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EFFECT OF DECARBONATION AND LAND USE ON HUMUS CONTENT AND ITS NITROGEN ENRICHMENT IN RENDZINA SOILS

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Rendzina is a widespread soil type in Serbia that can be found in several stages of evolutionary development and put to different land uses. Our objective was to investigate the effect of decarbonation of rendzina soils in Serbia and several land use variants on humus content and its enrichment in nitrogen.

Humus content is mostly high, and rarely medium, in the A horizon of calcaric forest rendzinas; medium or high under grassland, and very low under arable land. In non-calcaric forest rendzinas, humus content in horizon A is medium or low; under grassland it is low and very low, and under arable land again low and very low. Rendzinas are predominantly rich and very rich in total nitrogen in the uppermost layer of horizon A, and medium or well supplied in the layer below it. Enrichment of humus in nitrogen, shown as the C:N ratio, is mostly medium, and rerely low.

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Decarbonation was caused by decreasing humus content and total nitrogen in soil, while the enrichment of humus in nitrogen (C:N ratio) showed no significant change. Different land uses were found to have significant effect on decreasing humus and total nitrogen contents in rendzinas under grassland, and especially arable land, compared to forest rendzinas, while humus enrichment in nitrogen was significantly higher in rendzinas underlying grassland than forest.

Key words: organic carbon, C:N ratio, calcaric and non-calcaric rendzinas, forest, grassland, arable land

INTRODUCTION

The importance of soil organic matter is evident from the fact that the organic C is considered one of the major indicators of soil condition in soil databases worldwide (BREJDA *et al*., 2001; SCHIPPER AND SPARLING, 2000). Besides investigating the influence of intrinsic pedogenic factors on humus storage in soil (KULMATISKI *et al*., 2004; TAN *et al*., 2004b; THOMPSON AND KOLKA, 2005), special attention is focused today on human influences, i.e. on the effects of changing land uses, i.e. transformation of forests, grasslands and wetlands by tillage and intensive management practices, which largely contributes to C losses from soil. Decrease in soil organic matter may have very negative effects as it plays a crucial role in the development and maintenance of fertility, principally through the cycling, retention, and supply of plant nutrients and the creation and maintenance of soil structure (SWIFT, 2001).

Apart from decreasing contents of organic matter in soil, another outstanding problem today is the existing increase in atmospheric CO_2, caused by emission of organic C from soil, as well as by fossil fuel combustion. For this reason, soil carbon sequestration is again a topical subject at the beginning of the third millenium (HAYES AND CLAPP, 2001; LAL, 2004).

Original research data on humus contents and C:N ratios in rendzina soils in Serbia can be found only in soil map commentaries (ANTONOVIĆ *et al*., 1974; MILJKOVIĆ, 1972; SPASOJEVIĆ *et al*., 1975) or in studies made as part of soil preparation for agricultural production (ŽIVKOVIĆ *et al*., 1981). Rendzina has been estimated as a highly widespread soil type in Serbia, and in the hilly and mountainous parts it can be found in several stages of evolution and under different plant covers that define different land uses. This study aimed to investigate the effects of decarbonation and different land uses on the content of humus and its nitrogen enrichment in Serbian rendzina soils.

MATERIALS AND METHODS

The sites investigated in this study included the hillsides of Mt. Fruška gora in Vojvodina (profiles No. 12 and 13); Topola and Aranđelovac environs in central Serbia (No 18-21); Jablanica basin and areas around Lajkovac and Valjevo in western Serbia (No 15-17); Sjenica-Peštar plateau in south-western Serbia (No 11);

Negotin environ in eastern Serbia (No 1-10); and Niš-Pirot stretch in south-western Serbia (No 22-31).

At each site, we sampled carcaric and non-calcaric rendzina soils from each of the three defined land use variants, if all of them were available. Calcaric rendzinas predominated at all sites, so that more profiles of that sub-type were processed than of non-calcaric. Thirty soil profiles were investigated in this field study, i.e. 24 profiles of calcaric (9 forest, 9 grassland and 6 arable land) and 6 profiles of non-calcaric (3 forest, 2 grassland and 1 arable land) rendzina soils. A total of 51 soil samples where collected and analyzed from the A and AC horizons (where those were found).

