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EFFECT OF LAND USE ON GROUP AND FRACTIONAL COMPOSITION OF HUMUS IN RENDZINA SOILS IN SERBIA

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Abstract: The effect of land use on group and fractional composition of humus was examined in 13 rendzina profiles under forests, 12 profiles under grassland and 8 profiles under arable fields in different parts of Serbia where rendzinas are typically found. The difference regarding land use of rendzina soils (depending on cultural practices or absence of any, and different amounts and quality of plant residues) under forest, grassland or arable fields had a highly significant statistical effect on humus group composition and the fractional composition of humic and fulvic acids. Human activities have brought about some positive changes regarding humus composition by promoting its stable component in rendzinas under grassland and arable fields, which is not the case in forest rendzina. The conversion of forests into grasslands and arable fields did not significantly affect the type of humus in rendzina soils, which remained characteristic of that soil type.

Key words: Land use, soil humus composition, rendzina soil, Serbia.

I n t r o d u c t i o n

Serbian rendzina soils, which are typically found in uplands in Serbia, were originally covered with forest vegetation. In accessible terrains, forests have been converted into grassland or arable land. Today, their evolution proceeds under altered conditions. The differences regarding land use of rendzinas under

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forests, grassland or arable fields result from soil cultivation or absence of any, and from variations in the amounts and quality of plant residues in soil and some other factors. Cultivation and organic inputs affect many soil characteristics, including its humus as one of the most sensitive properties, as well as its group and fractional composition. Changes in the content and group and fractional composition of humus have impact on the ongoing pedogenetic processes and other soil characteristics.

The effect of land use on soil organic matter has been in a focus of attention of researchers worldwide. Agreeing with early investigators of organic matter in soil, modern authors have also found that its status in soil results from various physical and chemical processes taking place in soil and the character of local plant communities and land uses (T a t e, 2001). The dynamics of organic matter in soil, character and intensity of pedogenesis, and effects of agricultural practices on those processes in virgin soils, arable lands or degraded soils are being studied by looking closely at the group and fractional composition of humus and characteristics of humus matter (Котов et al., 2004; Donisa et al., 2003; Reintam et al., 2002; Thanasolulias et al., 2002; Kovaleva and Dergacheva, 2001; Убугунов et al., 2001; Urusevskaya et al., 2000; Убугунова and Убугунов, 1996, etc.). The important influence of land use has been acknowledged in a large number of studies worldwide focusing on the effects of various agricultural practices, primarily different soil cultivation and fertilization methods, on the composition of humus in soil (Doane et al., 2003; Ding et al,. 2002; Zalba and Quiroga, 1999).

Higherto research of humus in Serbian rendzina soils (Cupać et al., 2006) has shown that different land uses (tillage or its absence, and different amounts and quality of organic refuse input) have a significant statistical influence on humus and total nitrogen decrease in rendzinas underlying grassland, and especially arable land, in contrast to forest rendzinas, while N enrichment of humus is significantly higher under grassland than under forest. This study aimed to investigate the effect of different land uses on rendzina soils and the group and fractional composition of their humus. The group and fractional composition of humus has already been identified as an important indicator of soil evolution under human influence as a predominant pedogenetic factor.

Material and Methods

The effect of land use, and humus group and fractional composition in Serbian rendzina soils was examined in 13 profiles under forest (23 samples), 12 under grassland (18 samples) and 8 under arable fields (16 samples). Either one or two samples were collected from the A horizon, depending on depth, and one from the transitional AC horizon in profiles that have such horizon.

In the forest sites, predominating were deciduous species, mostly oak (*Quersuc cerris* L. and *Quercus pubescens* Willd.) with occasional hawthorn (*Crataegus spp.*), hornbeam (*Carpinus spp.*) and ash (*Fraxinus spp.*) trees. Grass vegetation is more abundant in western and central parts of Serbia than in eastern and south-eastern. Arable rendzina soils are mostly cultivated with wheat and maize crops. The main chemical characteristics of the investigated rendzinas have been reported elsewhere (Cupać et al., 2006).

The group and fractional composition of humus were determined by a method designed by Ponomarieva and Plotnikova (Пономарева and Плотникова, 1968). Humus status was determined according to Grishina and Orlov (cited from Орлов, 1985). The data were statistically processed by StatSoft Statistka 5.0 software. T-test was employed to compare the soil properties of forest, grassland and arable land variants of rendzina soils. Significance of the differences found was determined at 95% confidence level.

