

Soil Organic Matter and Soil Fertility

L. HARGITAI

University of Horticulture, Department of Soil Science, Budapest

The development of Hungarian agriculture in recent decades has been closely connected with new methods of fertilization, including high rates of fertilizer application and the general use of chemicals on a much larger scale than before. The whole system of traditional fertilization was suddenly changed in the nineteen sixties, giving way to new ways and means. The use of manures was dramatically decreased and at the same time the role of soil organic matter in soil fertility seemed to be much less important than earlier. On the one hand it was stated as a fact that organic manuring would cease to be the main source of nutrient supply for plants, while on the other hand the role of organic matter in the maintenance of soil fertility was unfortunately underestimated.

Some years later it was clearly to be seen that soils without organic manuring and without any regulation of the humus conditions sometimes suffer from increased acidity, leading to lower fertility. In extreme cases they may become nearly exhausted. The serious contradictions were based on the concept that the results of many earlier experiments showed the difficulty of increasing soil humus content by manuring, and also the difficulty of applying organic materials within the new systems of modern agriculture.

Recent results in soil research and practical experience gained in agriculture indicate more and more clearly that soil organic matter and humus content play a very important role in the maintenance of soil fertility as well as in environmental protection. The role of organic matter in soil fertility is composed of many factors, such as adsorption and the buffering capacity of humic substances. In addition, soil organic matter has outstanding importance in the storage and continuous supply of available nitrogen for plants.

The role of soil organic matter in environmental protection is based on the ability of humic substances to bind chemical contaminants, such as the residues of plant protection chemicals as well as toxic ions, perhaps heavy metals, which are strongly adsorbed and transferred as chelate complexes by humic acids.

In recent years a new complex method has been outlined for the evaluation of soil humus quality in connection with the practical value of soil organic materials. This method is based on a number of interconnected parameters. Thus, besides the total organic matter content, soil humus quality parameters are also determined. One of these is the humus stability coefficient, based on the optical properties of humus extracts. Another is the so-called R-parameter, which considers the N conditions through the C/N

ratio. This latter factor is suitable for characterizing the value of soil organic matter from the point of view of agricultural chemistry, as well as from that of environmental protection.

Material and methods

To investigate questions on the role of soil organic matter in soil fertility samples were taken over many years from different long-term experiments within the framework of an international cooperation. The investigated long-term experiments were as follows: Skerniewicze /Poland, 1923-/, VIUA Moscow /USSR, 1937-/, Martonvásár /Hungary, 1958-/, Gross-Kreutz /GDR, 1959-/, Thyrow /GDR, 1937-/ and Bad-Lauchstadt /GDR, 1952-/.

From these long-term experimental sites treatments with manures, with fertilization, and manure combined with fertilization were generally selected. The soil conditions vary from sandy soils with a very low humus content /Skerniewicze/ to chernozem-like soils or chernozems with a high organic matter content /Bad-Lauchstadt and Martonvásár/.

The total humus content and total N content of the soils were studied according to the methods of TYURIN and KJEHLDAL. The mobile N content was also determined, using a continuous hydrolysis method combined with oxidation. This method is based on the hydrolysis of the same soil sample with 0.5 n H_2SO_4 four times in succession. The fifth step is combined with oxidation using 3% H_2O_2 . The sixth step is simple hydrolysis with 0.5 n H_2SO_4 . On the same soil samples a seventh value is also determined by hydrolysis with the BREMNER method with 6 n HCl for the determination of the heterocyclic N content. In this paper only the results of the first step are evaluated, since this is most characteristic of the mobile N forms which are of major importance for uptake by plants.