The following laboratory procedures were employed (JDPZ, 1966): potentiometric method (in water and KCl) for soil pH; volumetric method by Scheibler's calcimeter for $CaCO_3$ content; Kappen's method for hydrolytic acidity (for non-calcareous samples); Kappen's method for total adsorbed basic cations (for non-calcareous samples); Tjurin's method modified by Simakov for total carbon; Kjeldal's semi-micro method for total nitrogen; and the C:N ratio was calculated.

Soil assessment regarding humus content in the A horizon (very high >10%, high 6-10%, medium 4-6%, low 2-4%, very low <2%) and enrichment of soil humus in nitrogen based on the C:N ratio (very high <5, high 5-8, medium 8-11, low 11-14, very low >14) was made according to Grishina and Orlov (cited from ОРЛОВ, 1985).

Statistical data processing was done using the StatSoft Statistka 5.0 software. Correlation analysis revealed a link between the basic soil properties, and C and N contents. T-test was employed to compare soil properties between calcaric and non-calcaric rendzinas, as well as the land use variants. Significance of the differences found was determined at 95% confidence level.

RESULTS AND DISCUSSION

The results of our investigation of chemical properties of calcaric rendzina soils are presented in Table 1 and non-calcaric rendzina soils in Table 2.

Carbonate content in calcaric rendzinas varies over a wide interval from 0.71 to 51.84%, soil pH reaction is neutral to slightly alkaline, substitutional acidity is not prominent, and pH values in KCl exceed 6.71. Non-calcaric rendzina soils are pH neutral, and substitutional acidity is weak or medium. An adsorption complex analysis indicates a high cation exchange capacity and high base saturation.

Organic carbon content

Organic carbon contents in the A horizons of investigated rendzinas vary over a wide interval from 1.15% to 6.25%, being 3.25% on the average. In the transitional AC horizons, carbon content is significantly lower, varying from 0.21% to 2.81%, or 1.30% on the average.

Table 1. - Hemical properties of calcaric rendzina soils

Profile	Depth cm	Horizon	$CaCO_3$ %	pH in H_2O	pH in KCl	Humus %	C %	N %	C:N
				Forest					
1	0-10	Amo	4.02	7.71	6.90	10.77	6.25	0.570	10.96
	10-25	Amo	4.21	7.82	6.86	6.14	3.56	0.370	9.62
2	0-10	Amo	8.73	7.53	6.87	9.10	5.28	0.479	11.00
	10-20	Amo	3.86	7.60	6.80	5.46	3.17	0.321	9.91
15	0-20	Amo	18.08	7.78	7.20	8.02	4.65	0.457	10.17
	20-40	AC	16.51	7.74	7.32	4.84	2.81	0.327	8.59
16	0-20	Amo	51.84	7.59	7.26	7.76	4.50	0.506	8.89
18	0-20	Amo	3.03	7.49	6.71	6.77	3.92	0.237	16.54
22	0-20	Amo	12.28	7.55	6.92	9.51	5.31	0.500	10.62
	20-30	AC	40.65	7.77	7.14	4.14	2.41	0.227	10.62
23	0-15	Amo	27.10	7.59	7.11	6.60	3.83	0.342	11.20
	15-50	AC	37.91	8.40	7.76	1.34	0.78	0.080	9.75
29	0-20	Amo	9.96	7.58	7.04	6.65	3.87	0.412	9.39
30	2-10	Amo	17.08	7.62	7.10	8.69	5.04	0.464	10.86
	10-30	AC	21.06	7.68	7.20	5.54	3.22	0.297	10.84
				Grassland					
3	0-15	Amo	6.00	7.73	6.95	5.43	3.15	0.316	10.16
	15-30	Amo	12.79	7.70	7.04	4.62	2.68	0.279	9.57
4	0-15	Amo	2.60	7.70	6.83	5.10	2.96	0.309	9.58
	15-30	Amo	3.26	7.60	6.86	4.52	2.62	0.286	9.36
5	0-15	Amo	5.38	7.58	6.84	5.19	3.01	0.322	9.41
6	0-15	Amo	4.39	7.33	6.80	6.36	3.69	0.381	9.68
	15-30	Amo	6.54	7.66	6.87	3.96	2.30	0.237	9.70
8	0-15	Amo	1.85	7.52	6.87	9.86	5.72	0.480	11.92
	15-30	Amo	0.71	7.55	6.80	4.45	2.58	0.254	10.16
11	0-15	Amo	17.54	7.63	7.11	7.94	4.60	0.489	9.41
12	0-20	Amo	21.72	8.05	7.57	5.74	3.33	0.353	9.43
13	0-20	Amo	14.78	7.69	7.28	7.43	4.31	0.509	8.47
28	0-14	Amo	14.42	7.70	6.93	3.39	1.97	0.235	8.38
	14-30	AC	20.97	8.15	7.13	0.52	0.30	0.050	6.00
				Arable land					
9	0-10	Ap	1.97	7.71	6.78	2.40	1.39	0.149	9.32
	10-25	Ap	1.58	7.70	6.76	2.33	1.35	0.143	9.44
14	0-20	Ap	43.90	7.72	7.22	3.17	1.84	0.206	8.93
	20-40	AC	51.57	7.82	7.39	2.35	1.36	0.145	9.38
19	0-17	Ap	8.85	7.78	6.95	5.31	3.08	0.240	12.50
24	0-20	Ap	14.54	7.98	7.58	1.98	1.15	0.123	9.34
	20-40	AC	29.63	8.30	7.73	0.35	0.21	NO	NO
27	0-20	Ap	6.74	7.71	6.93	3.32	1.93	0.238	8.11
	20-40	Ap	7.63	7.74	6.84	2.72	1.58	0.200	7.90
31	0-20	Ap	4.09	7.86	7.04	2.10	1.22	0.142	8.59
	20-40	Ap	3.28	7.66	7.04	1.87	1.09	0.127	8.58

