SOIL RESPIRATION AND MAIN SOIL CHARACTERISTICS ON DIFFERENT TYPES OF SOILS IN WEST SERBIA

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ABSTRACT

Soil respiration is an important indicator of soil health because it indicates the level of microbial activity, SOM content and its decomposition rate. The research was aimed to study the relationships between soil respiration and other soil characteristic between different soil types that are under different land use system within small test area. Moisture, temperature and availability of organic substrate most influential factors that impact soil respiration and given that precipitation and temperature are uniformed in the studied area, the main goal was to find the soil indices that is closely correlated to soil microbial respiration on different soil types. The results showed that soil respiration was greatest in Rendzna and in the soils containing carbonates. In spite of heterogeneity of soil cover, which implies different soil physical, water, chemical and biological characteristics, the soil microbial activity was closely and positevly correlated with soil acidity, clay content, content of carbon and nitrogen.

Keywords: soil respiration, soil type, clay content, microbial activity

INTRODUCTION

Soil respiration is a measure of carbon dioxide (CO_2) released from the soil from decomposition of soil organic matter (SOM) by soil microbes and respiration from plant roots and soil fauna. It is an important indicator of soil health because it indicates the level of microbial activity, SOM content and its decomposition. Soil respiration is the second largest carbon flux between terrestrial ecosystems and the atmosphere in the global C cycle (Jia and Zhou, 2009; Schlesinger and Andrews, 2000; Thomey et al., 2011), and plays an important role in regulating the soil carbon pool and ecosystem C-cycling (Cox et al., 2000; Saiz et al., 2006; Wang et al., 2016). In short term, high soil respiration rates are not always better; it may indicate an unstable system and loss of soil organic matter (SOM) because of excessive tillage, or other factors degrading soil fertility (Karbozova-Saljnikov, 2004).

The amount of carbon dioxide that soil respired is an indicator of nutrients contained in organic matter being converted to forms available to crops. Soil respiration depends on the content of organic and mineral compounds, the physical and chemical structure of soil, its moisture content, acidity, aeration and a range of abiotic and biotic factors in soil.

In this study, we describe the relationship between soil respiration and other soil characteristic between different soil types that are under different land use system within small test area. It is known that moisture, temperature and availability of organic substrate most influential factors that impact soil respiration. Given that precipitation and temperature are uniformed in studied area, the main goal of the study was to find the soil indices that is closely correlated to soil microbial respiration considering different pedological and geological origin of studied soils.

MATERIALS AND METHODS

Site description

Study area located around village Lisa, 6 km away from the city of Ivanjica, west Serbia, and occupied an area of 8.6 km^2 (43°37′40″ - 43°39′8″ latitude and 20°11′22″ - 20°13′47″ longitude) at 945 m and 532 m above sea level. Most part of the studied territory is under forest, with large territories under cultivated haylands or arable lands. The relief of the territory is very hilly-mountainous and is located between 945 m (profile 2) and 532 m (profile 23) above sea level. The mmountain climate is characterized with warm summers and cold winters. Precipitation is homogeneously distributed.

In total, 21 representative profiles were opened and sampled. Each profile was accompanied by 2-3 boreholes. On the investigated territory of Lisa village, the limestones and dolomites occupy significant area (about 1/3 of the territory), and are often found in complexes with other soft calcareous rocks and calcareous flis that together make about 2/3, or 75% of the territory.

