040 a	0.34 ±0.006 a
		0.25-0.05	3.31 ±0.200 b	0.23 ±0.015 b
	Bw	**2-0.25**	2.67 ±0.046 c	0.19 ±0.006 b
		0.25-0.05	1.74 ±0.125 d	0.13 ±0.012 c
	Bk/C	**2-0.25**	1.92 ±0.280 d	0.11 ±0.010 c
		0.25-0.05	1.23 ±0.118 e	0.1 ±0.006 c
Ok_2	**A_1**	**2-0.25**	4.7 ±0.124 bc	0.41 ±0.006 ab
		0.25-0.05	4.83 ±0.129 b	0.43 ±0.015 ab
	A_2	**2-0.25**	4.58 ±0.060 c	0.39 ±0.006 b
		0.25-0.05	4.99 ±0.012 a	0.45 ±0.012 a
	Bw	**2-0.25**	3.04 ±0.110 d	0.26 ±0.006 d
		0.25-0.05	3.17 ±0.006 d	0.32 ±0.006 c

(D: aggregate diameters).
(RP1 and RP2: Soil samples collected from the rhizospheres under the red pine in the first and second sampling sites).
(Ok1 and Ok2: Soil samples collected from the rhizospheres under the oak in the first and second sampling sites).
(The data are the mean of replicates and ± is the standard deviation).
(Means in each column followed by similar letter (s) are not significantly different at 5% probability level, using Duncan's Multiple Range Test).

TABLE 4
The distribution of SOC and TN in the aggregates >2 mm and <2 mm in the Bw horizons of the profiles

Profile	Horizon	D (mm)	SOC (%)	TN (%)
RP_1	**Bw**	**>2**	1.43 ±0.172 e	0.11 ±0.012 d
		<2	3.14 ±0.569 bc	1.28 ±0.010 a
RP_2	**Bw**	**>2**	1.73 ±1.727 de	0.16 ±0.006 cd
		<2	3.98 ±3.983 a	1.01 ±0.105 b
Ok_1	**Bw**	**>2**	3.09 ±3.087 bc	0.21 ±0.010 c
		<2	3.73 ±3.737 ab	0.24 ±0.012 c
Ok_2	**Bw**	**>2**	2.44 ±2.437 cd	0.24 ±0.006 c
		<2	3.03 ±3.030 bc	0.25 ±0.023 c

(D: aggregate diameters).
(RP1 and RP2: Soil samples collected from the rhizospheres under the red pine in the first and second sampling sites).
(Ok1 and Ok2: Soil samples collected from the rhizospheres under the oak in the first and second sampling sites).
(The data are the mean of replicates and ± is the standard deviation).
(Means in each column followed by similar letter (s) are not significantly different at 5% probability level, using Duncan's Multiple Range Test).

DISCUSSION

The SOC and TN distribution in different aggregate fractions of the horizons. Results revealed high CECs in the Ah horizons of RP1 (93.7 Cmol.kg-1), RP2 (157 Cmol.kg-1), Ok1 (49.7 Cmol.kg-1) and A1 of Ok2 (52.4 Cmol.kg-1) (Table 1). In this respect, as stated in several studies by Mueller et al. [49],Hobbie et al. [50],Mulder et al. [51], high CEC is responsible for the increased organic C in forest soils. According to these results, the SOC and TN contents of the Ah horizons of profiles RP1, RP2, Ok1 and the A1 horizon of Ok2 were higher in comparison to other horizons. The aggregates <2 mm contain higher SOC and TN than the aggregates >2 mm as was determined in the soils of all the horizons of the 4 profiles. In this context, It has also been well established that the changes of the

