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24 Influence of Organic and Mineral Fertilization on Fractions of Nitrogen and Carbon Components in Soil

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ABSTRACT

Long-term mineral and organic fertilization increased total nitrogen (N) and carbon (C) in soil. Extraction with 0.25M H_2SO_4 and 2% HCl was similar. Boiling with 2% HCl gave hydrolyzable-N at about 40% of the total N. Percentages of total C in humic acids (HAs) and in C_{HA}/C_{FA} ratios were higher in the cases of farmyard manure (FYM), indicating more stable N complexes. These were lowest when liquid manure was applied. The E_4/E_6 values were highest for applications of liquid manure (Exp. I), but lowest for straw and partly FYM (Exp. II). Infrared spectra of HAs did not show changes influenced as the result of fertilization.

INTRODUCTION

The objectives of long-term field experiments are to prove the effect of fertilizers not only on yield and quality of crops, but also their impact on soil properties. The purpose of this paper was to study the influence of long-term applications of mineral fertilizers, farmyard manure, straw, and liquid manure on fractions of nitrogen (N) and carbon (C) components in soil.

MATERIALS AND METHODS

Field Experiment I

Sandy loam soil, pH 5.8 ($CaCl_2$), Weihenstephan

- PK without N
- PK + N as farmyard manure (FYM), 30 Mg ha^{-1} every third yr (60 yr)
- PK + N as ammonium sulfate
- PK + N as calcium nitrate

Field Experiment II

Sandy loam soil, pH 6.7 ($CaCl_2$), Weihenstephan

- A1 NPK
- A2 NPK + FYM, 30 Mg ha^{-1} every third yr (60 yr)

- B1 NPK
- B2 NPK + 5 Mg straw and 50 kg N ha^{-1} every second yr (25 yr)

- C1 PK without N
- C2 liquid manure, 74 m^3 ha^{-1} every second yr (15 yr)

Methods

Total N and C (Kjeldahl and titrimetric oxidation)
0.25M H_2SO_4 extraction, room temp., 18 h
25% H_2SO_4 extraction, room temp., 18 h
2% HCl extraction, room temp., 1 h
2% HCl extraction, boiling, 3 h

RESULTS AND DISCUSSION

Field Experiment I

Mineral fertilization/farmyard manure:

The high yields of wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.) and potatoes (*Solanum tuberosum* L.), which were very similar when mineral fertilizers were applied, were not obtained from FYM as the source of N (Table 1). Although yields of sugar beet (*Beta vulgaris* L.) were higher for ammonium sulfate than for FYM, they were significantly less than for calcium nitrate because of the effect of the lowering of the pH to 4.85 (Bosch & Amberger, 1983).

Farmyard manure gave the largest increase in soil total N and C (Table 2). Organic N extracted with 0.25M H_2SO_4 was higher than that extracted with 2% HCl, but the differences between the treatments were small. However, increasing the H_2SO_4 concentration up to 25% resulted in values twice as great, while boiling with 2% HCl gave values 7 to 9 times greater (Amberger et al., 1993).

Table 1. Yields of dry matter in Experiment I with mineral fertilization/FYM.

Crops	Treatment				
	PK without N	PK + FYM†	PK + $(NH_4)_2SO_4$	PK + $Ca(NO_3)_2$	$LSD_{0.05}$
	Mg ha^{-1}				
Winter wheat	42.5	56.1	78.8	83.0	8.5
Barley	39.9	50.1	59.2	62.1	4.1
Sugar beets	85.0	107.0	128.0	157.0	15.0
Potatoes	48.3	59.7	78.6	73.2	6.0

†30 Mg ha^{-1} every third yr.

Table 2. Nitrogen and carbon contents of the whole soil and of the fractions extractable in soils in Experiment I for applications of N fertilizers/FYM.

Fractions	Treatment			
	Without N	FYM	$(NH_4)_2SO_4$	$Ca(NO_3)_2$
	mg 100 g-$soil^{-1}$			
Total N	96.0	111.0	108.0	99.0
0.25M H_2SO_4 extr'd	6.1	7.1	8.4	5.9
25% H_2SO_4 extr'd	14.0	15.7	16.5	15.0
2% HCl extr'd	3.5	5.5	5.5	4.0
2% HCl boiled	30.7	42.2	38.1	38.9
Total C	807.0	978.0	912.0	936.0
0.25M H_2SO_4 extr'd	74.5	80.9	76.7	70.3
25% H_2SO_4 extr'd	143.0	168.0	208.0	142.0
C/N ratio	8.4	8.8	8.4	9.5
pH_{CaCl_2}	5.8	5.8	4.9	5.8

Table 3. Carbon in fulvic and humic acids in soil in Experiment I with mineral fertilizer/FYM and E_4/E_6 ratios of humic acids.