Table 2. - Hemical properties of non-calcaric rendzina soils

Profile	Depth cm	Horizon	pH in H_2O	pH in KCl	H meq	S meq	T meq	V %	Humus %	C %	N %	C:N
						Forest						
7	0-20	Amo	7.15	6.40	1.88	41.27	43.15	95.64	5.69	3.30	0.300	11.00
	20-35	AC	7.28	6.26	1.24	32.89	34.13	96.37	2.17	1.26	0.132	9.54
20	0-20	Amo	7.37	6.72	1.04	52.41	53.45	98.05	7.83	4.56	0.425	10.73
26	0-12	Amo	6.99	6.08	2.49	37.29	39.78	93.74	8.65	5.05	0.460	10.98
	12-23	Amo	5.79	4.66	6.64	21.86	28.50	76.70	3.60	2.10	0.171	12.28
	23-40	AC	5.66	4.39	6.22	24.31	30.53	79.63	1.44	0.84	0.077	10.91
						Grassland						
17	0-20	Amo	7.19	6.38	1.24	27.58	28.82	95.70	3.65	2.12	0.262	8.09
21	0-20	Amo	7.64	6.77	0.83	37.90	38.73	97.86	2.16	1.26	0.143	8.81
						Arable land						
10	0-20	Ap	6.99	6.08	1.66	25.64	27.30	93.92	3.62	2.10	0.209	10.05
	20-40	Amo	6.98	6.20	1.66	28.19	29.85	94.44	3.27	1.90	0.189	10.05
	40-55	AC	7.28	6.81		$CaCO_3$	4.65%		1.98	1.15	0.126	9.13

Humus content is mostly high, and rarely medium, in the A horizon of calcaric forest rendzinas; medium or high under grassland, and very low under arable land. In non-calcaric forest rendzinas, humus content in the A horizon was found to be medium or low; low or very low under grassland, and again low and very low under arable land.

Average organic C content u the A horizons of non-calcaric rendzinas (Fig. 1) is lower than in calcaric rendzinas, and the difference has statistical significance ($t=3.16668$, $p=0.015781$). The dependencies of soil properties determined by correlation analysis, such as carbonate content, soil reaction, base saturation and C content, were statistically insignificant. However, it is evident that the more soil reaction in rendzinas sways either towards acidification or alkalization, the more total organic carbon content is decreasing. Neutral soil reaction thus provides an optimum condition for humification and stabilization of humic substances in soil.

