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THE BALANCE OF SOIL ORGANIC MATTER OF A CHOSEN AGRICULTURAL FARM IN SLOVAKIA

The balance of soil organic matter was calculated for the area of 939 ha of arable land of a chosen agricultural farm for three years period. It had been confirmed that the negative balance of soil organic matter did not exceed 2 tons of organic carbon per hectare when 40 tons of organic fertilizers (manure) per hectare (once in three years) was applied. The negative balance of soil organic matter, more than 8 ton per hectare was reached on 41 % area of arable land (e.g. 381 ha). The losses of organic matter from the soil in some fields were more than 10 t $C.ha^{-1}$ depending on crop system structure. The average dose 47.3 $t.ha^{-1}$ of organic fertilizers was necessary to balance of soil organic matter.

Key words: soil organic matter balance, manure, soil organic matter deficiency

Баланс органічного матеріалу ґрунту був обчислений для площі 939 га орної землі окремої сільськогосподарської ферми протягом трирічного періоду. Було підтверджено, що негативний баланс органічного матеріалу ґрунту не перевищував 2 тони/га органічного вуглецю при внесенні 40 тон/га органічних добрив (гною) на протязі трьох років. Негативний баланс органічного матеріалу ґрунту, більш ніж 8 тонн/га був досягнутий на 41 % площі орної землі (381 га). Збитки органічного матеріалу із ґрунту на деяких площах були більш ніж 10 тонн/га через певну систему сівозміни. При середній дозі органічних добрив 47,3 тони/га був досягнутий необхідний баланс органічного матеріалу ґрунту.

Ключові слова: баланс органічного матеріалу ґрунту, гній, недостача органічного матеріалу ґрунту

Баланс органического материала почвы был вычислен для площади 939 га пахотной земли отдельной сельскохозяйственной фермы в течение трёхлетнего периода. Было подтверждено, что отрицательный баланс органического материала почвы не превышал 2 тонны/га органического углерода при внесении 40 тонн/га органических удобрений (навоза) в течении трёх лет. Отрицательный баланс органического материала почвы, более чем 8 тонн/га был достигнут на 41 % площади пахотной земли (381 га). Убытки органического материала из почвы на некоторых площадях были более чем 10 тонн/га из-за определённой системы севооборота. При средней дозе органических удобрений 47,3 тонны/га был достигнут необходимый баланс органического материала почвы.

Ключевые слова: баланс органического материала почвы, навоз, недостаток органического материала почвы

INTRODUCTION

The soil organic matter is a significant part the decisive factors of soil fertility due to its wide influence on physical, chemical and biological soil properties. The productive and non-productive (ecological) soil functions (e.g. transformation, filtration, accumulation) depend on the contents and quality of soil organic matter.

The soil organic matter concern is the basic assumption of productive potential soil protection, especially, the arable soil with intensive crop production. The losses of organic matter from the soil caused by mineralization and humification of organic materials or by erosion have to be compensated by inputs of fresh organic matter into the soil.

The regular control of soil organic matter in each field of arable soil is the part of good agricultural practice. The quantification of sources and losses of organic materials is the basic condition of this control. A balance method has been developed by the researchers of the Soil Science and Conservation Research Institute, Bratislava. It is based on long-term research on various soil and climatic conditions of Slovakia (Jurcova, Bielek, 1997). The experimental results were evaluated by statistical methods (polynomial regression). They allow to achieve the balance of soil organic matter in each field of arable soil in Slovakia taking into consideration:

- the soil category that determines the total carbon losses with its mineralization,

- the yields of main product of cultivated crops during recent three years and
- the level of organic soil improvement during the recent three years.

MATERIALS AND METHODS

Both, the balance of soil organic matter and the determination of manure necessity were calculated for the farm Agrozoran Michalany (district Trebisov, close to the Hungarian border).

The characteristics of territory

The farm Agrozoran Michalany is situated in south-western part of Eastern Slovakian Lowland in Trebisov district (Figure 1). It borders with Hungary in western part. The Zemplin Mountains is the eastern border. The highest point of the farm is on 225 m above sea level (a.s.l.), the lowest one on 108 m a.s.l. The area is sorted as a maize technologic type with maize-barley subtype structure.

From the climatic point of view all the area belongs to one climatic zone – warm, too dry, plain, continental. The average annual air temperature is 8.7-9.2°C, the average amount of precipitation is 400-450 mm.

