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Original scientific paper

AGGREGATE COMPOSITION OF CARBONATE CHERNOZEM FROM SOUTH BANAT

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In order to estimate the aggregate composition of carbonate loamy chernozems on the loess of South Banat, utilized as cultivated and pasture, fractionation was performed of individual categories of structural aggregates according to their size and also the determination of structure coefficient, mean weight diameter and geometric mean diameter of the dry structural aggregates.

Laboratory analyses involved soil samples of the humus, i.e. arable (0-20-30 cm) and subarable horizons (20-40 and 40-60 cm) from 24 profiles of cultivated land and the samples of surface (0-20-30 cm) and subsurface layers (20-40 and 40-60 cm) of the humus horizons of 4 pasture profiles.

The results of the investigations showed that beside favourable, mainly crumby-beady structure there appeared also significant differences in aggregate composition, both between various profiles, in dependence

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on the utilization mode of the soil, and between various depth zones of the humus horizon.

The content of agronomically most valuable aggregates fraction (0.25–10 mm) in all depth zones of the humus horizon of the investigated profiles is >60%, which is, according to the classification by ŠEIN *et al*. (2001), a characteristic of good-structured soil.

According to the values of structure coefficient and the mentioned classification, the cultivated soil profiles (1.5-2.42) show good, and those from pasture (1.15-1.70) satisfactory structure. In cultivated soil profiles, mean weight diameter and geometric mean diameter of the dry aggregates is significantly higher than in those from the pasture, and when they are larger, the structure of the soil is better and vice versa.

Key words: chernozem, aggregate composition, agronomically most valuable fraction, mean weight diameter, geometric mean diameter, cultivated soil, pasture

INTRODUCTION

Aggregate composition is one of the most important soil physical characteristics and it depends on the conditions of the soil formation and on the application of various agro-technical and ameliorative measures. The main functional characteristics of soil as an environmental component and also as an object of technologic influences are determined to a high degree by aggregate composition.

Investigation of aggregate composition under the conditions of intensive cultivation is necessary, according to BONDAREV and KUZNJECOV (1973), especially in the cases of application of heavy agricultural machines, intensified soil erosion, application of irrigation and other agro-technical and ameliorative measures.

Estimation of soil structural characteristics is necessary both for characterization of soil-physical conditions of plant life, and for scientific explanation of the consequences of agro-technical and ameliorative measures. It is especially necessary for directed regulation of physical characteristics within intensive systems of soil cultivation (KUZNJECOVA, 1979).

For that reason KUZNJECOVa (1979) considers soil structure condition as one of the most important physical conditions of the fertility of soils with medium and heavy textural composition.

According to the data cited by VERSININ *et al*. (1959) and SOROCKIN (1991), beside the size and form of macroaggregates, for an agronomic estimation of soil structure, composition, mechanical hardness, water resistance and porosity of the macroaggregates are very important. Good soil structure for crop growth dependes on the presence of aggregates between 1 to 10 mm diameter (AMEZQUITA *et al*., 1998), i.e. of the proportion the agronomically most valuable fraction (0.25–10 mm) (MEDVEDEV and CYBULKO, 1995).

Aggregate composition of carbonate chernozems of South Banat is poorly investigated, according to the available literature.

So, the present study gives an agronomic estimation of the aggregate composition of the humus horizon of South Banat carbonate chernozems in dependence of the mode of their utilization in agricultural production

MATERIALS AND METHODS

The investigated area lies between 45°20' and 44°50' north geographic latitude and 20°30' and 21°10' east geographic longitude.

The investigation included the profiles of South Banat carbonate chernozem that belong to the collection of M. ŽIVKOVIĆ, and had been collected by M. ŽIVKOVIĆ, N. PAVIĆEVIĆ and B. PEJOVIĆ. Determination of some most important chemical characteristics ($CaCO_3$ content, humus content and pH value in water) had been performed by M. ŽIVKOVIĆ, while the determination of aggregate composition was performed by M. ŽIVKOVIĆ and B.GAJIĆ.