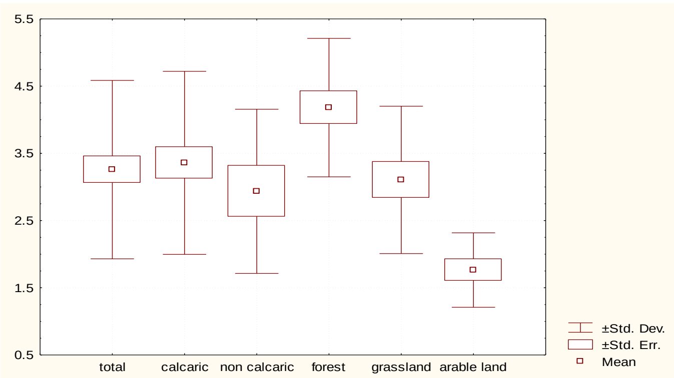

Figure 1. – Organic carbon content in rendzina soils investigated (in %)

The highest difference in organic C content was found between rendzinas under different land use variants. Statistically, forest rendzinas contain significantly more humus than grassland rendzinas (t=3.64666, p=0.002642), and even more than arable rendzinas (t=6.22721, p=0.000252). Humus content under grassland was also significantly higher than under arable land (t=3.88773, p=0.004624).

Different land uses, from forest via grassland to arable land, were found to effect different decreases in soil humus, the decrease basically proceeding in two main directions. One is towards a reduction in the amount of organic litter input in soil annually, from forest via grassland to arable land, and change in the quality of litter input, which results in decreasing humus content (LOPEZ-ULLOA *et al*., 2005; SWIFT, 2001). The other form of influence comes from the various tillage methods. Arable soils with their lowest contents of humus, compared to forest and grassland soils, were subjected to various tillage methods. Tillage generallyintensifies soil aeration and thus speeds up the process of litter and humus mineralization in soil (JARECKI AND LAL, 2005; VANDEN-BYGAAT AND KAY, 2004; WEST AND POST, 2002).

Humus content has been found to decrease with depth in rendzina soils in Serbia, and this is more evident under forest cover (36.2-79.7%) than grassland (11.76-37.73%) or especially arable land (2.92-29.89%). Although the forest rendzinas investigated in this study underly well illuminated oak woods with abundant grass vegetation, the decrease in humus content with depth in the A horizon is more prominent than in areas under grass vegetation, and especially arable land. Profile 8 in the Negotin environ is particularly interesting as it underlies grass vegetation in the vicinity of a forest, so that its humus is formed primarily from grass litter and forest organic litter. Humus decrease in that profile is 54.89% in the lower Amo horizon, which resembles more a forest than grassland type of rendzina. This example illustrates the effect of both the amounts and properties of organic litter on the content of soil humus. Differences in humus contents down the profile under different plant covers have been reported for many different soil types (MIKHAILOVA *et al*., 2000; NOVAKOVIĆ, 1991; PAVIĆEVIĆ AND TANČIĆ (1970).

Apart from plant cover, i.e. form of land use, other improtant factors determining organic C contents in soil include the relief (altitude and land incline) and climate (KULMATISKI *et al*., 2004; TAN *et al*., 2004a., 2004b), as well as soil texture (JARECKI AND LAL, 2005; TAN *et al*., 2004a; TANČIĆ, 1976). Our results show that altitude is not significantly affecting humus contents in rendzina soils. Land incline is an important factor as precipitous slopes are prone to erosion, but in this case again the form of land use, i.e. plant cover, plays a decisive role. The most precipitous terrains with no other potential use held forests on underlying rendzinas with the highest contents of humus. Considering each individual form of land use, no correlation was found between humus content in soil and form or relief.

High humus content in heavy-textured soils is believed to result from the fact that such soils are less drained and aerated, which slows down microbiological decomposition of organic matter in soil. Microbiological decomposition of organic matter is slowed down also through physical and chemical protection by clay minerals. The rendzinas investigated in Serbia range from weakly or heavily skeletoidal sandy loams to light clays with well defined soil structure (CUPAĆ, 2006; CUPAĆ *et al*., 2006a, 2006b). Correlation analysis revealed no significant dependency between colloidal clay and total C content in it.

Total nitrogen contents and C:N ratio

Total nitrogen content in the A horizon varies from 0.123% to 0.570%, with an average 0.320%. Rendzinas thus have high and very high amounts of total nitrogen in the top layer of horizon A, while the supply is medium and good in the sub-top layer. Depth-depending humus decrease in soil is accompanied by a decrease in total N content. In the transitional AC horizon, its content varies from 0.023% to 0.327%, being 0.142% on the average.