Figure 1 – Location of farm Agrozoran Michalany in Slovakia

The utilization structure of agricultural soils of the farm is presented in Table 1. It is worth to notice that the arable land presents almost three quarters of the total agricultural land of the farm. It is quite a high share of these soils. From the point of view of soils the Mollic Fluvisols dominate with 42 % of the total area, Cambisols cover 17 %, Fluvisols 16 % of the total area. The humus contents in the soils ranges between 1.0 and 3.0 %, the soils are most deep. Only Cambisols are shallow with increased skeleton contents.

Balance of soil organic matter

"Soil organic matter" means the comparison of sources (inputs into the soil) and losses (outputs of organic materials out of the soil) of chosen field of arable land by simple model (mathematical equation). In this model the amount of balanced soil organic matter is expressed in tons of organic carbon per hectare during one year (Jurcova, Bielek, 1997). The mentioned amount of organic mater is calculated as follows:

$$B_c = (/u \times K_c/ + /D_H \times C_H/) - (C_m \times K_m), \quad (1)$$

of which

B_c = balance of organic carbon - in t $C.ha^{-1}.year^{-1}$

u = yield of main product of cultivated crop in the year, when the balance is calculated - in $t.ha^{-1}$

K_c = indicator of re-calculation of crop remains on carbon for given interval of yields

Table 1

Structure of agricultural fund utilization

Type of land	Area (ha)	Share of agricultural soil area (%)
Agricultural soil	1303	100,0
Arable soil	957	73.4
Permanent grassland	338	26.0
Vineyards	1	0.1
Orchards	7	0.5

D_H = the ration of organic fertilizers applied in the year when the balance is calculated - in $t.ha^{-1}$

C_H = indicator of re-calculation of organic mater ration on carbon - in t C on 1 t of mater

C_m = basic losses of carbon from the soil due to mineralization in given soil category - in $t\ C.ha^{-1}.year^{-1}$

K_m = indicator of crop influence on the total carbon losses from the soil in given soil group.

RESULTS AND DISCUSSION

The area of cultivated crops and their yields in recent three years were used as initial input data for the calculation of soil organic matter balance. The data are presented in Table 2.

The organic materials (manure) of 37 $t.ha^{-1}$ average ration were applied on 231 ha from the total 939 observed hectares. Only ensilage maize, sunflower and sugar beet were improved by manure. The smallest loss of organic carbon was on these 9 fields – average value reached 1.9 t C per hectare. It was not important which crops were cultivated during the other two years, the mentioned ration of manure could cover the carbon loss from the soil during three years period. On the other side, the highest losses – about 10 $t.ha^{-1}$ – were reached in the fields where only dense sawn cereals and corn maize were cultivated. It is noteworthy that on 381 ha, e.g. 41 % of total area of arable land the negative carbon balance was more than 8 tons per hectare (Table 3) which indicates insufficient care about soil fertility from the farmer.

The fields were divided into 6 groups according to the carbon losses from the soil. These ones are presented in Table 3 and Figure 2.

In the first group there are the fields which have been improved by manure during the recent three years and the deficit of organic carbon was not more than 6 tons per hectare. In next group 585 ha of arable land has been classified where the deficit of organic carbon was higher than 6 tons. Only this value could be regarded as the limited one from the point of view of content and quality of organic matter put in jeopardy for the soils with humus content less than 1.5 % (according to the Soil Protection Law , 2003).

According to the balance model the total loss of organic carbon from the soils of the mentioned farm reaches the value of 6,226 tons and average carbon loss from one hectare is 6.63 tons. It is necessary to apply an average ration of 47.3 tons of manure per hectare of arable land to eliminate this deficit. The total need of manure for elimination of carbon deficit on the whole farm is 30,805 tons.

The annual production of manure in the farm (6,000 – 6,200 tons) secures to improve only 150 – 160 ha of arable land (e.g. 16-17 % of the total area) with 40 $t.ha^{-1}$ ration each year. It means that only the organic improvement can not solve the problem. It would be necessary to regulate both the organisation of agricultural fund in harmony with given soil, climatic conditions and crop rotation. The dense sawn cereals together with corn maize were cultivated on almost 60 % of total arable land area during the recent three years meanwhile the perennial crops were cultivated only on 2.0 % of the same area. In the framework of crop rotation this is not sufficient for equalizing the deficit of organic matter in the soil.

