Effect of NPK Fertilization and Organic Matter on the Respiration Dynamics and Microbial N Transformation Processes of the Soil

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A laboratory respiration model was established in our former work which gave information on the relation between physical and chemical properties and biological activity of the soil. On the basis of the respiration model several qualitative stages can be differentiated during the mineralization of the organic matter in the soil.

To extend the model, a control experiment was evaluated to characterize the dynamics of soil respiration as well as to monitor the microbial N-transformation processes and quantitative composition of soil microflora taking part in the decomposition of organic matters.

Materials and methods

The soil samples were collected from the ploughed layer of a calcareous chernozem /Nagyhörcsök/ and a calcareous, slightly humous sandy soil /Őrbottyán/ /Table 1/.

Table 1

The main physical and chemical characteristics of the investigated soils

Soil properties	Calcareous sandy soil /Őrbottyán/	Calcareous chernozem /Nagyhörcsök/
Physical sand: physical clay %	89:11	64:36
pH-H_2O	7.7	7.6
pH-KCl	7.6	7.1
$CaCO_3$%	3.3	1.8
Organic matter content,%	1.03	3.46
Total N, mg/100 g soil	66.8	230.9
Available N, ppm /Bremner/	34.0	36.0
P, ppm /Olsen/	8.0	11.0
K_2O, ppm /AL-soluble/	57.0	212.0

The treatments of the experiment were as follows: 1. Control /only moistened/; 2. NPK; 3. 1.0% w/w cellulose, and 4. 1.0% w/w cellulose + NPK.

NPK nutrients were added to the soil in the form of solution, corresponding to 75 ppm N, P_2O_5, and K_2O. The applied carbon source was cellulose powder. The respiration vessels contained 150 g of air-dried soil.

Soil samples were moistened to 70% of water holding capacity and incubated at 28 °C in continuous air flow for three months.

Evolved CO_2 was continuously trapped and periodically measured. Soil subsamples were removed to analyse their nitrate- and ammonium-N content and determine the quantity of microbial populations /number of bacteria, actinomycetes, microscopic fungi and nitrifying bacteria/ and potential denitrification. Samples were taken at given times during incubation.

Results and discussion

A respiration maximum occurred in the first week of the incubation period /Fig. 1/. Maximum respiration appeared at the 4th and 7th day in soil