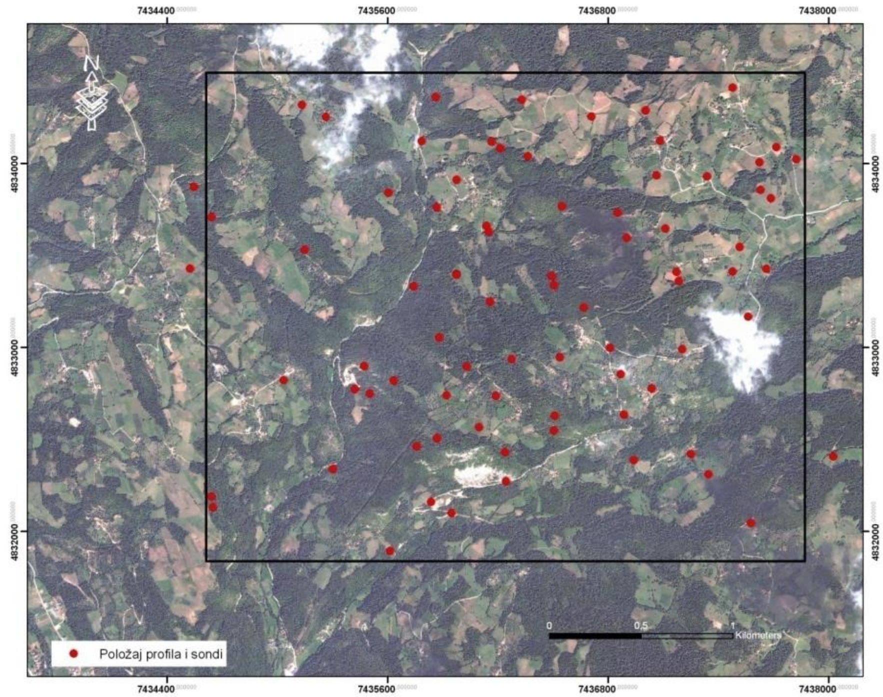

Figure 1. Sampled soil profiles in Lisa village, west Serbia

Analitical methods

The following soil characteristics were analyzed: pH (in KCl solution), total and organic N, total N, available P and K, bulk density, calcium carbonate, soil CEC, grain-size distribution, soil texture, mobile Al, and soil respiration, as an indicator of soil biological activity. Soil pH was determined with a glass electrode pH meter in a 1:2.5 distilled water and KCl (mol/l). Soil total C and N were measured with an elemental CNS analyser, Vario model EL III (Elemental Analysa systeme GmbH, Hanau, Germany) (Nelson and Sommers, 1996). Available P and K were determined by the AL-method (Egner and Riehm, 1958). Granulometric composition was determined by pipette method (Sheldrick and Wang, 1993). Calcium carbonate was measured volumetrcally. Content of humus was analyzed by Kotzman method and adsorbtive complex was determined by Kappen method.

The soil respiration was determined by the technique of laboratory incubation with constant temperature and moisture. The soil samples were placed into the 500ml container after adjusting their moisture for 55% of their water holding capacity. Then the vial with 10ml of NaOH was also placed into each container with soil. Then, the containers were hermetically closed and placed into the thermostat for 7 days' incubation. The respired carbon dioxide was trapped into the NaOH. On the 7^{th} day the alkali trap was removed, immediately closed and the remained amount of OH^- ions was back titrated with HCl solution. From the difference between the quantity of NaOH taken for binding carbon dioxide and remaining free, determined by titration with 1N HCl, the amount of released carbon dioxide during the incubation period is calculated (Horwath et al., 1996).

The total number of soil microorganisms was determined by plate count method on the agarised soil extract (Saric, 1989).

Statistical analyses were performed with SPSS version 16 software. The effect of treatments on all the variables was tested by ANOVA software. Statistical differences between the treatments were determined using the t test (95%) by a Pearson for Fisher LSD. The significance of their correlations was analysed by Pearson correlation matrix (SPSS, 2007).

RESULTS AND DISCUSSION

In the paper, selected soil indices were presented. Obtained results showed heterogeneity of soil main properties among studied soil types. The influence of strong geological movements are expressed by a very high heterogeneity of the terrain in terms of geological substrate and the anthropogenic factor greatly contributed to that. Different soil types overlap each other very irregularily. On the surveyed area there were recored nine types of soil: Lithosol - limestone and dolomite, Regosol (eutric and dystric), Colluvium, Ranker (eutric and dystric), Redzina, Calcomelanosol, Cambisol (eutric and dystric), Calcocambisol and Pseudogley.

Soil acidity was generally higher in the soils where $CaCO_3$ was present, that are dominantly Rendzina. Content of soil humus and total nitrogen was highest in Rendzina, as expected. The greater availability of substrate in this type of soils determined the greater total microflora (Table 1). Soil respiration was generally greater also in Rendzina.