Results and Discussion

Group composition of humus

The lowest total content of humic acids, on average, was found in forest rendzinas (Tab.1) with grassland rendzinas following very closely and those in arable fields having the highest average content. The differences, however, are not statistically significant. Forest rendzinas generally have the highest content of fulvic acids, those under arable land have less, and grassland rendzinas the least. Forest rendzinas have statistically significantly higher contents of fulvic acids than those under grassland vegetation (t=2.487514, p=0.023541). Grassland rendzinas were found to have the highest content of humin, on average, followed by those under arable fields and forest. Contents of humin were statistically significantly higher in rendzinas under grassland than forest (t=2.13300, p=0.047798).

The average values of the Ch:Cf ratio in arable land and grassland are close; the ratio is narrower under forest, but not significantly in statistical terms. Broader Ch:Cf ratios in arable soil, compared to grassland and forest, have been found in many soil types (Uruseskaya, 2000; Novaković, 1991; Živković, 1972). The broadening of the ratio in arable soils is due to an absolute or only relative increase in the content of humic acids, especially the stable fractions 2 and 3, and a decrease of fulvic acids, especially their mobile fractions. The change is a result of improved conditions for full humification of organic matter in arable soils, compared to virgin soils. According to Kononova (1975), cultivation and application of organic and mineral fertilizers may lead to essential changes in the organic component of soil as a result of intensified formation and decomposition of organic matter, but humus nevertheless retains its basic and typical

characteristics for that soil type. Consequently, humus in most of the examined rendzina profiles in Serbia belongs to the fulvate-humate type, regardless of land use.

T a b. 1. - Group composition of humus (% of total oganic C)

Property	Variant	n	Xmean	SD	Xmin.	Xmax.	Xmax-Xmin
Humic	Total	57	26.27	5.42	10.00	35.71	25.71
acids	Forest	23	25.35	5.45	11.90	35.71	23.81
	Grassland	18	25.87	5.48	10.00	33.64	23.64
	Arable land	16	28.04	5.21	19.04	35.25	16.21
Fulvic	Total	57	37.08	5.42	26.40	55.09	28.69
acids	Forest	23	38.77	4.72	29.76	49.47	19.71
	Grassland	18	34.92	3.85	26.40	43.65	17.25
	Arable land	16	37.06	7.09	26.94	55.09	28.15
Humin	Total	57	36.95	7.26	16.34	51.58	35.24
	Forest	23	35.88	6.67	21.00	45.26	25.26
	Grassland	18	39.26	5.48	28.79	49.99	20.70
	Arable land	16	35.91	9.40	16.34	51.80	35.24
Ch:Cf	Total	57	0.72	0.18	0.25	1.06	0.81
	Forest	23	0.66	0.17	0.28	0.95	0.67
	Grassland	18	0.75	0.19	0.25	1.06	0.81
	Arable land	16	0.77	0.18	0.44	1.05	0.61

Fractional composition of humic acids

Forest rendzinas were found to have the highest average content of free humic acids and those bound to mobile R_2O_3 and by far the broadest interval of values (Tab.2). Those values are statistically significantly higher than those in rendzinas under grassland ($t=2.592617$, $p=0.018967$) and arable land ($t=2.272783$, $p=0.038178$). The highest content of fraction 1 of humic acids in total humic acids was also found in soils under forest vegetation, while it was only half of that value under grassland and arable soil. This is the result of different amounts and quality of plant residues.

The highest content of humic acids bound to Ca^{2+} was found in rendzinas under arable land, slightly lower in those under grassland, and the lowest under forests. Grassland rendzinas showed the highest content of humic acids bound to Ca^{2+} in total humic acids, arable land rendzinas followed, while this fraction was least represented in the humic acids of forest rendzinas. Although the differences are not statistically significant, it is interesting that the highest content of fraction 2 of humic acids was found in arable rendzinas. According to Urusevskaya et al. (2000), the arable top soil horizon of grey forest soils in the former USSR had a lower content of humus and increased content of total humic acids and their fraction 2 than virgin grey forest soils.

