Manure, Soil Organic Matter and Soil Fertility

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Abstract

Higher content of soil organic matter can greatly reduce the difficulties of a good crop production system. Content of organic matter in the majority of Bulgarian soils is very low which is evident from the results of soil survey and the data from mass chemical soil tests – nearly 60% of studied soils are with humus content lower than 2.5%. The organic fertilization has direct effect on supplying humic substances in soil. On the basis of some Bulgarian soil types, it is shown the inclusion of organic fertilizers into the fraction of humic acids. A pot experiment and a small field study with Haplic Chernozems show an increase into the fraction of free humic acids and those bound with monovalent cations and mobile R_2O_3 oxides.

Key words: soil organic matter, nitrogen, fertilization, humic acids, Haplic Chernozems

Introduction

Humus content of the main soil types in Bulgaria is low (Angelov, E. et all, 1975, Filipov, H. 2003, Filcheva, E., Sl. Krastanov, 2003) compared to soils in the North of our country. This is due to a higher mineralization rate of crop residues as a result of a milder climate in Bulgaria. The actual problem in contemporary agriculture is the development of practices which will not only keep but also improve quantity and quality of soil organic matter. The question of quantity of organic substances which is needed to be added to soil in order to renew the loss of humus is important from scientific and practical aspect. It is known that organic matter decreases in consequence of the nutrient uptake by plants. The loss of soil organic matter has to be compensated, because it plays a key role in the limitation of nitrogen oxide emissions in the atmosphere.

The main task of this study is to establish the rate of humification of fresh manure (C: N=20.2) in Haplic Chernozem in dependence of applied fertilization rate which will serve as a base of evaluation of manure effectiveness on the accumulation of humus in soil. The other aim is to make an observation of soil types with low humus content and suggest good practices for improvement of agrochemical status of cultivated soils in Bulgaria on the basis of humus content of the main soil types, obtained at the agrochemical services in N. Poushkarov Institute of Soil Science, Agrotechnology and Plant Protection.

Materials and Methods

The studies are conducted as micro field experiment in Gorni Dabnik on Haplic Chernozem characterized with 0.13% total N and 2.4% humus. The added fresh no-straw-manure is labelled with ^{15}N isotope and contains 2.06% total N, 0.068% ammonium N and 0.024% nitrate N, C:N=20.2. The test crop is maize, (Pioneer 37-37), cultivated for grain. There are 3 treatments in 3 replications with plants and 1 replication with no plants. Each replication contains 41 kg soil. At the beginning and at the end of the experiment the quantity of total organic C was determined according to Tjurin's method

(Arinushkina, 1961) and the fractional composition of humus according to Kononova-Belchikova (Kononova, 1963).

Table 1. *Scheme of the micro field experiment*

Treatments	Replications			
	With plants			No plants
1-control-soil	1	2	3	4
2- soil+860g manure	1	2	3	4
3 soil+1720g manure	1	2	3	4

Results and discussion

The influence of manure (C: N=20.2), applied at rate 3 and 6 t/da on the total amount of C and the fractional composition of humus is presented in Table 2. At the beginning (application of manure) the increase of total organic C is significant, from 1.58 in the control soil to 1.69% in treatment with high rate of manure (GD=0.06). The change of C in humic acids is at the limit of the least significant difference. Therefore, we cannot affirmatively conclude that this increase is as an account of manure added organic material. A significant increase of C in humic acids was established 3 months later for the control soil Cx=0.37; for the treatment with the low rate of manure Cx=0.50 and for the one with the high rate Cx=0.56 (GD=0.08). The data from isotope analyses of N in humic acids confirm this assumption. While at the beginning of the experiment only 9.5- 8.5 % from added manure N is in humic acid fraction in pyrophosphate extract, 3 months later these values increase to 16-11.8% respectively for both the treatments with low and high rate of manure fertilization. The part of manure N in humic acid in alkaline extract after 3 months is lower – 12 and 8.2%. The quantity of fulvic acids weekly decrease for the mentioned period. Approximately by 6-7% also decreases the quantity of non-hydroxylated residue fraction in fertilized with manure treatments.