The C:N ratio in the A horizon varies from 8.09 to 16.54, and is 10.09 on the average. In the transitional AC horizon, it varies from 8.11 to 12.50, being 9.13 on the average. Enrichment of humus in nitrogen, measured as the C:N ratio, is mostly medium and rarely low in the top layer of horizon A. An exception to this is profile 18 of calcaric forest rendzina from Oplenac, in which the C:N ratio was found to be 16.54, and humus enrichment in nitrogen very low. The reason for such a wide C:N ratio is the presence of coniferous trees in the local park that provide organic litter richer in low available compounds. A wider C:N ratio in rendzinas underlying coniferous forests was also reported by Filipovski in Macedonia (ФИЛИПОВСКИ, 1999).

Humus content decreases with depth, as does, only slower, total nitrogen content, so that the C:N ratio is generally narrowing down. Enrichment of humus in nitrogen in the sub-top layer of the A horizon is mostly medium or high, and rarely low. Exceptions to this are profiles 6, 9, 14 and 26, in which the C:N ratio increases with depth. The narrowing of the C:N ratio with depth has been related in several reports (BOGDANOVIĆ, 1962; NOVAKOVIĆ, 1991: TANČIĆ, 1976; STOJANOVIĆ, 1965) with increase in the content of clay, whose crystal lattice may cause fixation of ammoniac nitrogen or increase in fulvic acids in the group composition of humus that are richer in nitrogen than humic acids. No statistical significance was found in correlation analysis of the relationships between contents of colloidal clay and fulvic acids (CUPAĆ, 2006) and the C:N ratio in the rendzinas investigated in Serbia.

Concerning arable rendzinas, it is worth mentioning that the C:N ratio does not follow a general trend, i.e. it does not significantly narrow with depth, but rather remains almost unchanged, or even expands. Citing Russian literature, BOGDANOVIĆ (1962) explained the expanding of the C:N ratio in the sub-top layer of horizon A in our chernozem soils with increased contents in humins in that zone, compared to the top arable layer. Thus, the top layer of the Ap horizon of chernozem soil subjected to agricultural practices contains more humus acids and less humins than the layer below the arable layer of horizon A, and consequently a narrower C:N ratio. In most profiles of arable rendzinas investigated in Serbia, the content of humins also increases with depth (CUPAĆ, 2006), which explains the expanded C:N ratio.

Statistically significant differences in total N contents were found between calcaric and non-calcaric rendzinas (t=3.3741, p=0.011854), as well as between different land use variants: under forest and grassland (t=2.5924, p=0.021288), especially under forest and arable land (t=6.3865, p=0.000212), as well as under grassland and arable land (t=5.8397, p=0.000387).

Along with increasing soil reaction, the enrichment of humus in nitrogen increases as well in calcaric (r=-0.36*) and non-calcaric rendzinas (r=-0.64*), where the C:N ratio narrows also through increase in base saturation (r=-0.64*). Although the C:N ratio in non-calcaric rendzinas is somewhat wider on the average, no significant difference was found in nitrogen enrichment of humus between calcaric and non-calcaric rendzinas.

Regarding land use, the enrichment of humus in nitrogen was highest in grassland rendzinas; arable rendzinas followed, while the lowest N enrichment of humus was in forest rendzinas (Fig. 2). Statistically significant differences in the C:N ratio were found only between the rendzinas underlying forest and grassland (t=2.76543, p=0.015178).