For the determination of macroaggregate composition in laboratory, soil samples were used originating from arable (0-20 cm) and subarable horizons (20-40 and 40-60 cm) and from 24 cultivated soil profiles, as well as samples from surface (0-20 cm) and subsurface (20-40 and 40-60 cm) layers of the humus horizons from 4 pasture profiles of carbonate chernozem (28 profiles in all, with 84 soil samples). Four cultivated soil profiles were deeply ploughed (60-80 cm).

Macroaggregate composition of the investigated soils was determined by dry sieving, according to Savinov (BOŠNJAK, 1997).

Structure coefficient (Ks) was calculated as the ratio between the content of crumby and beady, agronomically most valuable structural aggregates, with the diameter 10-0.25 mm, and the sum of very fine – powdery (<0.25 mm) and cloddy (>10 mm) aggregates separated by dry sieving (ŠEIN *et al*., 2001). Mean weight diameter (MWD) and mean geometric diameter (MGD) of the structural aggregates were determined by calculation (HILLEL, 2004). The results of the determination of aggregate composition were tested by the methods of variation statistics.

RESULTS AND DISCUSSION

Before proceeding with the results of the determination of aggregate composition of the investigated soils, there is presented a short review of their most important physical and chemical characteristics.

According the their textural composition, the investigated chernozems belong to medium and heavy loams, with the ratio of physical clay fraction (particles with the diameter <0.01 mm) between 32.67 and 51.10%, and the real clay fraction (particles < 0.001 mm) between 25.70 and 38.60%. Chemical reaction (pH in water) of the investigated samples is, according to the American classification, neutral to moderately alkaline, i.e. with pH values between 6.6 and 8.4. The humus content in the analysed samples of all the investigated profiles is found in surface samples of the humus horizon. According to the classification of

MÜCKENHAUSEN (1975) the investigated chernozems belong to the class of moderately to strongly humous soils with humus content between 2.20 and 8.00% in the surface layer. Carbonate content in the humus horizon of the investigated soils is very fluctuating and it varies within a wide range, between 1.16 and 15.5% (ŽIVKOVIĆ, 1988/89).

In the Table 1, statistically analysed results are presented of the determination of aggregate composition of the investigated carbonate chernozem profiles.

The results show that, beside the valuable, crumby-beady structure there are significant differences in aggregate composition, both between various profiles, in dependence on the mode of the soil utilization and on the influence of anthropogenic factor, and between various depth zones (subhorizons) of the humus horizon, in cultivated soil profiles between arable, the first (zone of plough bottom) and the second subarable subhorizons.

In all investigated depth zones of the humus horizon of these soils there prevails agronomically most valuable structural aggregate with the diameter between 0.25 and 10 mm, i.e. the fraction consisting of medium crumby (1-3 mm), big crumby (3-5 mm) and beady (5-10 mm) aggregates. The content of these agronomically most valuable aggregates in various depth zones (subhorizons) of the humus horizon in cultivated soil profiles varies between 59.79 and 70.74%, and in grazing land samples between 53 and 63%. The most abundant are big crumby aggregates. Similar aggregate composition is found in the chernozems of South Srem (GAJIĆ, 1992).

Because of the increased dispersion during tillage, as well as due to an increased compaction induced by threading, arable horizon of cultivated soils and the surface layer of the humus horizon of pasture chernozem show mainly significantly lower content of the most valuable (by size) aggregates, than the first and second subsurface layers of the same profiles. The same results were obtained by KOSANOVIĆ (1960) in his investigations of carbonate chernozem of Vojvodina. He explains the finding as a consequence of the fact that deeper zones of the humus horizon are without the influence of all those unfavourable factors which act in the surface layer in the direction of impairment of aggregation, such as the water from atmospheric precipitations, tillage with machines, etc.

