

CORRELATION BETWEEN THE NITROGEN CONTENT OF SOIL AND ELEMENT UPTAKE OF MAIZE IN A POT EXPERIMENT

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Introduction

The nitrogen content of the soil serves as a permanent nitrogen source for plants. Since a significant part of the nitrogen in the soil can be found partly in the humus materials and partly in other organic materials, plant and animal residues and in organic bounds in microorganisms, mineral nitrogen forms that are available for plant uptake account for only a few percentages of the total content.

Most of the biogeochemical nitrogen transformation processes occur in the humus-rich layer of the soil between the natural vegetation and the crops via the contribution of the organisms living in the soil. The humus balance and nitrogen management of soils closely correlate. ROSSWALL (1976) estimated the nitrogen turnover of the microorganisms and the plant system to be 95% (cit. NÉMETH, 1995). The transformation of organic matter in the soil is performed by the organisms living in the soil, the activity of which is largely determined by the ecological and agrotechnical factors.

In our pot experiment, the changes in the soil nitrogen forms and in the biomass and nitrogen uptake of maize were determined in soils from a long-term fertilization experiment.

Materials and methods

In the experiment with maize (*Zea mays L.*) as a test plant, soils from the different treatments of two long-term fertilization experiments were used. The selection of the test plant is verified by the good response of maize to nutrient supply (PEPÓ, 2004). The fertilizer dosages shown in Table 1 have been applied for 20 and almost 40 years on the calcareous chernozem (Debrecen-Látókép) and the typical meadow soils (Hajdúböszörmény), respectively.

From each treatment combination, 2.5 kg air-dry soil was measured in four repetitions. The standard treatment of pots was a joint solution of 40 mg/kg P₂O₅ and 40 mg/kg K₂O, in 10 cm³ of KH₂PO₄ and K₂SO₄. The water supply level (75 % of the total water capacity) was ensured by daily irrigation to a specific weight. At high vegetative mass, plants were also irrigated in the afternoon on hot days to avoid wilting.

Table 1. Treatment combinations of the two long-term experiments

Treatment	Calcareous chernozem soil Debrecen-Látókép			Typical meadow soil Hajdúböszörmény		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
	kg ha ⁻¹ year ⁻¹			kg ha ⁻¹ year ⁻¹		
1.	-	-	-	-	-	-
2.	60	45	45	80	50	60
3.	120	90	90	120	75	90
4.	180	135	135	160	100	120
5.	240	180	180	200	125	150

The experiment period was 28 May 2002 – 11 July 2002. Plants samples were collected three times (25 June, 3 July, 11 July). The green plant yields were dried at 60 °C until reaching constant mass in a desiccator and the dry matter production per pot was measured. The total nitrogen content of soils was measured with an Elementar Vario EL elemental analyser (NAGY, 2000). The easily soluble nitrogen forms of the soil were studied in 0.01 M CaCl₂ extract (LOCH *et al.* 1998). The total number of bacteria was measured in bouillon agar from a water-soil suspension using the plates dilution method while the number of nitrifying and protein decomposing bacteria was determined according to POCHON *et al.* (1962) with the method of the most probable bacterium number. Urease activity was measured by the modified method of Kempers (cit. FILEP, 1998).

Results and discussion

The calcareous chernozem and the typical meadow soils were of loam texture and clay-clayey loam texture, respectively. On the basis of soil sampling, it can be stated that with the increase of the fertilization doses, the pH value of the soils decreased, while the nitrate and AL-soluble phosphorus and potassium contents available to the plants increased in both long-term fertilization experiments. The organic carbon and nitrogen contents of the soils ranged within a smaller interval.

The CaCl₂-soluble inorganic (nitrate-, ammonia-) and organic nitrogen content of the chernozem soils increased gradually in parallel with the fertilizer dosages (7.50-12.46 mg kg⁻¹). A slight increase (2-9%) was also detected in the total nitrogen content (Table 2).