Results and conclusions

Investigations carried out for many years using complex methods for the evaluation of the humus and N status of soils have shown that the accumulation of humus is affected to a lesser extent by fertilization and to a greater extent by manuring. Combined fertilization and manuring also have a favourable effect. High doses of manure /60 t/ha/year/ over a period of 55 years /Skerniewicze/ resulted in a tremendous increase in the soil or-

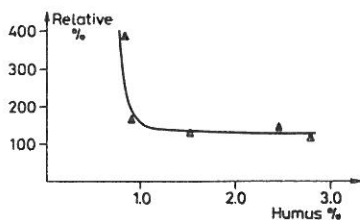


Fig. 1

Relationship between humus accumulation and manuring depending on the original humus content of the soils

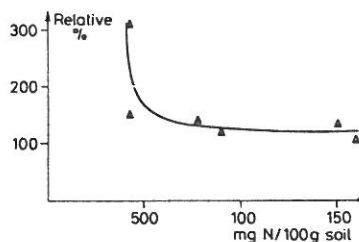


Fig. 2

Nitrogen accumulation depending on the original N content of the soils

ganic matter content: according to the current results /Fig. 1/ 372%, expressed as a relative % of the original humus content. The figure also shows the increase in humus content according to the results of different long-term experiments depending on the initial organic matter content of the soils. It can be clearly seen that the increase due to high doses of manure is always higher for a low initial organic matter content and less

Table 1

Changes in the humus and nitrogen contents of soils in long-term experiments at Martonvásár /1955-/

Plots	Soil organic matter content, %			Total N content of soil, mg N/100 g soil		
	Control	NPK	Manure	Control	NPK	Manure
1st series	2.91	2.94	3.23	163.55	-	184.59
2nd series	2.75	2.81	3.23	148.12	131.37	181.79
3rd series	2.85	3.02	3.22	160.74	167.46	138.00
4th series	2.87	3.10	3.08	128.59	168.85	159.19
5th series	2.49	2.74	2.72	207.20	221.85	244.81
Average of series	2.77	2.92	3.09	161.64	172.39	181.73
Increase compared to the control as a rel. %		+5.55%	+11.55%		+6.65%	+13.04%
Significance LSD _{5%}		0.105			Non-significant	

Table 2

Changes in the humus and nitrogen contents of soils in long-term experiments at Martonvásár /1955-/

Plots	Soil organic matter content, %				Total N content of soil, mg N/100 g soil			
	Control	NPK	Manure	NPK + Manure	Control	NPK	Manure	NPK + Manure
1st series	3.05	3.11	2.94	3.01	231.93	253.96	291.48	275.89
2nd series	2.95	2.94	3.42	2.91	264.04	247.52	317.33	248.45
3rd series	3.03	3.15	2.97	3.06	282.33	259.46	302.40	310.80
4th series	2.74	2.99	3.17	3.31	263.10	270.48	303.33	279.00
Average of series	2.94	3.05	3.08	3.07	260.30	257.85	303.64	278.80
Increase compared to the control as a rel. %		+3.74%	+4.76%	+4.43%		-0.94%	+16.66%	+7.10%
Significance LSD _{5%}		Non-significant				25.17%		

for a considerably higher original humus level. The results of earlier investigations showed that the humus content of soils is strongly regulated by natural factors affecting the process of humification and humus accumulation. This seems to be connected with the fact mentioned above that raising the humus level from a very low level to the equilibrium affected by natural factors is fairly easy, but producing a greater increase in organic matter content when the original humus level is high is almost impossible. The accumulation of N is characterized by a similar picture /Fig. 2/.

Table 3

Changes in humus and nitrogen conditions under the influence of fertilization and manuring in long-term experiments /Bad-Lauchstadt, GDR, 1952-/

Treatments	Humus		Nitrogen				C/N
	%	Relative %	Total	Mobile	Relative %	Mobile	
			mg N/100 g soil			% of total N	
Control	2.44	100	152.3	5.57	100	3.65	9.32
NPK	2.84	116	182.0	7.81	120	4.29	9.01
NPK + Manure	3.36	138	202.6	10.59	133	5.23	9.62

Results on the amounts of mobile N forms and their change and increase perhaps by fertilization applied together with manuring are especially interesting /Tables 1, 2 and 3/. According to the results of long-term experiments in Martonvásár and Bad-Lauchstadt, it can be seen from the tables that treatments with manure + fertilization lead to a considerable release of nitrogen in mobile forms, while at the same time a considerable increase in the total N content of the soils could also be determined.

All the results from the investigations of long-term experiments show that soil organic matter plays an important role in soil fertility even in the case of heavy fertilization. The results also indicate that an increase in yields could be achieved by a combination of manuring and fertilization /Bad-Lauchstadt, Thyrow/.