EFFECT OF SYSTEM MINERAL AND ORGANIC-MINERAL FERTILIZATION ON THE HUMUS CONTENT AND HUMUS FRACTIONS IN MOLLIC FLUVISOLS

ЕФЕКТ НА СИСТЕМНОТО МИНЕРАЛНО И ОРГАНО – МИНЕРАЛНО ТОРЕНЕ ВЪРХУ СЪДЪРЖАНИЕТО И ГРУПОВИЯ СЪСТАВ НА ХУМУСА НА АЛУВИАЛНА ЛИВАДНА ПОЧВА

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ABSTRACT

The effect of system mineral and organic-mineral fertilization on the humus content and humus fractions in mollic fluvisols in condition of long-term field experiment was studied. Forty years period of organic-mineral fertilization ($N_{420}P_{260}K_{380}$ + 27 t/dka manure) have had stabilizing effect on humus content in the soil. The system mineral fertilization led to a slight decrease of soil humus. The humus type was not influenced from the fertilization.

KEY WORDS: humus, soil nutrients, fertilization systems, mollic fluvisols

ABSTRACT

Проучено е влиянието на системното минерално и органо–минерално торене върху съдържанието и груповия състав на хумуса на алувиална ливадна почва в условията на дългогодишен полски опит. 40-годишният период на органо-минерално торене ($N_{420}P_{260}K_{380}$ + 27 t/dka оборски тор) имаше стабилизиращ ефект върху съдържанието на хумус в почвата. Системното минерално торене доведе до леко понижаване на хумуса в почвата. Торенето не влияе върху типа на хумуса.

KEY WORDS: хумус, хранителни елементи в почвата, системи на торене, алувиално-ливадна почва

INTRODUCTION

The influence of mineral fertilization on the soil humus composition has been thoroughly studied, although the research-workers' opinions are different. On the grounds of literary data it could be stated that, in case of systematic introduction of mineral fertilizers, the humus content in the soil reduced or maintained one and the same level, and in some cases it increased [6] generally shared view is that the organic fertilization contributed to preserving and increasing the humus content in the soils [4,3].

The intensive and long-term exploitation of soils without fertilization reduced the humus content in them [9,2,3]. At that, a destruction of the humic acids, characterized with a complex composition and valuable properties, occurred in the soil [3].

The purpose of the research was to establish the effect of the 40-year system fertilization in the conditions of a permanent field experiment on the humus content and humus fractions in mollic fluvisols in the region of Plovdiv.

MATERIALS AND METHODS

The permanent field fertilization experiment, including different fertilization systems in field crop-rotation, has been carried out since 1959.

Due to the higher location of the terrain and the accomplished drainage, the underground waters were deep – 150–200 cm. As a result of these conditions, together with the meadow process there was a beginning of development of solonetzic process. The water-soluble sodium content varied from 1,78 mg/100 g in new soil to 4,46 mg/100 g in arable soil.

The terrain was flat, with a slight incline to the south-east.

The examined soil had small thickness, it was calcic in terms of classification level 'sub-type'. It was an old mollic fluvisol, where there were no floodings, the underground waters were deeper than 1.5 m, and some other processes were more typical: the sod-forming and the meadow processes, which had existed in the past and on some places as a result of the interruption of the moistening underneath; the intensified exploitation had reduced the humus content, typical for the mollic fluvisols; the cultivation and the agronomic projects had affected the thickness of the humus horizon; the influence of the alluvial processes was too limited.

The scheme of the experiment in the crop-rotation was presented in another publication of ours [10].

The effect of the different fertilization systems on the soil was expressed by measuring the following indices and methods:

humus content, % - Tjurin's method in modification of Nickitin and Fishman [7];humus fractions – accelerated method of Kononova – Belchikova [5] , following one-time extraction with sodium pyrophosphate (0.1 M $Na_4P_2O_7.10\ H_2O$ mixed with 0.1 n NaOH). The humic acids (HA) and the fulvic acids (FA) were separated by precipitation of the HA, bringing the alkaline extract to pH ≈ 1 with concentrated H_2SO_4. The fraction of the combined with R_2O_3 and movable humic acids was obtained by additional treatment of the soil sample with a solution of 0.1 n NaOH, and the so-called 'brown' humic acids were separated by precipitation with concentrated H_2SO_4 to pH ≈ 1;

total nitrogen content, % - method of Keldal [1].