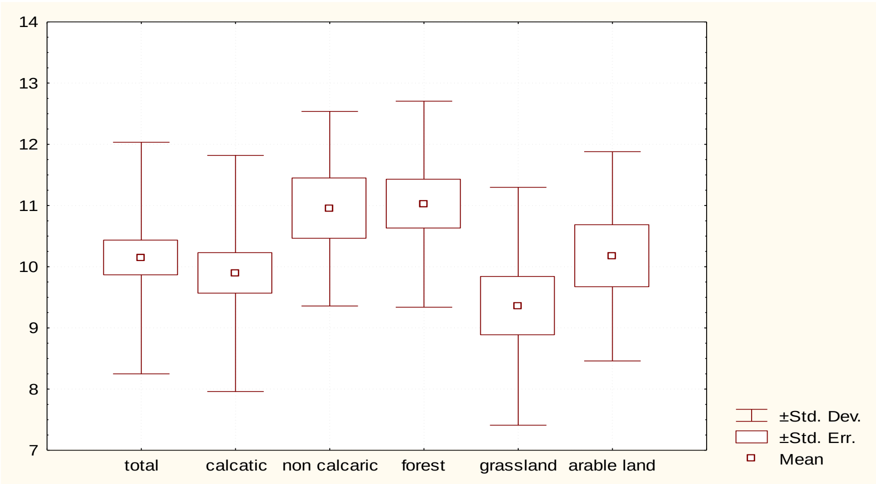

Figure 2. – C:N ratio in rendzina soils investigated

The C:N ratio noticably narrowed under grassland and arable land, compared to forest. We consider the narrowing of the C:N ratio under intensified cultivation to have the following explanations: in forest soils with immigration of dwarf scrubs, which have wider C:N ratios than herbs and grasses, and reduced or abandoned management, both the litter material and the fungi (replacing bacteria) have higher C:N ratios (SEEBER AND SEEBER, 2005); a larger decrease in C than in N after deforestation (WATANABE *et al*., 2001); cultivation may cause aggregate breakdown, while organic C associated with finer fractions has weaker protection against microbial and enzymatic degradation, C losses are higher than those of N, which results in narrowing C:N ratios (CARAVACA *et al*., 2004); itd.

Consequently, when soils are in long-term cultivation, soil humus is lost, soil structure is degraded, soil is eroded, and soil fertility is depleted (HAYES AND CLAPP, 2001). Special attentions is currently focused on finding out a tillage system that would satisfy agricultural requirements of individual crops, while not causing humus loss in soil, or even stimulating its increase, a goal that is important both from the agricultural and ecological aspects in view of the reducing atmospheric CO_2 concentrations. In that context, measures have been recommended, such as reduced tillage and fertilization, especially with manure amendments, enhanced rotation complexity, introduction of perennials (grasses, trees) on arable land, and promotion of organic farming (FREIBAUER *et al*., 2004; JARECKI and LAL, 2005; MIKHA AND RICE, 2004; WEST and POST, 2002).

CONCLUSION

Total C content in the rendzina soils investigated in Serbia was found to vary between 1.15% and 6.25%, being 3.25% on the average. Humus content in the A horizon of calcaric forest rendzinas was mostly high, rarely medium; medium or high under grass, and low under arable land. In non-calcaric forest rendzinas, humus content in the A horizon was medium or low; under grassland, it was low or very low, and under arable land again low and very low.

Total N content varies over a wide interval from 0.123% to 0.570%, being 0.317% on the average. Rendzina soils are therefore predominantly well and very well supplied with total nitrogen in the top layer of the A horizon, while its supply in the sub-top layer is medium or good. Enrichment of humus in nitrogen, shown by the C:N ratio, is mostly medium, and rarely low. The C:N ratio ranged between 8.09 and 16.54, which is the average 10.09.

Decarbonation process (eluviations of $CaCO_3$, lower pH and base saturation) in rendzina soils in Serbia is caused by decreasing contents of humus and total nitrogen, while the enrichment of humus in nitrogen (C:N ratio) did not change significantly.

Different land uses (application or absence of tillage, and different amounts and quality of litter input) had 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 was significantly higher under grassland than under forest.

REFERENCES

ANTONOVIĆ, G., PAVIĆEVIĆ, N., NIKODIJEVIĆ, V., FILIPOVIĆ, Đ., TANASIJEVIĆ, Đ. and ALEKSIĆ, Ž. (1974): Rendzina na laporcu. U: Zemljišta basena Timoka. Urednik G. Antonović. Centar za poljoprivredna istraživanja, Beograd, 146-150.

BOGDANOVIĆ, M. (1962): Odlike humusa u glavnim tipovima zemljišta NR Srbije. Doktorska disertacija. Zbornik radova poljoprivrednog fakulteta, Zemun, X, 335, 1-100.

BREJDA, J.J., MAUSBACH, M.J., GOEBEL, J.J., ALLAN, D.L., DAO, T.H., KARLEN, D.L., MOORMAN, T.B. and SMITH, J.L. (2001): Estimating Surface Soil Organic Carbon Content at a Regionale Scale Using the National Resource Inventory. Soil Sci.Soc.Am.J., 65, 842-849.

CARAVACA, F., LAX, A. and ALBALADEJO, J. (2004): Aggregate stability and carbon characteristics of particle-size fractions in cultivated and forested soils of semiarid Spain. Soil & Tillage Research, 78, 83-90.

CUPAĆ, S. (2006): Stanje humusa i najvažnije osobine huminskih kiselina u rendzinama Srbije. Doktorska disertacija. Poljoprivredni fakultet, Beograd, 1-131.