Characteristic	Treatment			
	Without N	FYM	$(NH_4)_2SO_4$	$Ca(NO_3)_2$
	% of total C			
Fulvic acid	42.0	35.0	46.0	41.0
Humic acid	22.0	25.0	15.0	13.0
C/H ratio	7.4	9.1	9.3	11.1
E_4/E_6 ratio	5.3	5.2	6.1	6.4

The percentage of total C in the fulvic acids (FAs) (Table 3), was higher in the case of calcium nitrate and predominately so in the case of ammonium sulfate (with decreasing pH). However, FYM formed more stable N complexes characterized by the lowest E_4/E_6 ratio (Chen et al., 1977). The C/H ratio for the humic acids (HAs) indicated similarities between those from the FYM and those from the ammonium sulfate treatment.

The lowest E_4/E_6 value (Table 3) was found in the case of the FYM treatment indicating a relatively high degree of condensation of aromatic constituents, whereas the high values after mineral fertilization suggested a large proportion of aliphatic structures. Infrared spectra for HAs did not show appreciable differences (data not shown).

Field Experiment II

Application of FYM increased the yields of potatoes and sugar beets between 5 and 10%, but not of cereals. Straw manuring (with 50 kg N ha^{-1} applied) had no effect on yields (Bosch and Gutser, 1985). Ammonium N of liquid manure (slurry) proved to be equal to fertilizer N (Amberger, 1988).

All forms of organic manure resulted in higher amounts of total N and C in the soil (Table 4). Organic N extracted with 25% H_2SO_4 was considerably lower after FYM and liquid manure application, but slightly higher when straw was applied. The amount of hydrolyzable-N was greatest when soil was boiled with 2% HCl, with big increases in the FYM and liquid manure plots (Amberger et al., 1993). Carbon in alkaline extracts and the ratio C_{HA}/C_{FA} increased with farmyard and straw manuring, but significantly decreased with liquid manure (Table 5). The lowest E_4/E_6 value was obtained after the straw application. Infrared spectra of HAs were very similar for all treatments (data not shown).

Table 4. Nitrogen and carbon contents in the soil and in fractions extracted with acids in Experiment II, as influenced by different organic manures.

Fractions	NPK (A1)	NPK + FYM (A2)	NPK (B1)	NPK + straw (B2)	PK (C1)	Liquid manure (C2)
	mg 100 g-soil^{-1}					
Total N	126	178	128	140	141	175
0.25M H_2SO_4 extr'd	5.3	8.3	7.0	7.2	6.8	5.7
25% H_2SO_4 extr'd	23.9	15.6	12.5	14.0	11.0	7.6
2% HCl extr'd	6.2	6.8	6.2	8.3	5.7	7.2
2% HCl boiled	41.6	60.9	45.7	46.4	47.0	55.4
Total C	1174	1308	1122	1239	1186	1349
0.25M H_2SO_4 extr'd	157	160	153	169	167	164
25% H_2SO_4 extr'd	136	188	160	174	191	174
C/N ratio	9.3	7.3	8.8	8.9	8.4	7.7

Table 5. Carbon in fulvic and humic acids in soil in Experiment II with different organic manures, and E_4/E_6 ratios of humic acids.

Characteristic	NPK (A1)	NPK + FYM (A2)	NPK (B1)	NPK + straw (B2)	PK (C1)	Liquid manure (C2)
	% of total C					
Fulvic acid	50	40	46	37	35	55
Humic acid	50	60	54	63	65	45
E_4/E_6 ratio	5.7	6.7	6.6	5.4	6.7	7.3

REFERENCES

Amberger, A. 1988. Utilization of organic wastes and its environmental implications. p. 37-55. Proc. 4th CIEC-Symposium, Braunschweig.

Amberger, A., St. Kalembasa, D. Kalembasa, K. Makowiecki, and A. Rykowsky. 1993. (a) The influence of different mineral nitrogen fertilizers on the yield of some plants, fractional composition of nitrogen and carbon compounds in soil spectrometric characteristic of humic acids. p. 83-94. (b) The influence of the application of farmyard manure, straw and liquid manure on the fractional composition of nitrogen and carbon compounds in soil, elementary composition and spectrometric characteristic of humic acids. p. 95-103. Proceedings of the Internat. Symposium 'Long-term static fertilizer experiments,' part II.

Bosch, M., and A. Amberger. 1983. Influence of long-term mineral fertilization on pH, humus fractions, biological activity and N-dynamics of brown earth. Z. Pflanzenernähr. Bodenk. 146:714–724.

Bosch, M., and R. Gutser. 1985. Influence of nitrogen and straw manjuring on yield, N-uptake, chemical and biological characteristics of a brown earth. Mitteil. Deutsche Bodenk. Gesellsch. 43:543–548.

Chen, Y., N. Senesi, and M. Schnitzer. 1977. Information provided on humic substances by E_4/E_6 ratios. Soil Sci. Soc. Am. J. 41:352-358.