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DYNAMICS OF ORGANIC MATTER IN PEAT SOIL UNDER THE CONDITIONS OF SAND-MIX CULTURE DURING 15 YEARS
(a short communication)

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A b s t r a c t. The results of a 15-year investigation on the dynamics of organic matter in peat soil under the conditions of sand-mix culture (SMC) are presented. The generalisation of the obtained results show that the SMC of peat soil in combination with the organic-mineral fertilizer system allows stabilisation of the balance of organic matter in arable layer and conservation of the organic matter below the arable layer. The application of mineral fertilizer only does not allow the creation of a zero balance of organic matter even by using perennial grasses crop rotation.

K e y w o r d s: peat soil, organic matter, sand-mix culture

INTRODUCTION

The German method of SMC of peat soils was developed for the conservation of organic matter. Its essence consists of shallow peat soils subjected to a special meliorative tillage at a depth of 0.8-1.2 m. At that depth a shift of soil horizons takes place, namely: the layers of peat and sand to a thickness of 40-50 cm are transferred from a horizontal position to an inclined one at an angle of $40\text{-}50^0$ and they alternate with each other within the ploughed area. The soil surface is disked several times after such tillage and as a result a new arable layer, consisting of peat and sand to a volume ratio of 1:1 is formed, with the inclined layers of peat and sand situated under the newly created arable layer. It is assumed that the peat layers buried below the upper sand-peat arable layer are conserved. However, despite of the use of this method in many countries for a long time there is no publication concerning the quantitative changes in the organic matter of such soils besides our data which were published by Belkovsky and Goroshko [3].

The purpose of this paper is to describe new data about regularities of soil organic matter changes in a long-term stationary experiment of SMC under conditions prevailing in Belarus.

OBJECTS AND METHODS

A field experiment of SMC was organized on the Polessyan Experimental-meliorative Station covering on area of 7 ha. Deep meliorative tillage was carried out in the autumn of 1979 by Haggens plough. The depth of peat layer before the fulfilment of special meliorative tillage was 50-80 cm grounded by sand. A new arable layer with a depth of 20-22 cm was created by repeated disking of the surface. This layer consisted of approximately equal volumes of peat and sand.

The field experiment with the sowing of agricultural crops was carried out in April 1980.

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The prepared area was divided into two parts: eastern and western. Barley, maize, potato and perennial grasses were cultivated in the eastern area and the same crops, but without perennial grasses, were cultivated in the western area. Mineral fertilizer $N_{120}P_{80}K_{200}$ was used during the first 5 years on both areas. Organic-mineral fertilizer with 20 t/ha of straw manure was used on the western area from 1986 onwards but only mineral fertilizer applied to the eastern area.

The first estimation of the organic matter store was carried out in April 1980 directly before sowing the first agricultural crop. Soil samples were collected at a distance of 2 m from the middle of boards in the very centre of every plot to a depth of 0-20 cm (Fig. 1). 108 samples were collected from the eastern area and the same quantity from the western area, in total - 216 samples. The quantitative content of organic carbon and total nitrogen were obtained in every sample by Turin and Kjeldal methods [1]. Similar investigations were carried out in 1983, 1985, 1990 and 1995, but soil sampling was made at a depth of 0-15 cm during the time of the experiment because the tillage was carried at a the depth of 15-16 cm. So, a small peat-sandy layer of about 5-7 cm, present between the arable layers, was transferred to an inclined layer of peat and sand. All the experimental data were treated statistically with calculations swings of fluctuations, average quantity for (X), error (±m) and coefficient of variation (V).

The variant of traditional black cultivation of peat soil was used for comparison.

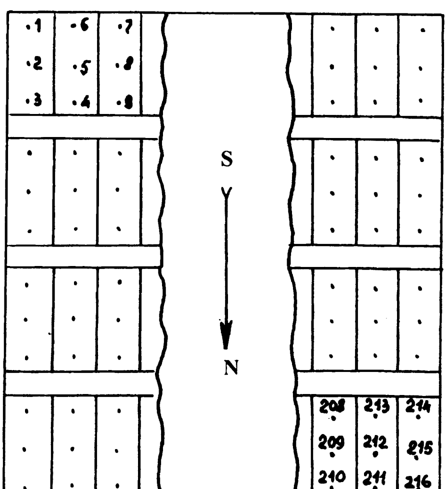

Fig. 1. Schema of sampling of soil on the eastern and western areas of the expeiment of sand-mix culture.

RESULTS AND DISCUSSION

The data about the dynamics of the organic carbon percentage content in the arable layer are presented in Table 1. First of all a substantial decrease of fluctuations of organic carbon content in the soil during 15 years is noticeable. Minimal carbon content increased from 0.67 to 0.87 % but maximal content decreased from 9.13 to 2.89 % at the eastern experimental area. At the western experimental area, where the straw manure was applied, the minimal content of organic carbon increased from 0.61 to 1.32 % but maximal content decreased from 9.13 to 2.89 %. Such a gradual decrease of fluctuation swings is quite natural and may be explained by homogenization of the arable layer in the course of time under the mechanical treatment of the soil. The decrease of variation coefficients from 65.5-63.7 to 26.5-22.8 confirms this explanation.

The average content of organic carbon in 1980, 1983 and 1985 remained practically at primary levels for each experimental area. Such stability during the first 5 years is explained by the organic matter of the primary arable layer being formed only from peat without fresh plant material. The peat from which the primary arable layer was formed, was then extracted from depth, and was therefore poor in micro-organisms and relatively resistant to mineralisation [2]. The biochemical decomposition of organic matter took place in the arable layer during the first 5 years, but its mineralisation was extremely slow and therefore the deficiency of its balance was compensated by post-harvested plant residues.

