Influence of High Doses of Farmyard Manure on Enrichment and Transfer of Nutrients on Loess Black Earth

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1 Introduction

The soil is one of the most important basis elements of life. World-wide the problems of food supply and environmental pollution cannot longer be seen within political or geographical borders. On the one hand, a high production of food is necessary to save the demands of an increasing world population. On the other hand, we have to maintain the environment and the natural resources.

To quantify the influence of different fertilizer systems on yield, quality and transfer of nutrients long-term experiments are essential.

2 Materials and methods

A long-term field experiment with rising doses of FYM was set up in 1983/1984 at the site Bad Lauchstädt (Körschens and Pfefferkorn, 1998). The soil is a Haplic Chernozem containing 21 % clay. The site is situated 110 m above sea level with an annual precipitation of 484 mm and 8.7℃ mean annual temperature (average 1896—1995).

It is a model experiment with 2 treatment factors: (1) organic manure (FYM) with 4 levels: without, 50 t/ha FYM, 100 t/ha FYM and 200 t/ha FYM every year. (2) land use with 2 levels: bare fallow and crop rotation (sugar beet, corn, winter wheat, potato, corn, winter wheat, sugar beet, potato, corn, sugar beet, potato, corn, sugar beet, potato)

The aim of this experiment was the examination of long-term effects of extremely high doses of FYM on yield, nutrient uptake and nutrient transformation.

After harvest 1997 soil samples were taken down to 5 m depth. The content of organic carbon, total nitrogen, P, K, NO_3^- and NH_4^+ were measured according to standard methods. The results after 14 experimental years are described. The weather conditions during this period are described in Fig. 1.

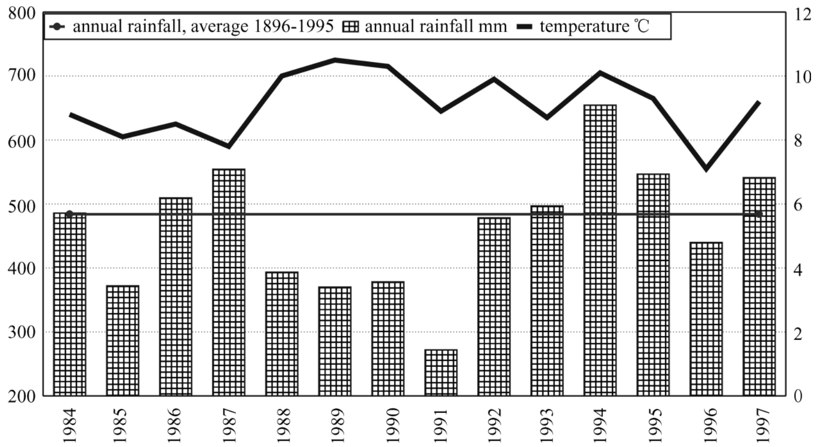

Fig.1 Annual rainfall and temperature in the period 1984—1997 at the site Bad Lauchstädt

3 Results

The first evaluation of soil samples down to a depth of 5 m was carried out in 1992 after 9 experimental years in 1992. The results were influenced by a very dry period with only 378 mm precipitation and a temperature above the long-term average in the 5 years before (Körschens, *et al.*, 1994). It could be shown, that up to this time there was no water movement deeper than 3 m. In the following 5 years (1993—1997) the rainfall was in the average 536 mm.

During the whole experimental period of 14 years the nitrogen applied with FYM and the N uptake by the plants per year have add to:

level 1: 0 kg N/ha fertilization - 168 kg N/ha uptake
level 2: 340 kg N/ha fertilization - 243 kg N/ha uptake
level 3: 680 kg N/ha fertilization - 265 kg N/ha uptake
level 4: 1,360 kg N/ha fertilization - 268 kg N/ha uptake

Considering an accumulation of nitrogen in the upper soil layers and an additional N input from the atmosphere of approximately 50 kg/ha per year (Weigel, *et al.*, 2000) there is a surplus of nitrogen in the treatment 3 and 4 up to 500 kg N/(ha • year).

Depending on fertilization the carbon contents show a significant increase down to 1 m depth for both the crop rotation and the bare fallow (Fig.2). Carbon content is higher in the crop rotation compared to bare fallow,

especially in the layer 0 m—0.30 m.

