Mineral Fertilization - Soil Organic Matter Quality

E. MICHÉLI, E. BARABÁS and P. STEFANOVITS

Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Gödöllő (Hungary)

Long-term experiments established in order to gain a better understanding of the effect of fertilizers, crop rotation and tillage systems on crop production and soil fertility have provided important data on the effects exerted on yield, and on the nutrient content and physical properties of the soil (MATTINGLY & JOHNSTON, 1976; COOKE, 1976, 1984; JOU, 1990).

Studies on the effect on humus reported a decline in soil organic matter in the initial years of cultivation (JENKINSON et al., 1977; JENKINSON & RAYNER, 1977), and generally lower levels of organic carbon incultivated soils compared with their counterparts under natural vegetation (GLENDINING & POWLSON, 1990; JOU, 1990). Less information is available on the effect of fertilizers on the quality (composition and stability) of soil organic matter.

The objective of this work was to study changes in the quantity and quality of organic matter in the soils of the Hungarian National Long-Term Fertilization Experiment after 20 years of NPK treatment.

Materials and Methods

The Hungarian National Long-Term Fertilization Experiment Network was established in 1969 to study the effect of different fertilization, rotation and tillage combinations at various locations (stations) throughout the country. At each station uniform cultivation techniques and fertilizer treatments have been conducted (SARKADI et al., 1984; PUSZTAI, 1980; DEBRECZENI, 1985).

Soil samples for the present study were chosen from the control and from one of the treated plots at six stations of the network, as follows:

1. Bicsérd - Chernozem soil (Calciustoll)
2. Hajdúböszörmény - Meadow soil (Chromustert)
3. Karcag - Leached chernozem soil (Haplustoll)
4. Keszthely - Chernozem brown forest soil (Argiustoll)
5. Kompolt - Chernozem brown forest soil (Argiustoll)
6. Putnok - Brown forest soil (Haplustalf).

The control plots have received no fertilizer for 21 years, while the treated plots have been treated with 250 kg N, 200 kg P_2O_5 and 200 kg K_2O per year per ha.

Changes in the carbon and nitrogen contents of the soils were determined by the Walkley-Black and Tuirin methods, respectively. Changes in the quality of the soil organic matter were characterized by the colour ratio (E4/E6) and stability coefficient (Hargitay method) of an alkali (0.2 NaOH) extract of the humic materials (PAGE et al., 1982; BUZÁS et al., 1988). Changes in the molecular size distribution were determined by the gel filtration technique using Sephadex gel G75 (KHAN & FRIESEN, 1972; KHAN & SCHNITZER, 1971).

Results and Discussion

Slight changes (not significant statistically) were observed in the quantity of humus (Table 1). There was a significant increase in the nitrogen content and hence a decrease in the C/N ratio, but the results of molecular size distributing studies indicate that the applied nitrogen is probably not retained in the organic form.

There were substantial changes in the quality of the humic material. On the basis of gel chromatography results the proportion of smaller fractions

Table 1

Results of measurements on the humus % and C/N ratio of the soils and the colour ratio (E4/E6) and stability coefficient of the humic material in control (Cr.) and treated (Tr.) samples

Sample No.	Humus %		E4/E6		Stability coefficient		C/N	
	Cr.	Tr.	Cr.	Tr.	Cr.	Tr.	Cr.	Tr.
1.	2.55	2.53	4.1	4.4	0.99	0.40	11.0	10.0
2.	5.88	7.20	4.4	4.6	5.18	15.48	30.7	11.1
3.	3.71	3.76	5.5	6.0	2.24	1.03	3.6	12.4
4.	1.97	2.31	4.6	4.9	0.25	0.12	9.7	8.0
5.	3.59	3.45	4.9	5.1	0.21	0.16	13.7	13.0
6.	2.17	2.64	4.5	4.7	0.76	0.51	12.3	8.7
$SD_{5\%}$	1.25		0.28		10.33		2.71	
$SD_{5\%*}$	0.63		0.35		1.17		1.06	

$SD_{5\%}$ = Significant difference; $SD_{5\%*}$ = Significant difference calculated without a consideration of sample No. 2.

increased (Fig. 1 A and B), while the proportion of higher molecular weight fractions decreased. This observation was supported by the results of colour ratio and stability analyses (Table 1).