An interesting finding is that the highest average content of agronomically most favourable aggregates is found in cultivated soil profiles, higher than in the pasture profiles. Even deeper layers of the humus horizon of grazing land profiles contain significantly less (53-63%) agronomically most valuable aggregates than those from cultivated soil (68.84-70.74%), which is, most likely, a consequence of the influence of threading and the lack of tillage, which decreased the ratio of the most valuable structural aggregates in the pasture samples.

It is also interesting that no differences were found in aggregate composition between twice deeply ploughed (to 60-80 cm) soil profiles (under plantations) and those ploughed in usual way (20-30 cm) (crop cultivation).

Total content of powdery (<0.5 mm) and cloddy (>10 mm) structural aggregates in all analysed depth zones of the investigated profiles is on average mainly <40%. In the investigated profiles of cultivated soil chernozem, the content of cloddy aggregates (17.53-26.89%) is 2-3 times higher than in the pasture ones (12.25-5.67%). Similar results were obtained during the investigations of Russian chernozems (BONDAREV and KUZNECOV, 1999). The participation of powdery aggregates in arable and subarable horizons of cultivated soil profiles is not high and it varies within a narrow range, between 4.42 and 6.89%. However, in the humus horizon (0-60 cm) of pasture profiles, it is about 3.5-4.5 times higher than in cultivated soil, and it varies between 4.42 and 6.89%.

Among other data, in Table 1 significant variations may be seen, at all depths, of the content of all structural aggregate fractions, which are, as expected, much more noticeable in cultivated soil than in pasture profiles.

On the basis of structure coefficient (Ks) values it may be concluded that the aggregate composition of the investigated chernozems under a long-term cultivation did not suffer significant quantitative changes in the humus horizon (Table 1).

Structure coefficient in the humus horizon of cultivated soil chernozems is significantly higher than in pasture samples. In cultivated soil profiles, its values are regularly higher than 1.5, and they vary between 1.51 and 2.42. According to the classification cited by ŠEIN *et al*. (2001), these values are characteristic for the soils with good structure. In the investigated pasture profiles of chernozem, the values of this coefficient vary between 1.15 and 1.70, which is, according to the mentioned classification, a property of soils with satisfactory structure.

For the estimation of the distribution of structural aggregates by their size, two parameters were used, namely: mean weight diameter (MWD) and mean geometrical diameter (MGD) of the aggregates which, according to HILLEL (2004) enable correlations with various indicators (such as erosion, infiltration, evaporation, aeration, etc.). When the values of the mentioned parameters are higher, aggregate, i.e. structural soil composition is better, and *vice versa*.

From the data presented in Table 1 it may be noticed that the values of mean diameters in cultivated soil profiles of carbonate chernozem of South Banat (5.42-6.62) are about 2 times higher than in pasture profiles (3.53-4.26).

Less marked differences were found between the values of mean geometrical diameters of cultivated soil aggregates and those from pasture profiles of the investigated chernozems. In the humus horizon of the cultivated soil profiles they vary within a very narrow range, between 0.62 and 0.64, while in pasture profiles they are somewhat lower and range between 0.52 and 0.62.

Presented values of the mean weight and geometrical diameters of structural aggregates show that cultivated soil profiles of the investigated carbonate chernozems have significantly better structure than those from pasture sites.

Indicators of the distribution of structural aggregates according to their size may be used as parameters of soil structure in modeling processes connected with it (BEREZINA *et al*., 1991).