CUPAĆ, S., Đorđević, A. and Jovanović, Lj. (2006a): Soil texture of calcaric and non-calcaric rendzina soils in Serbia. Zemljište i biljka, 55, 2, *in press*.

CUPAĆ, S., Đorđević, A. and Jovanović, Lj. (2006b): Soil structure of calcaric and non-calcaric rendzina soils under forest, grassland and arable land. Zemljište i biljka, 55, 2, *in press*.

ФИЛИПОВСКИ, Г. (1999): Почвите на република Македонија. Том II. Македонска академија наука, Скопје, 158-171.

FREIBAUER, A., ROUNSEVELL, M.D.A., SMITH, P. and VERHAGEN, J. (2004): Carbon sequestration in the agricultural soils of Europe. Geoderma, 122, 1-13

HAYES, M.H.B. and CLAPP, C.E. (2001): Humic substances: considerations of compositions, aspects of structure, and environmental influences. Soil Science, 166, 723-737.

JARECKI, M.K. and LAL, R. (2005): Soil organic carbon sequestration rates in two long-term no-till experiments in Ohio. Soil Science, 170, 280-291.

JDPZ. (1966): Hemijske metode ispitivanja zemljišta. Priručnik za ispitivanje zemljišta. Knjiga I. Beograd.

KULMATISKI, A., VOGT, D.J., SICCAMA, T.G., TILLEY, J.P., KOLESINSKAS, K., WICKWIRE, T.W. and LARSON, B.C. (2004): Landscape determinations of soil carbon and nitrogen storage in Southern New England. Soil Sci.Soc.Am.J., 68, 2014-2022.

LAL, R. (2004): Soil carbon sequestration to mitigate climate change. Geoderma, 123, 1-22.

LOPEZ-ULLOA, M., VELDKAMP, E., KONING, G.H.J. (2005): Soil carbon stabilisation in converted tropical pastures and forest depends on soil type. Soil Sci.Soc.Am.J., 69, 1110-1117.

MIKHA, M., M., RICE, C.W. (2004): Tillage and manure effects on soil and aggregate-associated carbon and nitrogen. Soil Sci.Soc.Am.J., 68, 809-816.

MIKHAILOVA, E.A., BRYANT, R.B., VASSENEV, I.I., SCHWAGER, S.J., POST, C.J. (2000): Cultivation Effects on Soil Carbon and Nitrogen Contents at Depth in the Russian Chernozem. Soil Sci.Soc.Am.J., 64, 738-745.

MILJKOVIĆ, N. (1972): Rendzine i pararendzine. *In*: Zemljišta Vojvodine, Editor: B. Živković, Institut za poljoprivredna istraživanja, Novi sad, p.115-118

NOVAKOVIĆ, M. (1991): Uporedna proučavanja sadržaja i sastava humusa u livadskim crnicama doline Kolubare pod šumskom, livadskom i njivskom vegetacijom. Magistarska teza. Poljoprivredni fakultet Univerziteta u Beogradu, 1-109.

ОРЛОВ, Д.С. (1985): Химия почв. Издательство Московского Университета, Москва, p. 275-279.

PAVIĆEVIĆ N. and TANČIĆ, N. (1970): Smeđe šumsko zemljište u slivu Lima i sastav humusa u njemu. Arhiv za polj. nauke, XXIII, 82, 115-134.

SCHIPPER L.A. and SPARLING, G.P. (2000): Performance of Soil Condition Indicators Across Taxonomic Groups and Land Uses. Soil Sci.Soc.Am.J., 64, 300-311.

SEEBER J. and SEEBER, G.U.H. (2005): Effect of land-use changes on humus forms on alpine pastureland (Central Alps, Tyrol). Geoderma, 124, 215-222.

SPASOJEVIĆ, M., NIKODIJEVIĆ, V. and FILIPOVIĆ, Đ. (1975): Rendzine. *In*: Zemljišta brdsko-planinskog područja sliva Jablanica (Valjevo) i predlog budućeg načina iskorišćavanja. Centar za poljoprivredna istraživanja, Beograd, p.37-45.

STOJANOVIĆ, S. (1965): Karakteristike humusnih komponenata humusno silikatnih (Ranker) zemljišta Srbije. Doktorska disertacija. Poljoprivredni fakultet Univerziteta u Beogradu, 1-160.

SWIFT, S.R. (2001): Sequestration of carbon by soil. Soil Science, 166, 858-871.