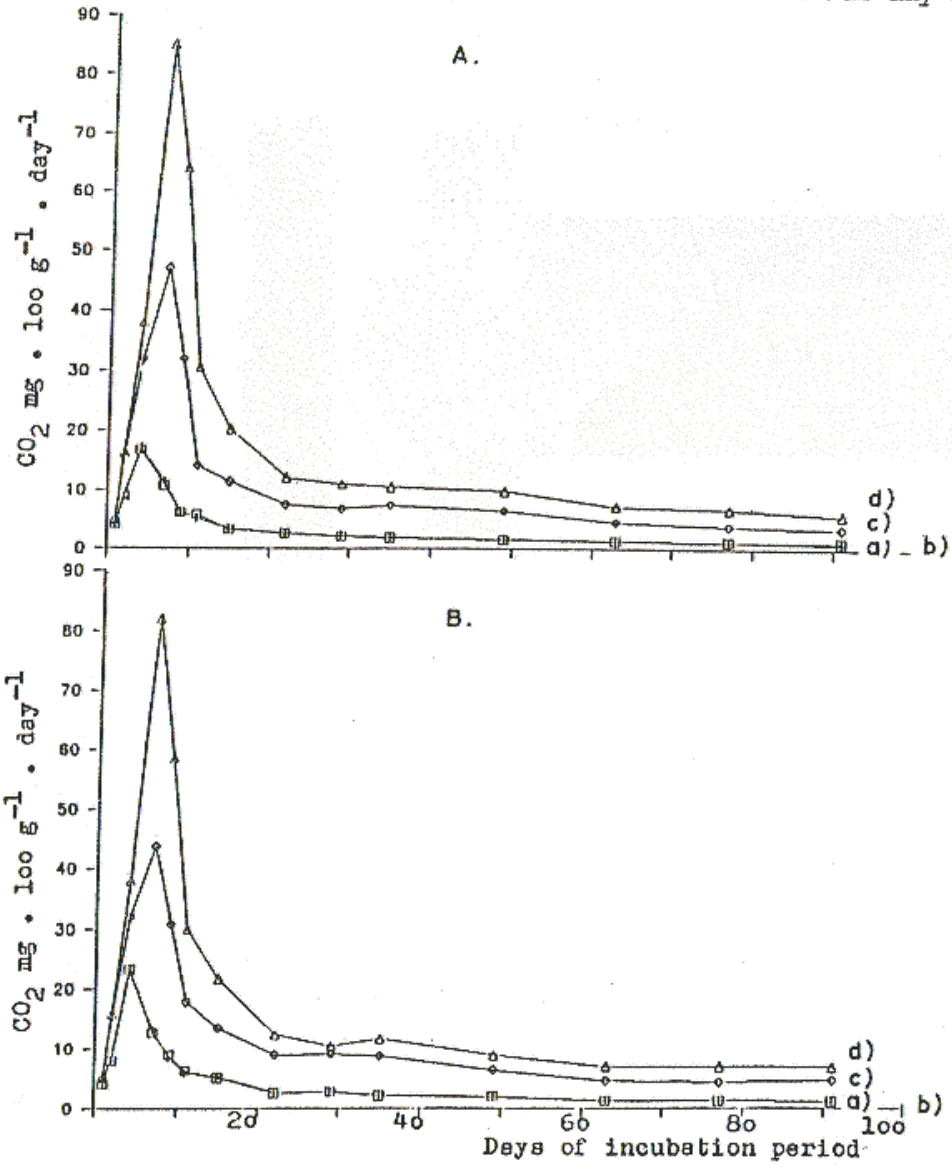

Fig. 1

Daily CO_2 production in the soil samples from Őrbottyán /A/ and Nagyhörcsök /B/. a/ Control; b/ NPK; c/ Cellulose; d/ Cellulose + NPK

samples incubated with and without cellulose, respectively, after which the CO_2 production rapidly decreased. This was caused by the depletion of mineralizable organic matter supply in the case of soil samples incubated without cellulose, while in soil samples incubated with cellulose a considerable immobilization of available mineral nutrients proceeded, and primarily the N content of the soil /Fig. 2/ was the factor affecting the decrease in CO_2 production.