RESULTS AND DISCUSSION

Our results showed that the 40-year cultivation of field crops without fertilization led to a decrease of the humus content in the surface layer (0-20 cm) with 22 %,

Table 1. Introduced quantities of nutrients and manure in the experiment
Внесени количества хранителни елементи и оборски тор в опита

Fertilization systems	Manure	Nutrients, kg/dka		
	t/dka	N	P_2O_5	K_2O
1	-	-	-	-
2	27	210	260	380
3		420	260	380
4		630	260	380
5		420	260	380
6		420	200	380
7		420	260	300

Table 2. Humus status of mollic fluvisol
Хумусно състояние на алувиална ливадна почва

Fertilization for the 40-year period	Humus in the soil, %	Humus reserve in the soil, t/dka	Energy reserve in the humus, MKJ/dka	Nitrogen in the soil, %	Nitrogen reserves in the soil t/dka	Humus enrichment with N;C/N atomic
1. Without fertilization	2.465	6.41	138.556	0.164	9.218	10.2
2. $N_{210}P_{260}K_{380}$	2.758	7.17	155.02	0.193	10.85	9.7
3. $N_{420}P_{260}K_{380}$	2.827	7.351	158.9	0.183	10.29	10.5
4. $N_{630}P_{260}K_{380}$	2.483	6.455	139.57	0.188	10.57	8.96
5. $N_{420}P_{260}K_{380}$+27t/dka manure	3.086	8.023	173.46	0.210	11.80	9.97
6. $N_{420}P_{200}K_{380}$	2.362	6.141	132.77	0.180	10.12	8.90
7. $N_{420}P_{260}K_{300}$	2.845	7.396	159.91	0.191	10.73	10.11
8. Initial soil	3.172	8.248	178.29	0.204	11.47	10.55
HCP (LSD) 5%	0.119					

compared to its initial level (Table 2). The humus content reached 2.84 % in result of fertilization with low and moderate rates of industrial fertilizers, which was in fact an increase with 14.5 % compared to the variant without fertilization, but compared to the initial level the humus content decreased from 10.7 to 25.8 %. Fertilization with high nitrogen fertilization rates led to a decrease of the humus content with 17.4 % compared to the initial level. The humus content was the highest in case of combined application of organic and mineral fertilizers. The introduction of 27 t manure, 420 kg nitrogen, 260 kg P_2O_5 and 380 kg K_2O per dka under cultivation for the 40-year period led to an increase of the humus content compared to the variant without fertilization and stabilized its content on the initial level.

The changes in the humus content in mollic fluvisols brought about changes in the total nitrogen content (Table 2). Our calculations showed that there was a strong positive correlation between the humus content and the total nitrogen content with value of the correlation coefficient R=0.712.

The quantity of the humic acids, estimated by the method of Kononova – Belchikova (1972), increased on introduction of the triple nitrogen rate ($N_{90}P_{30}K_{40}$). The quantity of the fulvic acids increased more visibly in the mineral fertilization system with temporary exclusion of the fertilization phosphorus from the crop-rotation. The fertilization influenced considerably the humus fractions by changing the ratio $C_{H.A.}/C_{F.A.}$ in favour of the fulvic acids, but only in the mineral system without fertilization phosphorus the humus type changed from humic into humic-fulvic. The lowest values of the ratio $C_{H.A.}/C_{F.A.}$ were registered here. The humification level and thence the humus type in all other fertilization systems was of a very strongly exhibited humic character, including in the variant without fertilization. The application of moderate and high nitrogen fertilization rates on the background of phosphorous-potassium fertilization led to a majority of the humic acids, and thence the ratio $C_{H.A.}/C_{F.A.}$ had the highest absolute values. This phenomenon could be explained with the specific character of the environmental conditions, stimulating the humification processes, confirmed by the considerably higher humification level in the variant without fertilization compared to the initial soil. In the variant without fertilization, where only the stubble stimulated the biological circle of substances, the humic acids constituted 28 % of the soil organic substance, and in the initial soil they were 18 %. There were no movable and combined with R_2O_3 humic acids, which could be explained with their predominant combination with Ca^{2+}. A proof of that was the impossibility to extract organic substance with 0.1 n NaOH. At the same time we did not ascertain extraction of aggressive fulvic acids with 0.1 n H_2SO_4. On the other hand, the considerable quantity of organic colloids in the form of calcium humate permanently and invariably increased the absorption of all nutrients, supplied with the mineral fertilizers (Donan's phenomenon). This showed that soil cultivation might bring about positive changes in the humus, expressed in decrease or even extinction of the aggressive fulvic acids and increase of the immobile humic acids, combined with calcium (Table 3).