Table 2. *Fractional composition of humus after manure fertilization in micro field experiment*

Treatment	Days	Humus, %	Total C, %	C in pirophos. extract	Ch, %	Cf, %	Ch:Cf	From NaOH extract		C in residue	Cf in 0.1n H_2SO_4
								Ch free and bound R_2O_3	Ch bound with Ca		
1	**0**	2.72	1.58	0.56	0.39	0.17	2.3	0.07	0.32	1.02	0.04
1				35.4	24.7	10.7		17.9	82.1	64.1	2.5
				0.53	0.37	0.16		0.05	0.32	1.03	0.04
	90	2.69	1.56	34.0	23.7	10.3	2.3	13.5	86.5	66.0	2.6
	0	2.79	1.62	0.62	0.44	0.18	2.4	0.08	0.36	1.00	0.04
2				38.3	27.2	11.1		18.2	81.8	61.7	2.5
				0.63	0.50	0.13		0.08	0.42	0.97	0.05
	90	2.75	1.60	39.4	31.3	8.1	3.8	16.0	84.0	60.6	3.1
	0	2.91	1.69	0.63	0.44	0.19	2.3	0.05	0.39	1.06	0.04
3				37.3	26.0	11.3		11.4	88.6	62.7	2.5
				0.69	0.56	0.13		0.11	0.45	1.00	0.05
	90	2.91	1.69	40.8	33.1	7.7	4.3	19.6	80.4	59.2	3.0

* GD	0	0.06	0.05
GD	90	004	0.08

The mentioned increase in humic acids in fertilized plots without plants is observed in the relevant treatments with plants at the end of the experiment. The results indicate a significant increase in the group of free and mobile R_2O_3 bound humic acids under the influence of plants. The changes vary from 0.08 (16%) and 0.11 (19.6%) in the treatments without plants to 0.11 (22%) and 0.17 (30.9%) in those with plants, respectively for treatments with low and high rate of fertilization. The quantity of hydrolysate residue decreases significantly which is due to plant vegetation. This is a proof that plant growth increases organic matter mineralization rate. Over time, the carbon in the fraction of free and R_2O_3 oxides bound humic acids increases. Such a tendency was established also in the pot experiment with Haplic Chernozem (Petkova, 2001).

The different conditions of soil formation in Bulgaria determine the formation of soils with different fertility and agricultural properties presented in 15 soil types. In soil-agrochemical studies are included 11 groups of soils, of which the most prevalent are Cinnamonic forest soils (29% of the country's territory), followed by the Chernozem soils (29% of the country's territory), the Grey forest soils, 17%, Brown forest, 15%, Aluvial-meadows soils, 7%, Vertisols, (Smolnica), 6% of the area of the country.

All the cultivated land accounts to ~ 52% of area of the country. These cultivated lands are the so called deep soils. They are characterized with significant fertility and favourable agrotechnical properties, and occupy the plains and hilly terrains, where are possible full mechanization and modern artificial irrigation and fertilization. In recent years economic activity has an adverse effect on soil resources in three directions: reduction of arable land, increasing the degraded soils (eroded, surface waterlogged, acidic and saline) and contamination of soils. Climate changes create significant problems, which increase the mineralization of soil organic matter and thus contribute to the reduction of humus in the soil.

The analysis of the results of soil-agrochemical studies on the content of humus in the main soil types presented in Table 3 indicates that the highest is the percentage of soils with humus content between 1-2.5%- totally 52.23% of the cultivated land. Approximately 30% of soils fall among the next column of the Table with 2.5- 3.5% humus content. In accordance with the Grishina's (Grishina, 1986) gradation scale these soils are with very low (2%) < and low content of humus (2-4%). It is known that humus content defines the potential fertility and correlates with the stock of basic nutrient elements. The quantity of total nitrogen also changes in most of the cases according to humus content in soil (Fokin, 1986, Stevenson, 1982, Mooleki, et al. 2004). It is therefore, necessary to take measures to maintain and increase the content of soil organic matter which will lead to improvement of soil fertility. The root and post-harvest residues are the main resources for adding to organic matter in soil. There is a serious threat to strong disturbance of the balance of soil organic matter in nowadays tendency of decreasing organic fertilization. The addition of farmyard manure and other organic materials together with leaves, stems and roots from the residual products of cultivated agricultural crops creates favorable conditions for formation of young organic matter. Their faster mineralization provides effective nutrient regime for crop vegetation. Nutrient management is a key factor in organic agriculture. For some nutrients, a balance approach is an option, however for nitrogen this is not sufficient enough. Availability and crop demand should be synchronized as close as possible for optimal efficiency and minimal losses. Because of the number and complexity of processes involved, a model approach can be useful (Burgt et al., 2009).