SOC is more rapid in the macroaggregates compared with the microaggregates [52], in addition, the finer aggregates have the ability to protect SOC from the changes that may occur via physico-chemical and faunal activities An et al. [53],Zhang et al. [54],Leff et al. [55],Gunina et al. [56],Schmidt et al. [57],Rabbi et al. [58].Therefore, in general, except of profile Ok1, the SOC and TN contents of the aggregate fractions from 0.25 to 0.05 mm were determined higher than the aggregate fractions from 2 to 0.05 mm in the Ah, A2 horizons of profile RP1, and all the horizons of profiles RP2 and Ok2. Bossuyt et al. [59] reported high amounts of labile SOC that accumulated in the microaggregates. He et al. [60],Maguire et al. [61] also indicated that the C and N contents were high in the aggregates of <0.1 mm in comparison to the macro-aggregates in the soils they studied. The highest SOC (4.99%) and TN contents (0.45%) of profile Ok2 were obtained in the 0.25 to 0.05 mm size aggregates in the A2 horizon. Several authors Choné et al. [62]; Desjardins et al. [63],Koutika et al. [64],Neill et al. [65], reported similar contents of SOC for the soils with high contents of clay as is the case for the A2 horizon of this profile with high clay content (54%) (Table 1). Jimenez and Lal [66] reported that soil texture and the age of the forest soils were identified as the main factors that explained the variability in SOC and the fine silt with the clay fraction containing the highest contents of SOC in all forest stands.

Comparison of the SOC and TN contents in the Bw Horizons of the Profiles. The Bw horizons of the RP1 and RP2 profiles are higher in SOC and TN contents than the Ok1 and Ok2 profiles. These results are consistent with the results of Gruba and Mulder [67],Augusto et al. [68]. Moreover, among the two different sizes of micro-aggregates of the Bw horizons of the soil profiles under oak canopy, the aggregates from 0.25 to 0.05 mm protected higher contents of SOC and TN (%) than the aggregates from 2 to 0.25 mm. These results implied that SOC is more stable in the size fraction of 0.25-0.05 mm than in the fraction 2-0.25 mm of the soils under oak canopy. This may point out that the smaller fractions are able to occlude comparatively more SOC than the larger. On the other hand, in comparing the SOC and TN contents of the aggregate sizes of >2 mm and <2 mm in the Bw horizons of all the 4 profiles, the <2 mm aggregate fractions were determined to contain higher SOC and TN (%).

CONCLUSION

The results revealed a direct relationship between SOC, TN and CEC in the surface soils (Ah horizons of RP1, RP2, Ok1 and A1 of Ok2) of the red pine and oak canopies. The Ah horizon of Red pine had significantly higher CEC and therefore higher SOC and TN contents from the Ah and A1 horizons of the oak canopies. We may also, conclude that the Red pine reforestation has high merit in mitigating climate change by its high SOC sequestration in macro (<2 mm) and micro- aggregates (0.25 - 0.05 mm).

Results revealed that independent of depth and slope, under red pine and oak covers the soil organic carbon levels of the study site are two to threefold higher in carbon content than the agricultural soils of the region. Thus, at 100 - 700 m elevations of the limestone areas of the Mediterranean Region of Turkey, maintaining red pine (Turkish pine) and oak vegetation is an efficient tool for combating and mitigating climate change via sequestration of carbon.

TABLE 5
The distribution of SOC and TN in the aggregates from 2 to 0.25 mm and 0.25 to 0.05 mm in the Bw horizons of the profiles

Profile	Horizon	D (mm)	SOC (%)	TN (%)
RP_1	**Bw**	**2-0.25**	1.83 ±0.734 d	0.10 ±0.006 e
		0.25-0.05	1.78 ±0.095 d	0.13 ±0.006 e
RP_2	**Bw**	**2-0.25**	2.67 ±0.046 c	0.19 ±0.006 d
		0.25-0.05	1.74 ±0.125 d	0.13 ±0.012 e
Ok_1	**Bw**	**2-0.25**	3.40 ±0.118 b	0.23 ±0.006 cd
		0.25-0.05	5.07 ±0.081 a	0.37 ±0.006 a
Ok_2	**Bw**	**2-0.25**	3.04 ±0.110 bc	0.26 ±0.006 c
		0.25-0.05	3.17 ±0.006 bc	0.32 ±0.006 b

(D: aggregate diameters).
(RP1 and RP2: Soil samples collected from the rhizospheres under the red pine in the first and second sampling sites).
(Ok1 and Ok2: Soil samples collected from the rhizospheres under the oak in the first and second sampling sites).
(The data are the mean of replicates and ± is the standard deviation).
(Means in each column followed by similar letter (s) are not significantly different at 5% probability level, using Duncan's Multiple Range Test).

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