The 40-year growing of field crops without fertilization led to a decrease of the quantity of the main reserve of the

Table 3. Humus fractions according to Kononova – Belchikova for the layer 0-20 cm of mollic fluvisol
Фракционен състав на хумуса по Кононова-Беличкова за слоя 0-20 cm от алувиално-ливадна почва

Fertilization for the 40-year period	Total C, %	Extracted with O,1n H_2SO_4 aggressive fulvic acids	Extracted with a mixture of 0,1n NaOH and 0,1M $Na_4P_2O_7$			Insoluble residium /humine/	$\frac{C_{H.A.}}{C_{F.A.}}$	Extracted with 0,1n NaOH		D_4/D_6 Velte's coeffi-cient	Total N %	C/N
			Total	H.A.	F.A.			H.A. combined with R_2O_3	H.A. combined with Ca			
1. Without fertilization	1,43	0,0625 4,371	0,4908 34,32	0,3974 27,79	0,0934 6,53	0,92 64,34	4,25	-	100	3,2	0,164	8,7
2. $N_{210}P_{260}K_{380}$	1,60	0,0802 5,01	0,6108 38,175	0,4195 26,22	0,1913 11,96	0,9352 58,45	2,19	-	100	3,3	0,193	8,29
3. $N_{420}P_{260}K_{380}$	1,64	0,0843 5,14	0,4254 25,94	0,3864 23,56	0,0390 2,38	1,088 66,34	9,91	-	100	3,5	0,183	8,96
4. $N_{630}P_{260}K_{380}$	1,44	0,0734 5,10	0,4799 33,33	0,4306 29,90	0,0493 3,42	0,7656 53,17	8,73	-	100	3,4	0,188	7,66
5. $N_{420}P_{260}K_{380}$ +27t/dka об.тор	1,79	0,0815 4,55	0,6326 35,34	0,4085 22,82	0,2241 12,52	0,8658 48,37	1,82	-	100	3,6	0,210	8,52
6. $N_{420}P_{200}K_{380}$	1,37	0,0720 5,255	0,5563 40,606	0,2539 18,53	0,3024 22,07	0,5532 40,38	0,84	-	100	3,5	0,18	7,61
7. $N_{420}P_{260}K_{300}$	1,65	0,0598 3,62	0,5781 35,04	0,3643 22,08	0,2138 12,96	0,8991 54,49	1,70	-	100	3,5	0,191	8,64
8. Initial soil	1,84	0,0829 4,51	0,5126 27,86	0,3754 20,40	0,1372 7,46	1,5639 84,99	2,74	-	100	3,5	0,204	9,02

humus – the humine, with about 10 %. This confirmed cultivation's stimulating influence on the mineralization processes, in which probably only the neoformed humine was influenced. The higher rates of mineral fertilizers and the combined organic-mineral fertilization caused a more expressed decrease of humine's quantity, in which a part of the inherited humine was probably also mineralized in result of the higher microbiological activity (Table 3).

In the examined mollic fluvisol the humus enrichment with nitrogen ranged from 7.6 to 9.0. In the soil without fertilization it was logical to observe higher values as a sign of low mineralization level. In the fertilized variants the values varied, but were lower compared to the control. Naturally, more favourable conditions for microbiological activity were created here, which was connected with the formation of higher quantities of plant residues and mineral nitrogen. G. Panayotova's research (1988) confirmed this fact, stating that the mineralization index (C:N) narrowed on application of separate and combined fertilization.

The coefficient of colour Q, introduced by W. Shpringer, was widely used for evaluating the character of the humus substances' colour. It was equal to the ratio of the optical densities of two wave lengths with sufficiently intensive maximum of absorption - 465 and 665 nm:

$Q = \lambda_{465} / \lambda_{665}$ The increase of the optical density was correlated with the level of hydrolisability of the humic acids and more precisely with the participation of inhydrolisable residium in the molecule. A dependence between the correlation of the most important fractions in the humic acids' molecule and their colour was revealed. The "more mature" humic acids had the highest values of optical density. The aromatic nuclei, carriers of carboxylic groups, prevailed in their structure.

The obtained results showed that a moderate level of condensation of the aromatic nuclei of the humic acids was exhibited in the examined soil, their molecular weight was > 150 000, corresponding to Q = 3,2 – 3,6.

It could be assumed that the nitrogen here was connected with the aliphatic fragments as amino acids' nitrogen.

CONCLUSIONS

1. The organic-mineral fertilization system ($N_{420}P_{260}K_{380}$ + 27 t/dka manure for 40 years) had stabilizing effect on the ecological soil resistance, expressed in preserving the humus content in its initial level, as well as preserving the total nitrogen content.

2. The continuous complete exclusion of the fertilization in growing cultures led to a decrease of the humus content with 22 % compared to its initial level and an annual decrease of the total nitrogen content with 10 mg/1000 g soil and of the movable phosphates with 0,325 mg P_2O_5/100 g soil compared to the fertilized soil.

3. The increasing rates of nitrogen fertilization in the mineral fertilization system led to a slight decrease of the humus content in the soil.

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