Results showed that the soils of the explored areas are generally good and well supplied with organic matter, what is on the most of the area is determined by good management of agricultural soils; while soils under the forest nuturally maintained high soil organic matter due to the high input of organic substrate.

Total nitrogen supply of soil is largely dependent on the amount of organic matter. Generally, content of N was very favorable, which is partly due to the good management of this nutrient in agricultural areas.

Results show that the studied soils are poorly supplied with plant available phosphorus. This is associated with a large representation of acid soils, where phosphorus is immobilized due to binding to Al and Fe oxides.

Potassium supply of the studied soils is very favorable, where the areas with high content of his element is not needed additional application, except for crops that have high requirements for these nutrients. Good supply of potassium is determined by parent material and fertilization of fruit crops.

Content of total organic matter was rather associated to soil type and long-term land use, except Caclomelanosol, while soil respiration via microbial activity was more associated to the clay content, soil acidity, carbon and nitrogen of soil organic matter. Kadono et al. (2008) in his broad investigation suggested that the amount of plant residues and clay content give better explanation of changes in labile organic matter content, which is the main source for microbial attack. Not only greater amount of plant residues contributes to soil respiration, but also clay-associated OM. Greater amount of organic substrate in grassland and forest would result in greater amount labile SOM, i.e. greater microbial activity.

The soil microbiological activity was mostly influenced by the soil pH, then by the content of soil organic matter (Figures 1 and 2). Content of $CaCO_3$, influenced indirectly microbial activity: the soil containing carbonates also have higher content of clay and/or humus (Table 1 and Figure 3). The other soil characteristics didn't show effect on the amount of CO_2 respired during the laboratory incubation.

Table 1. Soil general characteristics

Soil type	Land use	Humus	Total N	Clay <0.002 mm	pH in KCl	respiration CO_2	Total microflora	Av. P_2O	Av.K_2O	$CaCO_2$
		%	%	%		ppm	10^6	mg/100g		%
Pseudogley		3.32	0.17	32.3	3.6	125				
Calcocambisol		2.8	0.15	25.6	3.2	189				
Rendzina	Forest	5.73	0.3	48.6	6.5	200	59.33	0.11	20.89	0.83
Rendzic Ranker dystric	Potato	2.84	0.15	23.2	3.5	88	6.67	1.1	9.38	0
Rendzic, Ranker dystric	Forest	4.94	0.26	18.9	4.6	159	62	17.87	30.42	0
Regosol	Potato	1.72	0.09	38.3	6.7	160	43.67	5.42	38.75	0.4
Regosol	Forest	4.37	0.23	19.2	3.7	127	15	1.62	26.05	0
Rendzina	Forest	6.02	0.31	40.8	7	196	73.67	0.58	19.3	0.83
Ranker eutric	Potato	3.29	0.17	22.6	5.5	85	11	0.1	7.39	0
Rendzina	Forest	4.59	0.24	34	7.1	231	56.33	2.83	15.73	4.15
Cambisol eutric	Meadow	3.7	0.19	33.9	6	169	20.33	0.11	21.29	0
Calcomelanosol	Forest	2.04	0.11	62.4	6.5	194	21.33	0.44	22.87	0
Calcomelanosol	Forest	2.54	0.13	41	6.1	122	27.67	0.38	16.92	0
Rendzina	Meadow	5.99	0.31	64.3	6.8	188	69.67	0.25	26.84	0
Cambisol dystric	Potato	3.12	0.16	25.7	4.1	98	55	0.48	12.55	0
Cambisol dystric	Raspberry	2.62	0.14	28.7	4	94	23	0.43	6.6	0
Rendzina	Potato	6.32	0.33	42.3	6	187	70.67	9.61	33.2	0
Cambisol dystric	Forest	3.87	0.2	18.4	3.8	118	1.33	0.68	9.38	0