The most favourable conditions for full humification of plant refuses, and for their most favourable quality, were found in rendzinas under arable soil and grassland, while poorer conditions were in forest rendzinas, which is indicated by

fraction 2 of humic acids and its proportion in total humic acids. Also, fraction 3 of the stable humic acids shows the highest average content in arable rendzinas and the narrowest interval of values. Forest rendzinas follow, while slightly less was found in those under grasses. The differences have no statistical significance.

T a b. 2. - Fractional composition of humic acids

Fraction	Variant	n	Xmean	SD	Xmin.	Xmax.	Xmax-Xmin
			% of total organic C				
Humic	Total	57	2.19	1.52	0.00	6.93	6.93
acids1	Forest	23	2.99	1.71	0.76	6.93	6.17
	Grassland	18	1.73	1.27	0.00	4.17	4.17
	Arable land	16	1.58	0.93	0.00	3.26	3.26
Humic	Total	57	14.07	4.35	3.57	21.58	18.01
acids 2	Forest	23	12.55	3.87	7.69	19.94	12.25
	Grassland	18	14.79	4.57	5.31	21.27	15.96
	Arable land	16	15.43	4.35	7.59	21.58	13.99
Humic	Total	57	10.01	3.37	1.89	15.82	13.93
acids 3	Forest	23	9.81	3.75	1.89	15.82	13.93
	Grassland	18	9.35	3.80	3.33	15.78	12.45
	Arable land	16	11.03	1.90	7.37	13.33	5.96
			% of total humic acids				
Humic	Total	57	8.46	6.13	0.0	28.0	28.0
acids1	Forest	23	12.06	6.96	3.3	28.0	24.7
	Grassland	18	6.41	4.58	0.0	15.4	15.4
	Arable land	16	5.61	3.48	0.0	12.5	12.5
Humic	Total	57	53.58	14.06	29.6	84.8	55.2
acids 2	Forest	23	49.99	15.72	29.6	84.8	55.2
	Grassland	18	57.60	15.32	31.4	80.3	48.9
	Arable land	16	54.24	8.34	37.5	69.8	32.3
Humic	Total	57	37.62	11.18	5.1	58.1	53.0
acids 3	Forest	23	37.14	12.59	5.1	50.0	44.9
	Grassland	18	35.98	12.01	16.9	57.2	40.3
	Arable land	16	40.16	7.76	25.6	58.1	32.5

Fractional composition of fulvic acids

Forest rendzinas have the highest average content of mobile 1a and 1 fractions of fulvic acids (Tab.3), while arable renzdinas follow, and the lowest content was found in rendzinas under grassland. Fraction 2 of fulvic acids has the highest content in arable fields, which also have the highest content of fraction 2 of humic acids that they are bound to, with forest and grassland rendzinas following. In all three variants a very high content of fraction 3 of fulvic acids was found, and the values were close to fraction 2, but the difference is not statistically significant. A significant difference regarding fraction 3 of fulvic acids was found between forest and arable rendzinas (t=3.999489, p=0.001161).

T a b. 3. - Fractional composition fulvic acids (% of total organic C)

Fraction	Variant	n	Xmean	SD	Xmin.	Xmax.	Xmax-Xmin
Fulvic	Total	57	5.26	1.82	2.61	10.71	8.10
acids 1a	Forest	23	5.43	1.96	2.67	10.71	8.04
	Grassland	18	5.00	1.30	3.26	7.36	4.10
	Arable land	16	5.27	3.08	2.38	9.52	7.14
Fulvic	Total	57	5.66	2.70	0.00	11.09	11.09
acids 1	Forest	23	6.74	2.26	3.32	11.09	7.77
	Grassland	18	4.61	2.48	0.77	9.43	8.66
	Arable land	16	5.27	3.08	0.00	10.56	10.56
Fulvic	Total	57	13.78	3.52	7.52	24.49	16.97
acids 2	Forest	23	13.41	2.91	8.71	22.42	13.71
	Grassland	18	12.85	2.72	7.52	17.91	10.39
	Arable land	16	15.37	4.66	9.05	24.49	15.44
Fulvic	Total	57	12.37	2.35	6.31	18.18	11.87
acids 3	Forest	23	13.20	2.28	9.25	18.18	8.93
	Grassland	18	12.46	1.86	8.57	16.67	8.10
	Arable land	16	11.07	2.49	6.31	14.67	8.36

Humus stability

In order to determine more precisely the composition of humus in Serbian rendzina soils under different land uses, summa of mutually bound fractions of humic and fulvic acids was calculated and presented in Fig.1. The summa of mobile fractions 1 of humic and fulvic acids and fraction 1a of free fulvic acid was mostly found in forest rendzina soils, while the content of stable fractions 2 and 3, as well as humin content, are higher in rendzina soils under arable land and grassland. The differences, however, are not statistically significant and Fig.1 shows that even in forest rendzinas the mobile component of humus is to be found only at 15%, which shows that humus is generally very stable in all investigated variants of rendzina soils.