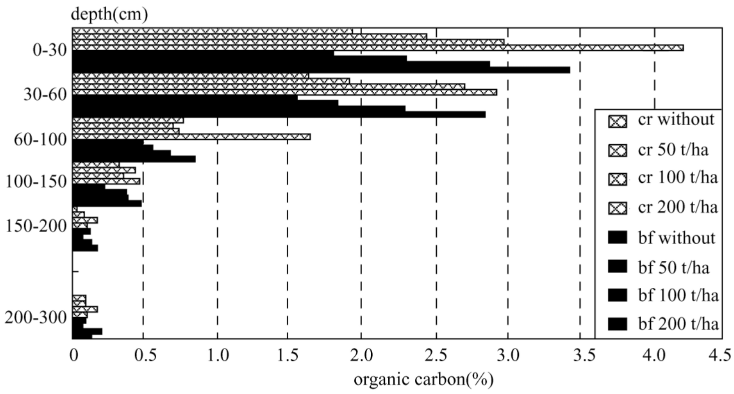

Fig. 2 Influence of extremely high doses of FYM (yearly) and different land use (cr = crop rotation, bf = bare fallow) on organic carbon content of a loess black earth in different layers after 14 experimental years at the site Bad Lauchstädt, 1997

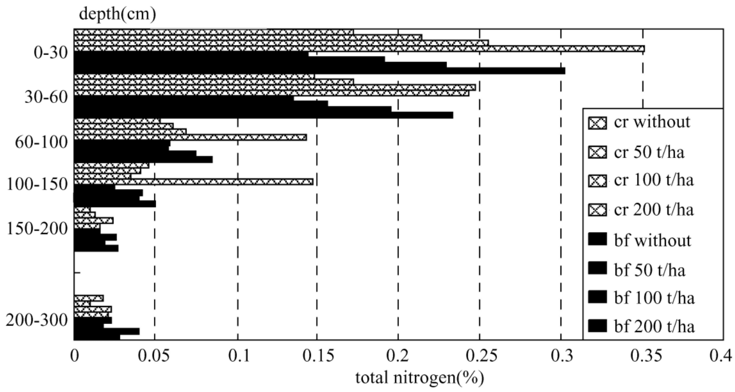

Fig.3 Influence of extremely high doses of FYM (yearly) and different land use (cr = crop rotation, bf = bare fallow) on total nitrogen content of loess black earth in different layers after 14 experimental years at the site Bad Lauchstädt, 1997

In deeper layers the differences can be neglected. Applying 50 t/ha.year FYM the C content in the first layer already exceeded the optimal value of 2.1 % which was calculated for this site by Körschens and Schulz, 1999. Deeper than 1 m the carbon content is in all treatments below 0.5 %, the result of the layers 3m—5m are not shown here.

Comparable results we found for the total nitrogen content (Fig.3).

Large differences occur in case of NO_3–N depending on fertilizer level and plant growth (Fig.4). Increasing amounts of FYM caused drastical increases in NO_3–N contents down to 1.5 m depth both in the crop rotation as well as in the bare fallow.

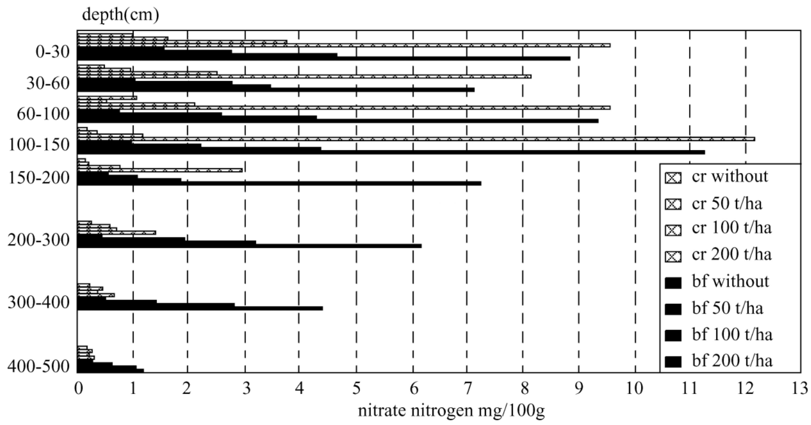

Fig. 4 Influence of extremely high doses of FYM (yearly) and different land use (cr = crop rotation, bf = bare fallow) on nitrate nitrogen content of a loess black earth in different layers after 14 experimental years at the site Bad Lauchstädt, 1997

Between 1.5 m and 5 m depth we measured only in the bare fallow a greater enrichment of nitrate nitrogen. At the highest level of FYM this was more than 1500 kg/ha compared to crop rotation. In contrast in all treatments the measured concentration of NH_4–N is very low, only in the first 1 m the ammonia concentration at the highest level of FYM reached 0.8 mg/100 g soil. This is without importance compared to NO_3– N.

The concentration of phosphorus in the layer 0—0.6 m is in all treatments with FYM much higher than the reference value of approximately 7 mg/100 g soil (Fig. 5). However, there are as well distinct differences between the fertilization levels. At the highest FYM level this value is tenfold exceeded. A transport (or movement) of P deeper than 1 m did not occur.