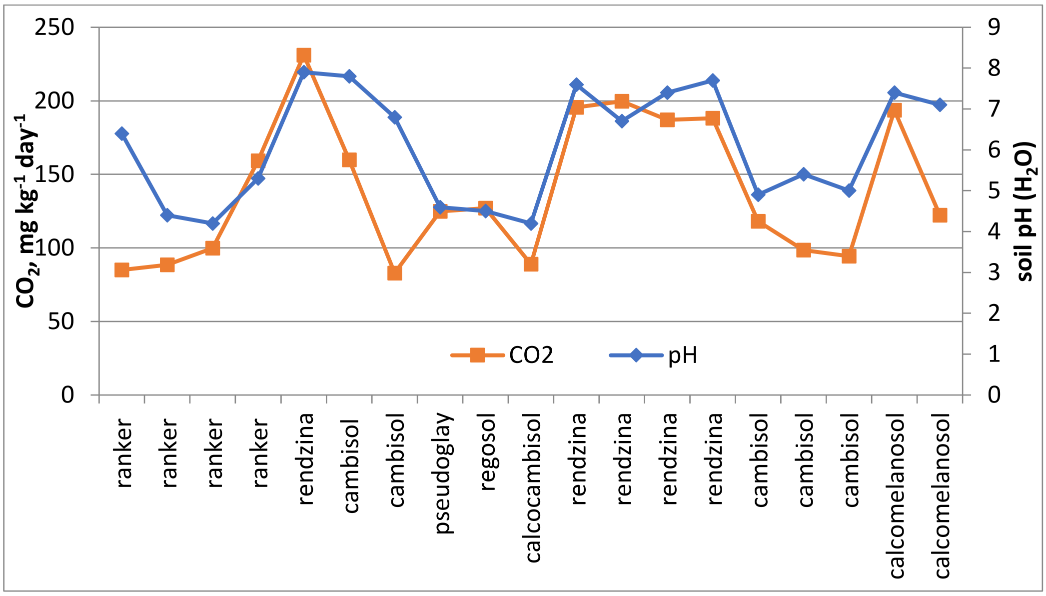

Figure 2. Soil respiration and acidity in studied soil types

As expected, the higher soil pH favoured the microbiological activity, especially in the soils with higher content of soil organic matter. In such soils the amount of easily available source of energy (organic C) and source of nutrient (N) for soil microorganisms are sufficient, what resulted in more intensive soil respiration in contrast to the soils where acidity and low content of organic substrate restrict the activity of soil microorganisms. Thirteen out of 20 soils samples showed the respiration value higher than 100 mg of CO_2 per kg per day, what indicates the good biological status of these soils. The highest respiration value, more than 231 mg CO_2/kg/day was recorded for the Rendzina on limestone with the highest soil pH, high content of soil organic matter and the highest content of $CaCO_3$.