The Table 4 presents the balance of organic matter in the soil and organic improvement needed in particular fields. In the fields named A, D and F sugar beet was cultivated and there was applied the manure in the ration 40 $t.ha^{-1}$,

Table 2

Area and yields of cultivated crops in various years

Crop / year	2005		2006		2007	
	Area (ha)	Yield ($t.ha^{-1}$)	Area (ha)	Yield ($t.ha^{-1}$)	Area (ha)	Yield ($t.ha^{-1}$)
Winter wheat	380	3.73	380	4.16	260	3.02
Winter barley	25	3.22	5	1.94	30	2.46
Spring barley	60	2.57	35	3.43	95	3.71
Winter rye	-	-	15	3.04	15	1.28
Oat	20	1.97	-	-	-	-
Corn maize	60	4.07	85	5.17	125	1.55
Winter rape	75	2.65	100	1.73	10	0.33
Sunflower	100	1.81	100	2.04	165	1.56
Pea	40	1.12	40	2.20	40	2.27
Soybean	45	1.35	40	2.67	58	1.03
Lens	-	-	-	-	15	0.52
Sugar beet	45	37.5	50	34.4	57	22.34
Silage maize	21	37.40	21	33.23	15	33.78
Spring mixture	36	14.85	40	14.9	22	13.9
Grass on arable land	33	1.47	-	-	-	-
Perennial fodder crops	19	4.60	20	4.64	20	2.36

Table 3

Classification of fields according to organic matter losses

Group of organic matter losses	Range of organic carbon losses ($t.ha^{-1}$)	Number of fields	Area (ha)
1 group	less than 6	16	353.7
2 group	6 – 8	14	204.3
3 group	8 – 9	14	217.5
4 group	9 – 10	4	61.8
5 group	10 – 11	6	101.6

and the deficit of organic carbon reaches only 1.8-3.15 tons per hectare in these fields. In the fields named B, C and E cereals and corn maize were cultivated during the recent three years and the loss of organic carbon was still too high 9.5-10.9 t $C.ha^{-1}$. Immediately, 56-64 tons of manure per hectare was necessary to apply only for these fields in order to eliminate the mentioned deficit of organic matter in the soil.

The achieved results point out to the fact that the losses of organic matter of soils with middle and lower production capacity will be too high without organic improvement.

CONCLUSIONS

It has been confirmed that the negative balance of soil organic matter will not exceed 2 tons of organic carbon per hectare if 40 tons of organic material (manure) per hectare (once per three years) is applied. The losses of organic carbon will be more than 10 tons per hectare without organic improvement and depending on crop system structure. The negative balance of soil organic matter with more than 8 ton per hectare was got on 41 % area of arable land (e.g. 381 ha). The average dose of 47.3 $t.ha^{-1}$ organic mater is necessary to equalize the stated deficiency. It is also necessary to regulate the share of individual grown crops and to cultivate more crops with positive influence on soil organic matter – legumes, their mixtures with grass and temporary grass.