TAN, Z.X., LAL, R., SMECK, N.E. and CALHOUM, F.G. (2004a): Relationships between surface soil organic carbon pool and site variables. Geoderma, 121, 187, 195.

TAN, Z.X., LAL, R., SMECK, N.E., CALHOUM, F.G. and SLATER, B.K. (2004b): Taxonomic and geographic distribution of soil organic carbon pools in Ohio. Soil Sci.Soc.Am.J., 68, 1896-1904.

TANČIĆ, N. (1976): Sastav i priroda ritskih crnica Srbije. Dokrodska disertacija. Arhiv za polj. nauke, 29, 108, 31-83.

THOMPSON, J.A. and KOLKA, R.K. (2005): Soil carbon storage estimation in a forested watershed using quantitative soil-landshape modeling. Soil Sci.Soc.Am.J., 69, 1086-1093.

VANDEN-BYGAAT, A.J. and KAY, B.D. (2004): Persistence of soil organic carbon after plowing a long-term no-till field in southern Ontario, Canada. Soil Sci.Soc.Am.J., 68, 1394-1402.

WATANABE, A., SARNO, J., RUMBANRAJA, J., TSUTSUKI, K. and KIMURA, M. (2001): Humus composition of soils under forest, coffee and arable cultivation in hilly areas of south Sumatra, Indonesia. European Journal of Soil Science, 52, 599-606.

WEST, T.O. and POST, W.M. (2002): Soil Organic Carbon Seqestration rates by Tillage and Crop Rotation: A Global Data Analysis. Soil Sci.Soc.Am.J., 66, 1930-1946.

ŽIVKOVIĆ, M., ĆOROVIĆ, R. and JAKOVLJEVIĆ, M. (1981): Randzina. *In*: Pedološko-agrohemijska i meliorativna studija »Bukovskog zlatnog brda«. Poljoprivredni fakultet Univerziteta u Beogradu, p.34-53.

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UTICAJ PROCESA IZLUŽIVANJA I NAČINA KORIŠĆENJA RENDZINA NA SADRŽAJ HUMUSA I NJEGOVU OBEZBEĐENOST AZOTOM

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I z v o d

Rendzina je veoma rasprostranjen tip zemljišta u Srbiji u području brdsko-planinskog reljefa, nalazi se u više evolucionih stadijuma razvoja i koristi se na različite načine, odnosno, nalazi se pod različitim biljnim pokrivačima. Cilj našeg rada je zato bio ispitivanje uticaja procesa izluživanja i različitog načina korišćenja zemljišta tipa rendzina u Srbiji na sadržaj humusa i njegovu obezbeđenost azotom.

Sadržaj ukupnog C u ispitivanim rendzinama Srbije varira od 1.15 do 6.25%, a u proseku iznosi 3.25%. Sadržaj humusa u A horizontu karbonatnih šumskih rendzina je uglavnom visok, ređe srednji; pod travnjacima srednji ili visok, a pod njivama veoma nizak. U izluženim šumskim rendzinama sadržaj humusa u A horizontu je srednji ili nizak; pod travnjacima nizak i veoma nizak, a u njivskim, takođe, nizak i veoma nizak. Sadržaj ukupnog azota varira u širokom intervalu, od 0,123 do 0.570%, a u proseku iznosi 0.317%; stoga su rendzine pretežno bogato i veoma bogato obezbeđene ukupnim azotom u površinskom delu A horiznonta, a u potpovršinskom obezbeđene su srednje ili dobro. Obezbeđenost humusa azotom, izražena preko odnosa C:N, uglavnom je srednja, a ređe niska. Odnos C:N kreće se od 8.09 do 16.54, a u proseku iznosi 10.09.

Procesi izluživanja (ispiranje $CaCO_3$, niži pH i stepen zasićenosti bazama) u zemljištima tipa rendzina u Srbiji uslovili su smanjenje sadržaja humusa i ukupnog azota, pri čemu se obezbeđenost humusa azotom (odnos C:N) nije značajno promenila.

Razlike u načinu korišćenja zemljišta (primena ili odsustvo obrade i razlike u količini i kvalitetu biljnih ostataka) statistički su značajno uticale na smanjenje sadržaja humusa i ukupnog azota u rendzinama pod travnjacima i naročito njivama u poređenju sa šumskim rendzinama, dok je obezbeđenost humusa azotom značajno veća u travnjačkim u poređenju sa šumskim rendzinama.

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