The dynamics of the changes of average carbon content was specific to each experimental area. In the eastern area, where only

Table 1. Dynamics of carbon content in arable layer (0-15 cm) at the area of SMC (% to the soil dry matter). X - average quantity, ±m - error and V - coefficient of variation

Years	Swing of fluctuations	X	±m	V
		Eastern experimental area		
1980	0.67-9.13	2.02	0.15	65.5
1983	0.77-7.18	2.01	0.14	59.4
1985	0.70-5.40	2.17	0.17	66.2
1990	1.09-3.33	1.83	0.09	29.3
1995	0.87-2.89	1.70	0.08	26.5
		Western experimental area		
1980	0.61-8.44	2.68	0.20	63.7
1983	1.06-6.56	2.67	0.15	47.3
1985	1.20-5.13	2.72	0.12	35.8
1990	1.32-4.96	2.50	0.13	31.2
1995	1.68-4.69	3.09	0.12	22.8

mineral fertilizers were used, the carbon content in the arable layer continued to decrease and reached a level of 1.70 % in 1995. In the western experimental area, where straw manure was applied from 1986, the average carbon content in the soil increased up to 3.09 % in 1995.

The data dynamics of nitrogen content into arable layer are given in Table 2. The fluctuation swings decreased substantially, with maximal nitrogen content decreasing noticeably, from 0.45-0.49 to 0.17-0.26 %. The average nitrogen content in the soil of each experimental area remained without change despite the average carbon content changing subsantially. The stability of average nitrogen content in the arable layer can be explained by a combination of several different processes, namely: mineralisation of organic matter, contribution of nitrogen with mineral fertilizers and post-harvested plant residues.

The variation coefficients of nitrogen content did not change practically during the first 5 years and remained at a level 52.2-61.1 %. But they decreased to 23.5-25.5 % during the following 10 years in the eastern experimental area. In the western area the variation coefficients continued to remain at a high level (48.9 %) even in 1990, and it decreased to 31.3% only in 1995. The slower decrease of variation coefficients in the western area is explained by the unequal distribution of manure in the soil.

The data about the store of organic carbon, humus and nitrogen in the arable layer are presented in Table 3. The carbon store decreased from 1980 to 1995 by 7 t/ha in the eastern area, but in the western one it increased by

Table 2. Dynamics of nitrogen content in arable layer (0-15 cm) at the area of SMC (% to the soil dray matter). Explanations as in Table 1

Years	Swing of fluctuations	X	±m	V
		Eastern experimental area		
1980	0.05-0.045	0.12	0.02	52.2
1983	0.01-0.042	0.12	0.02	60.6
1985	0.03-0.038	0.14	0.02	61.1
1990	0.08-0.022	0.13	0.01	23.4
1995	0.06-0.017	0.11	0.02	25.5
		Western experimental area		
1980	0.60-0.49	0.15	0.02	52.7
1983	0.06-0.39	0.16	0.02	47.5
1985	0.03-0.34	0.16	0.02	41.1
1990	0.05-0.25	0.11	0.02	48.9
1995	0.05-0.26	0.16	0.02	31.3

Table 3. Store of the organic carbon, humus and nitrogen in arable layer at the area of SMC (t/ha). Explanations as in Table 1

Years	Carbon		Humus		Nitrogen	
	X	±m	X	±m	X	±m
			Eastern experimental area			
1980	41.60	4.20	71.80	7.20	2.74	0.44
1983	41.80	3.40	72.10	5.90	2.49	0.46
1985	43.10	1.60	74.30	2.80	2.78	0.45
1990	40.06	2.64	69.60	4.55	2.84	0.66
1995	34.60	3.33	59.68	5.74	2.24	0.28
			Western experimental area			
1980	54.20	4.10	93.40	7.10	3.30	0.42
1983	54.40	3.10	93.80	5.30	3.25	0.43
1985	55.30	2.50	95.40	4.30	3.25	0.44
1990	50.10	3.30	86.30	5.70	2.20	0.52
1995	60.46	1.90	104.30	3.27	3.13	0.67

6 t/ha. Accordingly, the humus store decreased in the eastern area during 15 years from 71.80 to 59.68 t/ha, but in the western area it increased from 71.8 to 104.3 t/ha. Such opposite changes are explained mainly by the use of different fertilizer systems: mineral and organic-mineral ones. In contrast to this the nitrogen store remained unchanged during 15 years because of the above mentioned reasons.

So, the experimental data obtained confirms it is possible to govern organic matter balance in the arable layer of peat soils. The combination of SMC and an organic-mineral fertilizer system can create favourable conditions for zero or positive balance of organic matter in the arable layer of peat soils. The combination of SMC and only a mineral fertilizer system does not allow the creation of zero balance of organic matter in the arable layer of peat soils.

We had no possibility to study the organic matter balance in the inclined peat layers buried under the arable layer because of the absence of a suitable investigation method. But the size, outward look and morphology of peat of this layer was not changed. This fact indicates that the mineralisation of organic matter buried in the peat layer took place extremely slowly or did not take place at all. It is possible to speak about the conservation of organic matter in this layer of peat soils with some reservations.

There was a decrease of the peat layer at the variant of black cultivation of peat soil to a depth of 26-38 cm during 15 years and the total loss of organic matter made up 113 t/ha or 7.5 t/ha per year on average. The average statistically reliable loss of organic matter of peat soils in Belarus is 7 t/ha [2].

CONCLUSIONS

The German method of SMC of peat soils in combination with a organic-mineral fertilizer system allows the creation of a zero or positive balance of organic matter in the arable layer and conservation of organic matter in the inclined peat layer buried under arable layer. The use of a mineral fertilizer system only does not allow the creation of a zero balance of organic matter in the arable layer.

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