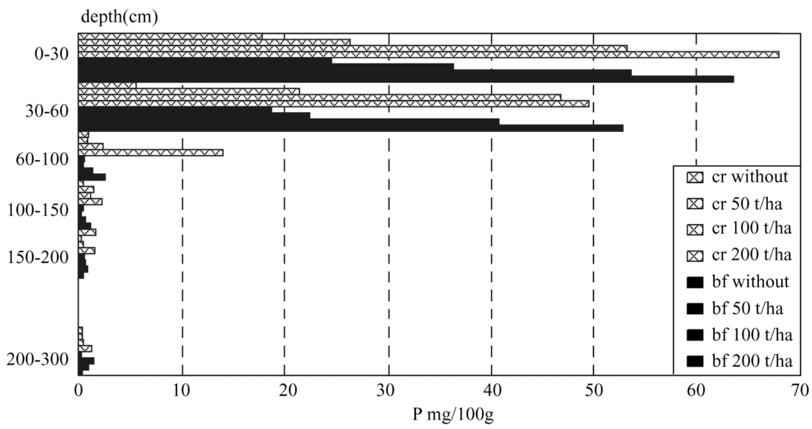

Fig. 5 Influence of extremely high doses of FYM (yearly) and different land use (cr = crop rotation, bf = bare fallow) on plant available P content of a loess black earth in different layers after 14 experimental years at the site Bad Lauchstädt, 1997

A similar picture show the potassium contents (Fig. 6).

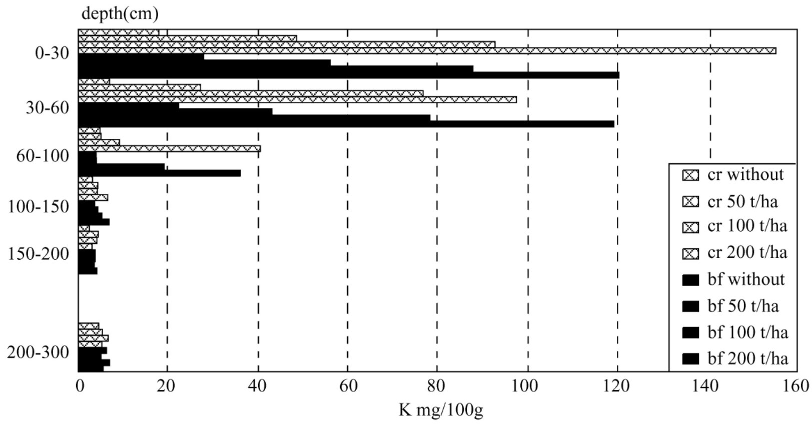

Fig. 6 Influence of extremely high doses of FYM (yearly) and different land use (cr = crop rotation, bf = bare fallow) on plant available K content of a loess black earth in different layers after 14 experimental years at the site Bad Lauchstädt, 1997

4 Discussion and conclusions

In the presented 14 experimental years a nitrogen uptake from the nil plot of 168 kg/ha and year was measured which is the result of a relatively high supply of soil organic matter (SOM) as well as of P and K at the experimental startup in 1983.

As a consequence of the high doses of FYM the C content and simultaneously of course the N content increased drastically and have doubled in the treatment 200 t FYM/ha.year. Applying 50 t/(ha • year) FYM the optimal amount of organic fertilization is 5 times exceeded (Körschens *et al.*, 1998).

Compared to crop rotation high doses of FYM cause remarkable negative effects on the C and N content in the bare fallow, especially in the first layer 0m—0.3m.

High amounts of FYM in the treatment without plant growth and consequently also without N uptake are connected with a transport of (nitrate) nitrogen below the rooting zone.

Evaluating these results we must take into consideration that the site conditions at Bad Lauchstädt are very favourable regarding nutrient utilization which prevents environmental pollution due to leaching. The enormous water capacity of 500 mm in the rooting zone up to 2 m and the low precipitation prevent a shifting of nutrients in the ground water to a great extend. But on the other hand the N balance show the high risk of gaseous nitrogen losses up to 20 % (Körschens *et al.*, 1994). The high P and K content are of less danger for the environment under these site conditions, but the enormous excess of the reference values represents a high load.

References

Körschens, M., Schulz, E., Knappe, S. 1994. Einfluß von Dauerbrache und Fruchtfolge auf die N-Bilanzen einer Löß-Schwarzerde unter Berücksichtigung extremer Düngungsvarianten.
Arch. Acker- Pfl. Boden., **38**, 415-422

Körschens, M., Pfefferkorn, A. 1998. Der Statische Düngungsversuch und andere Feldversuche – The Static Fertilization Experiment and other Long-Term Field Experiments.
UFZ-Umweltforschungszentrum Leipzig-Halle GmbH (ed.)

Körschens, M., Weigel, A., Schulz, E. 1998. Turnover of Soil Organic Matter (SOM) and Long-Term Balances – tools for evaluating Productivity and Sustainability. Z. Pflanzen-ernähr. Bodenk. **161**, 409-424

Körschens, M., Schulz, E. 1999. Die organische Bodensubstanz. Dynamik-Reproduktion-ökonomisch und ökologisch begründete Richtwerte. UFZ-Bericht Nr. 13/99, ISSN 0948-9452

Weigel, A., Russow, R. and Körschens, M. 2000. Quantification of airborne N-input in long-term field experiments and its validation through measurements using ^{15}N isotope dilution. J. Plant Nutr. Soil Sci., **163**, 261-266