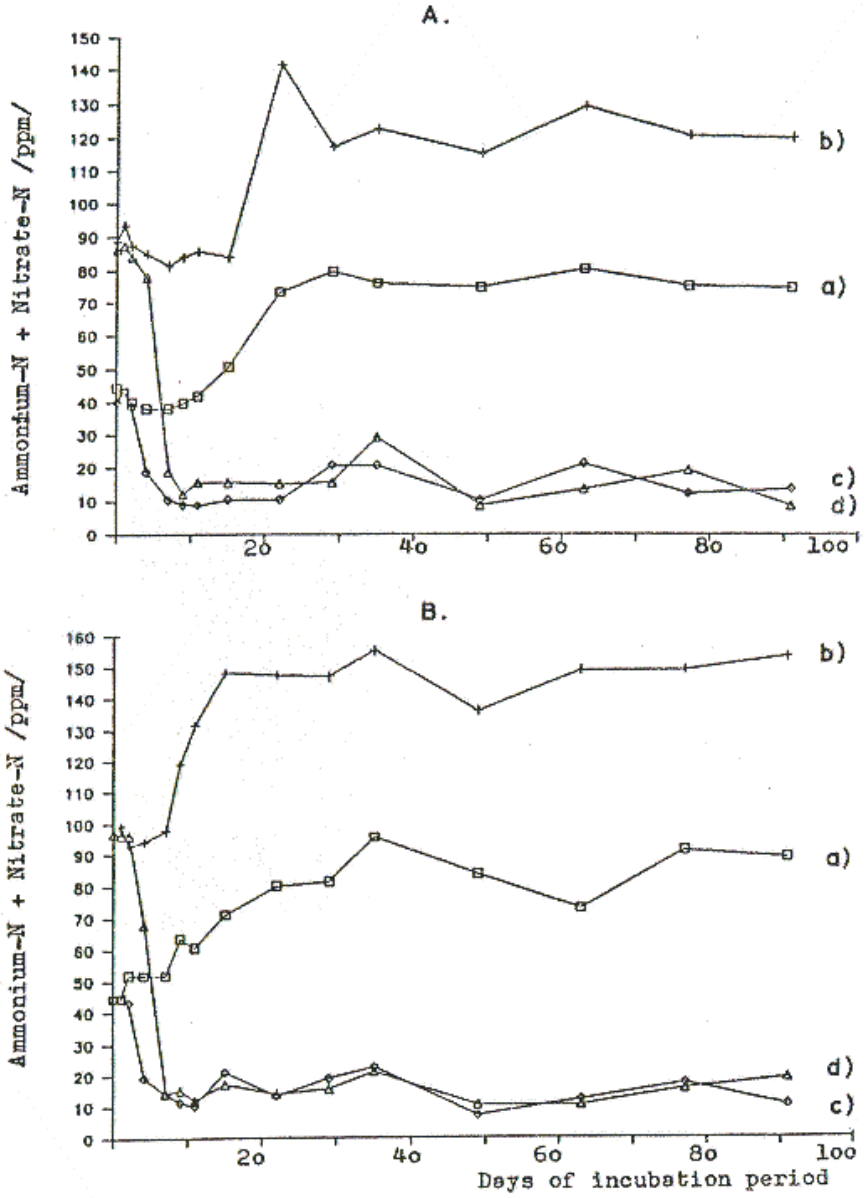

Fig. 2
Available nitrogen content in the soil samples from Őrbottyán /A/ and Nagyhörcsök /B/. For treatments a/-d/: See Fig. 1

The number of bacteria also increased in the first week /Fig. 3/, after which a decrease occurred, while the number of actinomycetes /Fig. 4/ and microscopic fungi /Fig. 4/ increased.

The amounts and forms of inorganic nitrogen compounds significantly changed during the intensive respiration period /Fig. 2/.

The application of cellulose C-source caused a very quick N-immobilization. The originally available soil N-compounds and fertilizer-N was immobi-