The soluble nitrogen content of the treated soils increased compared to the meadow soil used as a control, however, no significant difference was found between the treatments. In the meadow soils, both the organic and the inorganic nitrogen contents were higher than in the chernozem soils. The total nitrogen content also increased in the treated soils (11-25%). Both the total soluble (by 60-100%) and the total nitrogen contents (by 37-70%) were higher in the meadow soils. The ratio of the inorganic N forms ranged between 0.5 and 0.8% and between 0.59 and 0.66% in chernozem and meadow soils, respectively.

Table 2. Changes in the soluble nitrogen forms of soil in 0.01 M CaCl₂ extraction (mg kg⁻¹)
(Ch = calcareous chernozem soil; M = typical meadow soil)

Treatments	Nitrate-N	Ammonia-N	Inorganic- N	Organic-N	Total CaCl ₂ soluble - N	Total N
Ch1.	2.82	1.24	4.05	3.45	7.50	1420
Ch2.	2.52	1.91	4.43	3.98	8.41	1500
Ch3.	3.14	2.31	5.44	4.17	9.61	1450
Ch4.	2.92	2.65	5.57	4.51	10.08	1490
Ch5.	3.15	3.42	6.56	5.90	12.46	1550
M1.	5.92	0.84	6.76	5.23	11.99	1940
M2.	3.99	2.32	6.31	7.96	14.26	2420
M3.	3.73	2.91	6.64	7.47	14.11	2350
M4.	5.25	1.85	7.10	7.29	14.32	2150
M5.	6.09	1.65	7.74	7.28	15.02	2310

At the beginning and the end of the experimental period, the characteristic values of a few microbiological processes were determined. We found at the beginning of the experiment that the nitrate-nitrogen content of the chernozem and meadow soils ranged within a relatively small (6.3-14.0 mg kg⁻¹) and a wider interval (10.5-97.0 mg kg⁻¹), respectively. By the end of the experiment, the nitrate content of the chernozem and meadow soils reduced to 20-60 % and 6-38% of the original, respectively. Apart from a few exceptions, a similar reduction was detected in the amount of nitrifying bacteria. On the other hand, the total number of germs and the amount of ammonifying bacteria were 1.5-14 times higher by the end of the experiment.

Table 3. Nitrogen uptake of test plants during the experiment (N mg pot⁻¹)
(Ch = calcareous chernozem soil; M = typical meadow soil)

Treatments	N-uptake of the shoot-leaf biomass			
	1 st sampling	2 nd sampling	3 rd sampling	Total
Ch1.	53.1	33.3	10.3	96.8
Ch2.	62.9	34.5	13.3	110.7
Ch3.	81.9	49.6	16.3	147.8
Ch4.	89.5	51.0	21.6	162.1
Ch5.	88.0	70.8	18.9	177.7
M1.	52.0	21.2	8.7	81.9
M2.	74.5	40.4	15.0	129.8
M3.	81.5	45.6	17.5	144.6
M4.	79.2	44.1	16.2	139.4
M5.	81.1	39.9	15.3	136.3

In Table 3, it can be seen that the nitrogen uptake of plants on the calcareous chernozem soil increases with the increasing fertilizer dosages at the three sampling dates. Accordingly, the cumulated amount of nitrogen extracted per pot shows a similar trend. Compared to the nitrogen uptake by maize in the control, the nitrogen uptake was almost twice as high in the treatment with the highest fertilizer dose.

In the typical meadow soil, even the smallest fertilizer dose increased the nitrogen uptake of plant as compared to the control, at higher dosages it was practically independent from fertilization.

With the advancing season, the nitrogen uptake of plants significantly decreases. This is due to the fact that the plants used most of the limited amount of available nitrogen in the pot.

Conclusions

- The CaCl_2 -soluble inorganic (nitrate-, ammonia-) and organic nitrogen content of the chernozem soils increased gradually in parallel with the fertilizer dosages.
- The organic and inorganic nitrogen contents of the meadow soils were higher compared to the chernozem soils, however, no significant difference was found between the treatments.
- Both the total soluble and the total nitrogen contents were higher in the meadow soils.
- By the end of the experiment, the nitrate content decreased considerably in both soil types. A similar trend was detected as regards the amount of nitrifying bacteria. On the other hand, the total number of germs and the amount of ammonifying bacteria considerably increased.
- The nitrogen uptake of plants during the season follows the decrease in the available nitrogen content of the soil.

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