Table 1. Statistically analysed data obtained by the determination of aggregate composition of carbonate cultivated soil and pasture chernozems of South Banat

Depth of the sample taking, cm	Structural aggregate fractions, mm	Statistical characteristics							
		Content of structural aggregates, %			Standard deviation, ± σ	Standard error, ± m	Variation coefficient	Indicator of the result correctness	Structure coefficient, Ks
		mean	min	max					
Cultivated chernozems (*n = 24*)									
0-20	< 0.5	6.42	2	18	4.31	0.99	67.15	15.41	1.49
	0.5–1	6.95	2	30	6.38	1.46	91.85	21.07	
	1–3	27.47	15	39	6.41	1.47	23.35	5.36	
	3–5	12.89	9	23	3.62	0.83	28.07	6.44	
	5–10	19.42	8	26	4.10	0.94	21.11	4.84	
	>10	26.89	7	54	12.8	2.95	47.76	10.96	
	0.5–5	47.26	26	67	11.1	2.54	23.41	5.37	
	1–10	59.79	42	76	8.92	2.05	14.93	3.43	
	MWD*	6.62	2.86	10.1	1.85	0.53	28.00	6.42	
	MGD*	0.69	20.44	0.91	0.12	0.06	16.78	3.85	
20–40	*	4.42	1	9	2.65	0.61	59.99	13.76	2.21
	<0.5	4.11	1	9	1.97	0.45	47.96	11.00	
	0.5–1	30.11	19	43	6.38	1.46	21.21	4.87	
	1–3	17.53	8	33	6.53	1.49	37.24	8.54	
	3–5	20.89	15	30	3.98	0.91	19.07	4.37	
	5–10	22.63	1	47	10.8	2.49	47.89	10.99	
	>10	52.05	31	74	11.2	2.58	21.62	4.96	
	0.5–5	68.84	44	89	11.4	2.61	16.52	3.79	
	1–10	6.39	3.45	9.1	1.36	0.31	21.48	4.93	
	MWD	0.68	0.51	0.85	0.08	0.02	11.90	2.73	
40–60	MGD	6.89	1	14	4.19	0.96	60.75	13.74	2.42
	<0.5	4.95	1	11	2.46	0.56	49.73	11.41	
	0.5–1	35.53	11	49	8.78	2.01	24.71	5.67	
	1–3	17.53	8	28	5.57	1.28	31.79	7.29	
	3–5	17.68	13	25	3.33	0.76	18.85	4.33	
	5–10	17.53	4	59	12.9	2.97	73.99	16.97	
	>10	57.89	21	76	13.4	3.07	23.12	5.30	
	0.5–5	70.74	38	89	12.9	2.96	18.23	4.18	
	1–10	5.42	3.61	10	1.68	0.39	31.09	7.13	
	MWD	0.62	0.50	0.95	0.11	0.02	17.22	3.95	
	MGD								

Pasture (n = 4)									
0-20	< 0.5	22.75	8	64	31.2	18.0	111.6	64.42	1.17
	0.5–1	6.75	7	8	0.58	0.33	7.53	4.35	
	1–3	32.25	11	43	16.8	9.71	56.08	32.38	
	3–5	16.50	8	20	6.66	3.84	42.50	24.54	
	5–10	9.50	6	12	3.21	1.86	38.57	22.27	
	>10	12.25	2	22	10.4	6.00	100.7	58.15	
	0.5–5	55.5	27	69	22.9	13.2	43.02	24.84	
	1–10	58.25	26	74	24.9	14.4	46.26	26.71	
	MWD	3.53	1.59	5.35	1.88	1.09	53.34	30.80	
	MGD	0.52	0.49	0.56	0.04	0.02	7.33	4.23	
20–40	<0.5	18.00	8	38	21.2	15.0	92.23	65.22	1.70
	0.5–1	5.00	5	7	1.41	1.00	23.57	16.67	
	1–3	36.33	16	50	24.0	17.0	72.85	51.52	
	3–5	20.33	8	25	12.0	8.50	72.85	51.52	
	5–10	14.67	10	17	4.95	3.50	36.66	25.93	
	>10	5.67	2	14	8.48	6.00	106.1	75.00	
	0.5–5	61.67	31	80	34.6	24.5	62.43	44.14	
	1–10	71.33	41	85	31.1	22.0	49.39	39.42	
	MWD	3.63	3.11	4.16	0.74	0.52	20.43	14.44	
	MGD	0.56	0.47	0.65	0.13	0.09	22.73	16.07	
40–60	<0.5	19.00	10	43	23.3	16.5	88.05	62.26	1.15
	0.5–1	5.00	5	8	2.12	1.5	36.24	23.08	
	1–3	30.67	15	33	12.7	9.0	53.03	37.50	
	3–5	20.33	9	24	10.6	7.50	64.28	45.45	
	5–10	13.67	9	17	5.66	4.00	43.51	30.77	
	>10	11.33	11	16	3.53	2.50	26.19	18.52	
	0.5–5	56.00	32	62	21.2	15.0	45.13	31.91	
	1–10	64.67	33	74	28.9	20.5	54.19	38.32	
	MWD	4.25	3.9	4.61	0.50	0.36	11.80	8.34	
	MGD	0.61	0.59	0.64	0.04	0.03	5.75	4.07	