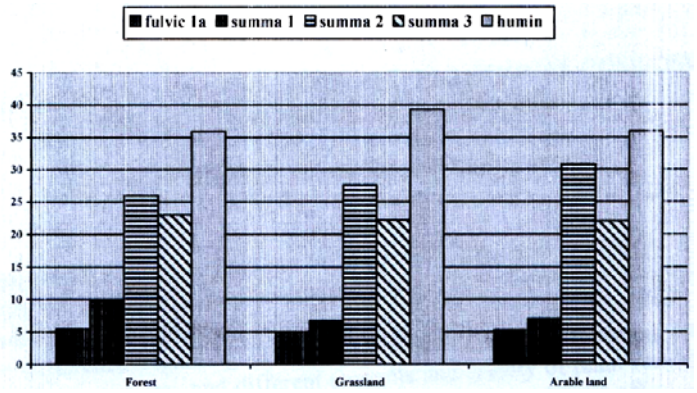

Fig. 1. – Average content of mobile and stable fractions of humus (% of organic C)

Conclusions

Different land uses (cultivation or non-cultivation and amounts of plant remains) of rendzina soils under forest, grassland or arable land were found to cause statistically significant impact on:

- group composition of humus – forest rendzinas have significantly more fulvic acids than those under grassland, and the latter contain significantly more humin than the former;
- fractional composition of humic acids – forest rendzinas contain significantly more fraction 1 of free humic acids and those bound to mobile R_2O_3 than rendzinas under grassland and arable fields;
- fractional composition of fulvic acids – forest rendzinas have significantly higher contents of fraction 3 of fulvic acids bound to humic acid 3 than arable rendzinas.

Human activities have brought about positive changes regarding humus composition in terms of increasing its stable component in rendzina soils under grassland and arable fields, compared to forest rendzinas. By turning forests into grassland and arable land the type of humus in rendzina soils was not significantly altered. The type of humus is known to be and was proved in this investigation to be a characteristic of that soil type.

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UTICAJ NAČINA KORIŠĆENJA ZEMLJIŠTA NA GRUPNI I FRAKCIONI SASTAV HUMUSA U RENDZINAMA SRBIJE

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R e z i m e

Uticaj načina korišćenja zemljišta na grupni i frakcioni sastav humusa u rendzinama Srbije ispitivan je na 13 profila rendzine pod šumom (23 uzoraka), 12 pod travnjakom (18 uzoraka) i 8 pod njivom (16 uzoraka). Iz A horizonta uzet je jedan ili dva uzorka, zavisno od dubine, i po jedan uzorak iz prelaznog AC horizonta, u profilima koji su imali razvijen AC horizont.

Razlike u načinu korišćenja zemljišta (primena ili odsustvo obrade i razlike u količini i kvalitetu biljnih ostataka) u rendzinama pod šumom, travom i njivom, statistički su značajno uticale na: grupni sastav humusa (značajno su bogatije fulvo kiselinama šumske nego rendzine pod travom, a rendzine pod travom sadrže značajno više humina nego šumske), frakcioni sastav huminskih kiselina (šumske rendzine sadrže značajno više frakcije 1 slobodnih huminskih kiselina i vezanih s mobilnim R_2O_3 nego rendzine pod travom i njivom) i frakcionom sastav fulvo kiselina (šumske rendzine sadrže značajno više frakcije 3 fulvo kiselina vezanih s huminskim kiselinama 3 u odnosu na njivske rendzine).

Čovekova aktivnost dovela je do pozitivnih promena u sastavu humusa u pravcu povećanja stabilnog dela humusa u rendzinama pod travnjacima i njivama u poređenju sa šumskim rednzinama. Pretvaranje šuma u travnjake i njive nije značajno uticalo na tip humusa rendzina u Srbiji, koji je, kao što je poznato, a ovim istraživanjima potvrđeno, karakteristika tipa zemljišta.

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