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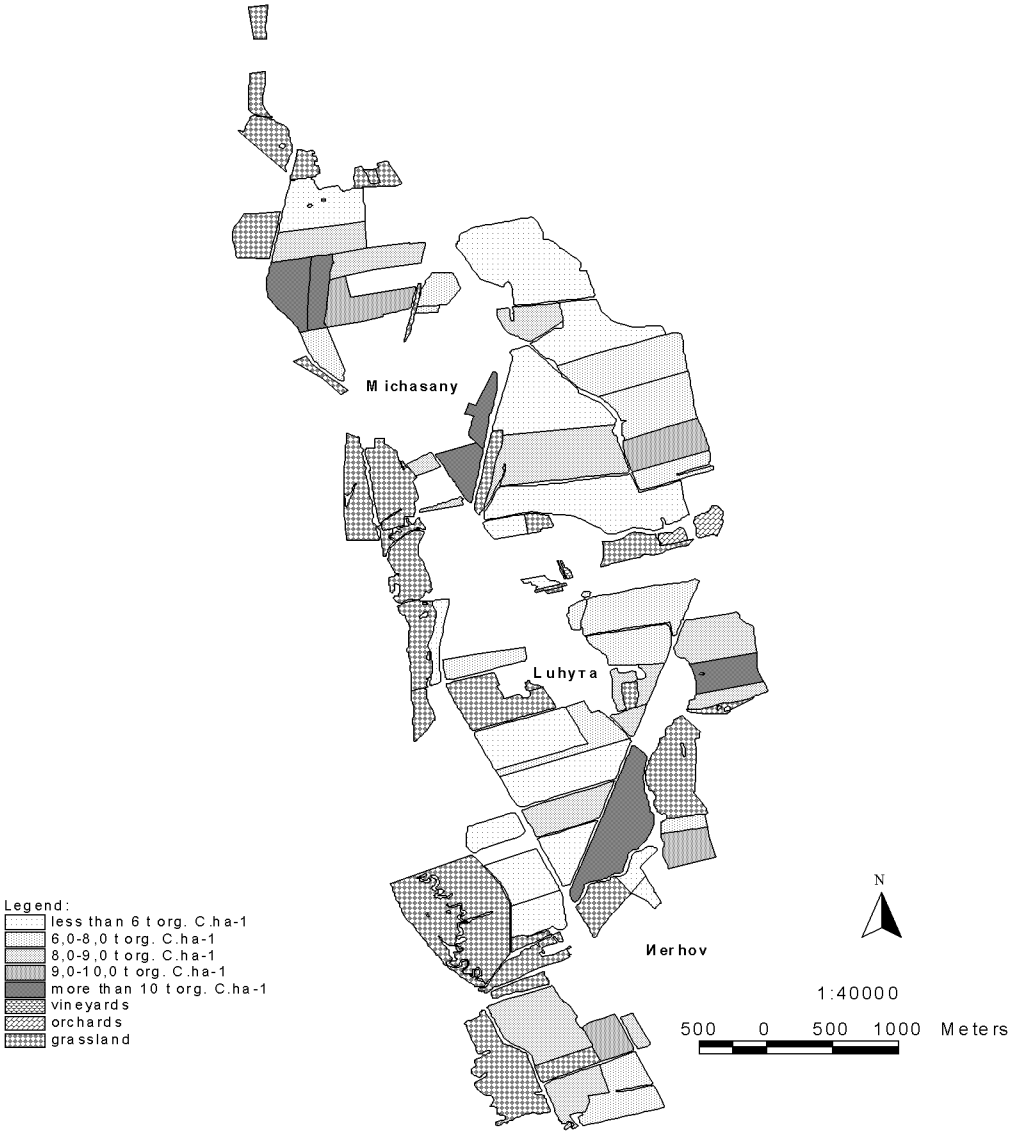

Figure 2 – The soil organic matter balance in individual fields of chosen agricultural farm – Agrozoran Michalany

Table 4

The soil organic matter balance of individual fields and the need of organic mater of chosen agricultural farm Agrozoran Michalany

Field	Year	Area (ha)	Crop	Yield	C balance	C balance total	Sort of improvement	Requirement $t.ha^{-1}$	Requirement t per field	Improvement needed
A	2005	15,0	Winter wheat	3,4	5,18					
	2006		Sugar beet	34,0	-4,39					
	2007		Spring barley	5,1	-2,63	**-1,84**		**0,0**	**0,0**	**No need**
B	2005	15,0	Oats	2,0	-3,46					
	2006		Winter rye	3,0	-2,51					
	2007		Winter rye	1,3	-3,58	**-9,55**	Manure	**56,2**	**842,5**	**Necessary**
C	2005	15,0	Spring barley	2,0	-3,53					
	2006		Corn maize	3,3	-3,92					
	2007		Winter wheat	2,5	-3,44	**-10,89**	Manure	**64,1**	**961,2**	**Necessary**
D	2005	10,0	Winter wheat	4,2	5,59					
	2006		Sugar beet	22,8	-4,49					
	2007		Peas	2,0	-3,17	**-2,08**		**0,0**	**0,0**	**No need**
E	2005	17,0	Corn maize	3,4	-3,54					
	2006		Corn maize	8,0	-2,95					
	2007		Corn maize	1,5	-4,19	**-10,87**	Manure	**62,8**	**1067,3**	**Necessary**
F	2005	17,0	Winter rape	4,1	3,61					
	2006		Winter wheat	3,5	4,04					
	2007		Sugar beet	22,3	-4,50	**3,15**		**0,0**	**0,0**	**No need**