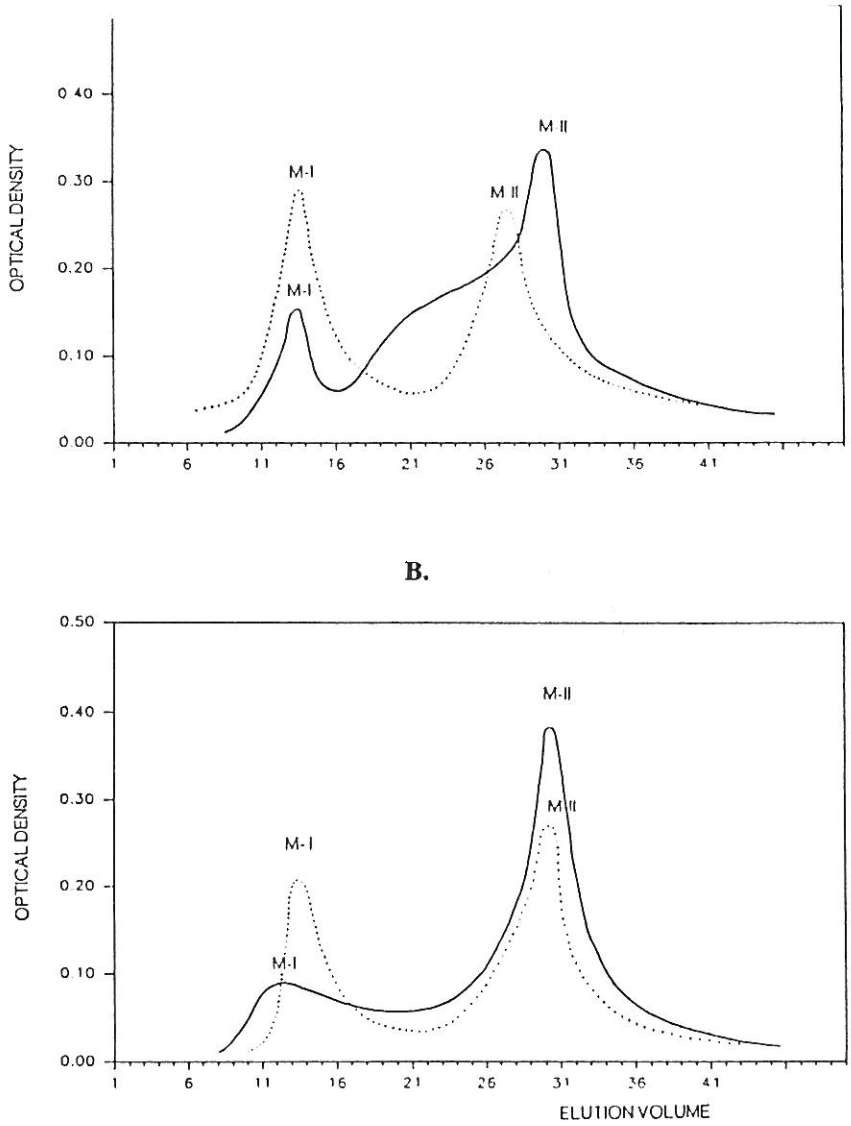

Fig. 1
Example of the gel filtration of humic materials on Sephadex gel G 75 on control (...) and treated (---) samples of : A. Soil 1 (Calciustoll); B. Soil 6 (Haplustalf).
M-I high; M-II low molecular weight fractions

Almost all the parameters measured for sample 2 (Hajdúböszörmény) were extreme. Since the total number of samples studied was low, this sample caused a distortion in the results of statistical analysis. For this reason, the value of the significant difference was determined both with and without a consideration of sample No. 2.

Regarding the actual nutrient supply and activity of the soil, the increase in the smaller fractions can be evaluated positively. However, attention should be drawn to this tendency, since it is mainly the larger molecules which are responsible for the stability of soil organic matter and for a number of physical soil characteristics.

The results for the six studied soils were in agreement but further samples will have to be analysed before reliable conclusions can be drawn.

Summary

Control and treated samples taken from a long-term fertilization experiment were analyzed to give a better understanding of changes in soil organic matter due to the application of 250 kg N, 200 kg P_2O_5 and 200 kg K_2O per year per ha over a 20-year period.

Changes in the carbon and nitrogen contents of the soils were determined by the Walkley-Black and Tuirin methods, respectively. Changes in the quality of the soil organic matter were characterized by the colour ratio (E4/E6) and stability coefficient (Hargitay method) of an alkali (0.2 NaOH) extract of the humic materials. Changes in the molecular size distribution were determined by the gel filtration technique using Sephadex gel G75.

No significant change was found in the quantity of organic carbon in the soils; however, substantial changes were observed in the quality and stability of the organic matter.

Regarding the actual nutrient supply and activity of the soil, the increase in smaller molecular, more labile fractions can be evaluated positively, but in the long-term attention should be paid to this tendency, since it is mainly the larger, more stable organic matter fractions which are responsible for a number of important physical soil characteristics.

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