Table 3. *Analyses of the results from soil agrochemical tests in Bulgaria*

	Humus content in A horizon up to 1%						from3,5 to 5%		over5%		total	avarage
	1%		1% - 2,5%		2,5 - 3,5%		3,5 - 5%		5%			
Groups Soils	Number of fields	da	Number of fields	da	Number of fields	da	Number of fields	da	Number of fields	da	da	In groups
1	57	22818	3531	2046128	3449	2431121	1178	875063	34	19162	5394292	2.78
2	79	42276	4906	3094648	4124	3014865	786	536756	34	30973	6719518	2.6
3	35	17787	4277	2446557	1248	693352	140	74567	11	5466	3237729	2.15
4	329	84162	5055	1897689	649	259019	248	69376	25	11335	2321581	1.98
5	55	14048	713	277253	104	34883	39	9246	19	2259	337689	1.94
6	48	13981	3056	1280685	3514	1682879	1168	631713	60	30106	3639364	2.84
7	3940	1118224	8009	2724352	994	360298	444	150556	76	26542	4379072	1.65
8	393	124754	560	186859	14	6462	0	0	8	2640	320715	1.24
9	1198	471203	1260	275370	206	30932	131	22125	92	25407	825037	1.56
10	1824	638396	7553	2444701	1921	607108	844	286098	367	91102	4067405	2.03
11	87	22620	505	130934	367	104769	115	29499	126	40279	328101	2.98
Sum	8045	2570269	39425	16805176	16590	9225688	5093	2864999	852	285271	31571403	
%		8.14%		53.23%		29.22%		8..5%		0.9%		

Legend:
1. Calcic Chernozems
2. Haplic Chernozem
3. Luvic Chernozems, Luvic Phaeozems
4. Luvisols
5. Planosols
6. Vertisols and Pfaeozems
7. Luvisols
8 Planosols
9. Cambisols, Umric Cambisols, Umrisols
10. Fluvisols, Gleyic Luvisols, Gleyic Chernozems, Gleyic sols, Saline soils
11. Rendzic Leptosols

^{x} – according to WRBSR (2006)

Conclusion

The isotopic analysis of nitrogen in the fraction of humic acids indicates that three months (90 days) after the introduction of manure with C:N = 20.2, the amount of carbon in humic acids increases from 0,37 in the control soil to 0.50% in the treatments fertilized with low rate of manure and to 0.56% (GD=0.08), respectively in those fertilized with high rate of manure. While at the beginning of the experiment only ~ 9.5 - 8.5% of the manure added nitrogen is in the fraction of humic acids, in the pyrophosphate extract three months later these values increased to 16 and 11.8%, respectively for treatments with low and high rate of fertilization. The contribution of fertilizer nitrogen in the fraction of humic acids in the alkaline extract after 3 months was low, 12 and 8.2%. The amount of fulvic acids after 90 days of experiment slightly decreases. By 6-7% decreases the amount of non-hydrolysable residue in treatments fertilized with manure. The introduction of organic manure contributes not only to an increase in humus content, but also to improvement of its quality by increasing the carbon stock in the fraction of humic acids. A significant increase into the fraction of free humic acids and those bound with monovalent cations and mobile R_2O_3 oxides under the influence of plants was registered. From 0.08 (16%) and 0.11 (19.6%) in the treatments without plants the humic acids contents change to 0.11 (22%) и 0.17 (30.9%) in the treatments with plants.

The analysis of the results of soil-agrochemical studies on the content of humus in the main soil types indicates that the highest is the percentage of soils with humus content between 1-2.5%- presented as 52.23% from cultivated lands. Approximately 30% of soils are with 2.5-3.5% humus content which characterizes them as soils with very low (<2%) and low (2-4%) content of humus. This requires to focus farmer's attention on the opportunities for efficient utilization of all natural resources, farmyard manure, poultry manure, as well as organic residues such as leaves, stems and roots of the residual production of crops and various composts of organic material, in order to replenish stocks of humus in soil. Periodic soil application of nitrogen-containing organic materials alongside with mineral fertilization ensures the preservation of the natural composition of nitrogen in soil organic matter and its mobility. This will provide conditions for a positive balance of soil organic matter by keeping a balance between the processes of mineralization and humification. This efficient agricultural activity will lead to sustainable use of soil and will provide stable and high quality yields.

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