Note: MWD* –mean weight diameter of the structural aggregates; MGD** –mean geometrical diameter of the structural aggregates.

CONCLUSION

On the basis of the obtained results of the determination (by dry sieving) of aggregate composition of surface (0-20 cm) and subsurface (20-40 and 40-60 cm) layers of humus horizons of cultivated soil and pasture loamy carbonate chernozems of South Banat, the following conclusions may be drawn:

The investigated carbonate chernozems of South Banat are characterized with good structure of humus horizons in dry condition. In them, there prevail (>60%) crumby-beady, agronomically most valuable structural aggregates with the diameter between 1 and 10 mm.

Subsurface layers of the humus horizons of cultivated soil and pasture chernozems show significantly more favourable aggregate composition than their surface layers.

Long-term cultivation did not lead to a more substantial quantitative change of the aggregate composition of cultivated soil chernozem, which is supported by structure coefficient values (Ks) which are >1.5.

Chernozems under pasture, according to the values of the indicators of structural aggregate distribution (mean weight diameter and mean geometrical diameter), show less favourable aggregate composition in comparison with the cultivated soil.

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AGREGATNI SASTAV KARBONATNIH ČERNOZEMA JUŽNOG BANATA

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I z v o d

U cilju ocene agregatnog sastava karbonatnih ilovastih černozema na lesu Južnog Banata, pri njivskom i pašnjačkom načinu korišćenja, izvršeno je frakcionisanje pojedinih kategorija strukturnih agregata prema njihovoj veličini i određivanje koeficijenta strukturnosti, srednjeg masenog i srednjeg geometrijskog dijametra strukturnih agregata.

Laboratorijskim analizama obuhvaćeni su zemljišni uzorci humusnog, odnosno oraničnog (0-20-30 cm) i podoraničnog horizonta (20-40 i 40-60 cm) iz 24 njivska profila i uzorci površinske (0-20-30 cm) i podpovršinskih proba (20-40 i 40-60 cm) humusnog horizonta iz 4 pašnjačka profila.

Rezultati istraživanja pokazali su da pored povoljne, pretežno mrvičasto–graškaste strukture postoje i znatne razlike u agregatnom sastavu kako među raznim profilima, u zavisnosti od načina korišćenja zemljišta, tako i u raznim dubinskim zonama humusnog horizonta.

Sadržaj agronomski najpovoljnijih agregata (0.5-10 mm) u svim dubinskim zonama humusnog horizonta istraženih profila je > 60%, što je, prema klasifikaciji Šein-a *et al*. (2001), karakteristika zemljišta dobre strukture.

Prema vrednostima koeficijenta strukturnosti i navedenoj klasifikaciji njivski profili (1.5-2.42) pokazuju dobru, a pašnjački (1.15-1.70) zadovoljavajuću strukturnost. U njivskim profilima prosečni maseni i geometrijski prečnik agregata znatno je veći nego u pašnjačkim, a kada su njihove vrednosti veće struktura zemljišta je bolja i obratno.

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