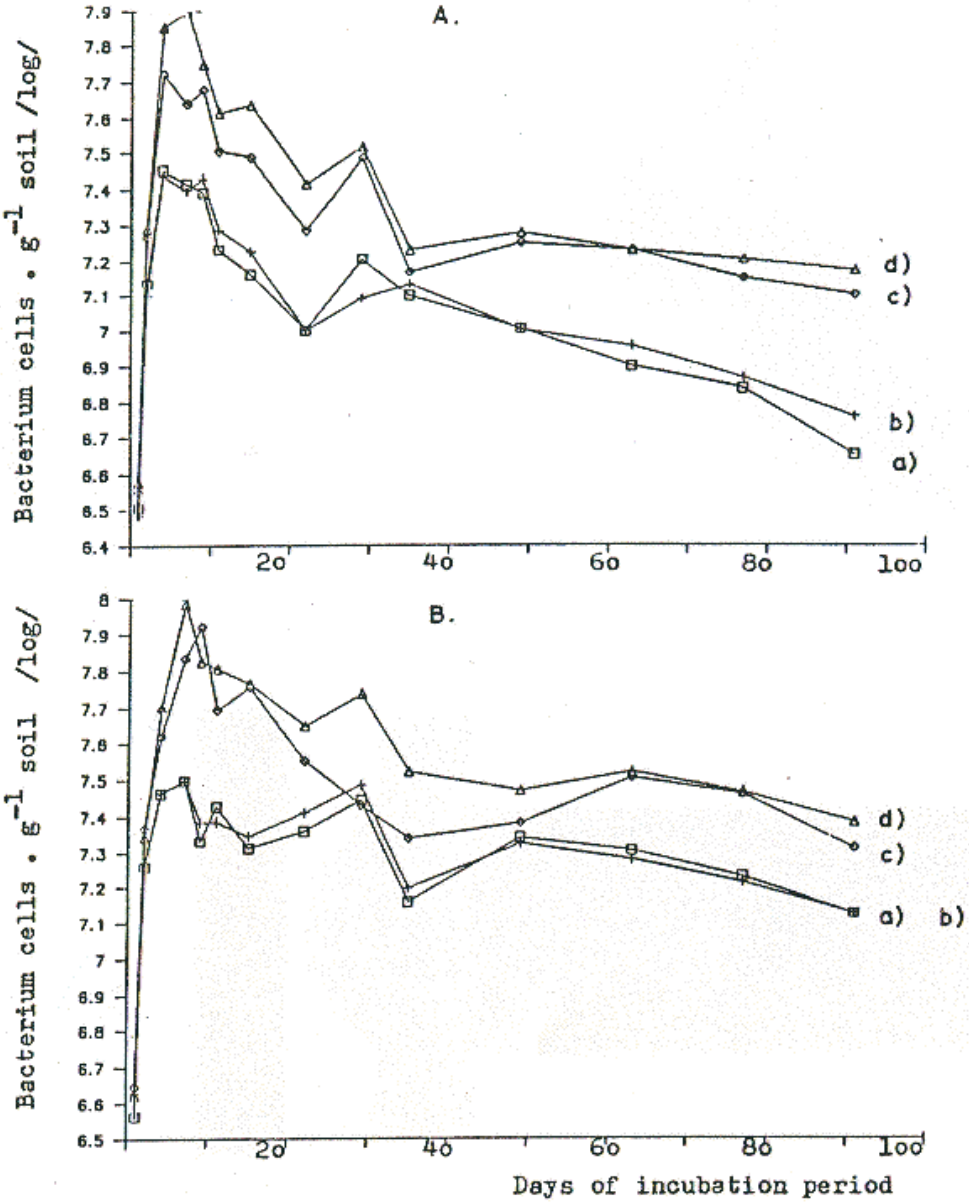

Fig. 3

Number of bacteria in the soil samples from Őrbottyán /A/ and Nagyhörcsök /B/. For treatments a/-d/: See Fig. 1

Table 2

log MPN of nitrifying bacteria during incubation

	Days of incubation										
	7	9	11	15	22	29	35	49	63	77	91
Őrbottyán											
Control	4.28	3.82	5.85	5.20	4.20	4.20	4.20	4.53	4.64	4.85	5.03
NPK	4.45	3.98	5.68	5.51	4.41	4.41	4.20	4.53	5.03	5.03	5.03
Cellulose	3.34	2.90	3.99	3.41	3.34	3.66	3.99	3.82	4.34	3.82	3.66
Cell.+NPK	3.62	3.19	4.20	4.20	2.95	3.66	4.20	3.82	3.82	4.20	4.20
Nagyhörcsök											
Control	4.85	3.64	5.68	4.85	4.41	4.64	4.64	4.85	4.53	4.20	4.20
NPK	4.85	3.98	4.93	6.03	4.53	4.68	4.68	5.03	4.64	4.15	4.15
Cellulose	3.99	3.82	3.83	4.53	3.20	3.20	3.99	3.82	4.41	4.45	4.45
Cell.+NPK	4.19	4.11	4.03	4.53	3.34	3.82	4.20	3.82	4.20	4.45	4.45