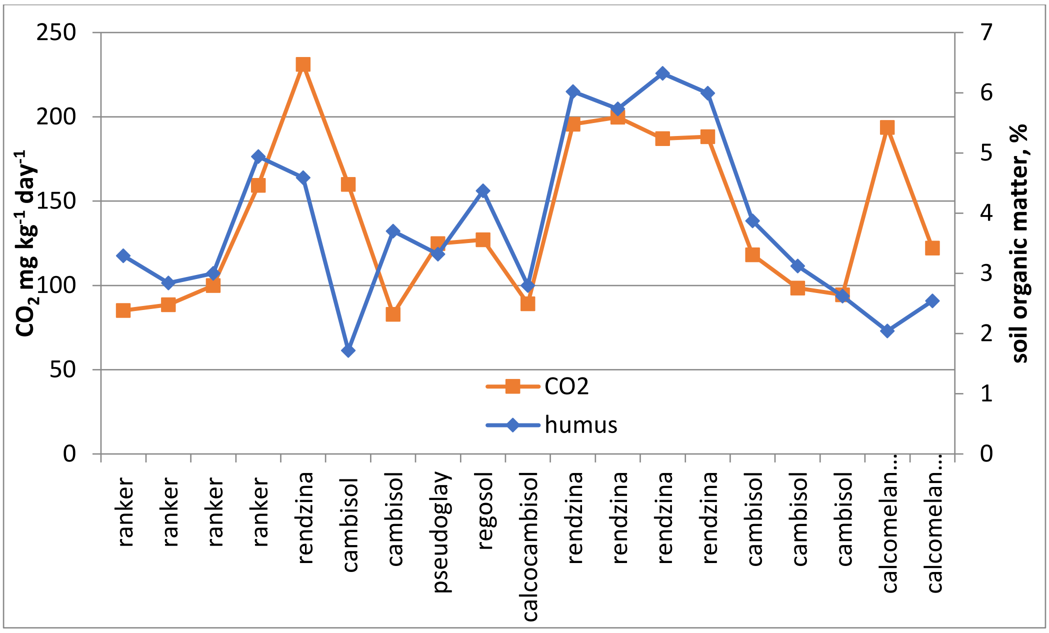

Figure 3. Soil respiration and content of organic matter in studied soil types

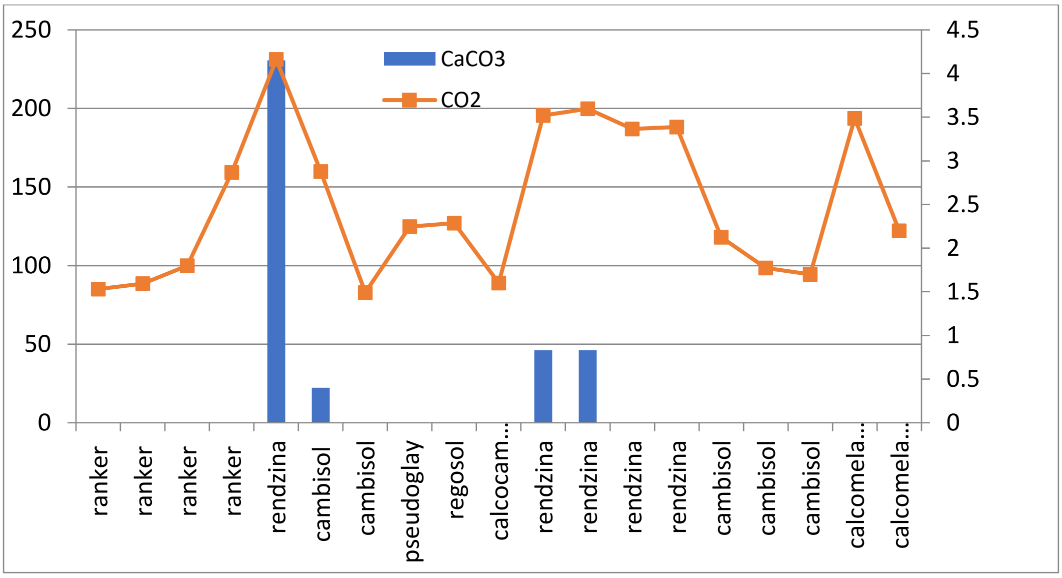

Figure 4. Soil respiration and content of calcium carbonate in studied soil types

The correlation coefficients presented in Table 2 confirms the findings that soil microbial activity via respiration under the uniform climatic conditions regardless of soil type is influenced by content soil organic matter, nitrogen, soil acidity and clay content.

Table 2. Correlation coefficients between microbial respiration and soil indices

	Clay	pH	Humus	Total N	Respiration
Clay	1	.724**	.292	.306	.513*
pH	.724**	1	.391	.455*	.677**
Humus	.292	.391	1	.914**	.462*
Total N	.306	.455*	.914**	1	.649**
Respiration	.513*	.677**	.462*	.649**	1

Grego and Lagomarsino (2008) confirms that at the global scale, climate plays a significant role in the dynamics and storage of SOM; however, at the regional scale, factors such as soil texture and vegetation type may be stronger determinants of variability of SOM content, as well as its rates of accumulation and decomposition.

CONCLUSIONS

Studied area is characterized with heterogenious pedological units: Lithosol - limestone and dolomite, Regosol (eutric and dystric), Colluvium, Ranker (eutric and dystric), Redziina, Calcomelanosol, Cambisol (eutric and dystric), Calcocambisol and Pseudogley that is specific for mountanous areas of Serbia. Soil respiration was the greatest in the Rendznas and in the soils containing carbonates. In spite of heterogeneity of soil cover, which implies different soil physical, water, chemical and biological characteristics, the soil microbial activity was closely and positevly correlated with soil acidity, clay content, content of carbon and nitrogen.

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