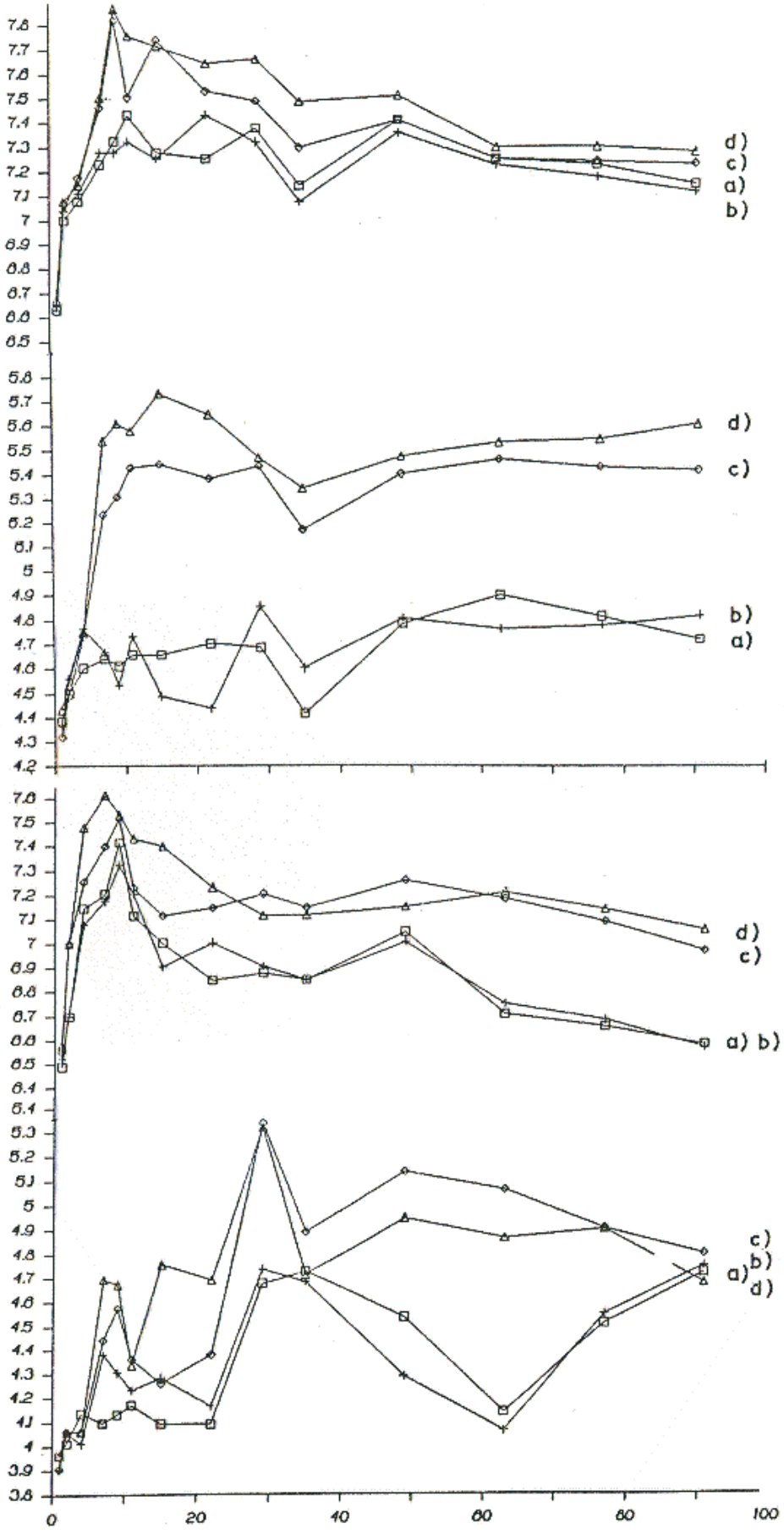

Fig. 4

Number of Actinomycetes and fungi in the soil samples from Őrbottyán /A/ and Nagyhörcsök /B/. For treatments a/-d/: See Fig. 1

lized. Later, the intensity of cellulose decomposition was controlled by the rate of mineralization of the organic N-forms of the soil. The maximum number of nitrifying bacteria was registered on the second week of incubation /Table 2/.

The number of the nitrifying microorganisms was lower in the soil samples treated with cellulose in all cases. This shows the assimilation of soil ammonium-N to microbial biomass. A few days after starting incubation the potential denitrification had a sharp peak, then it decreased very rapidly /Fig. 5/. The application of cellulose significantly enhanced the rate of this alternative respiration process, but a week later it was hardly supplied by nitrate due to the increased N-assimilation.

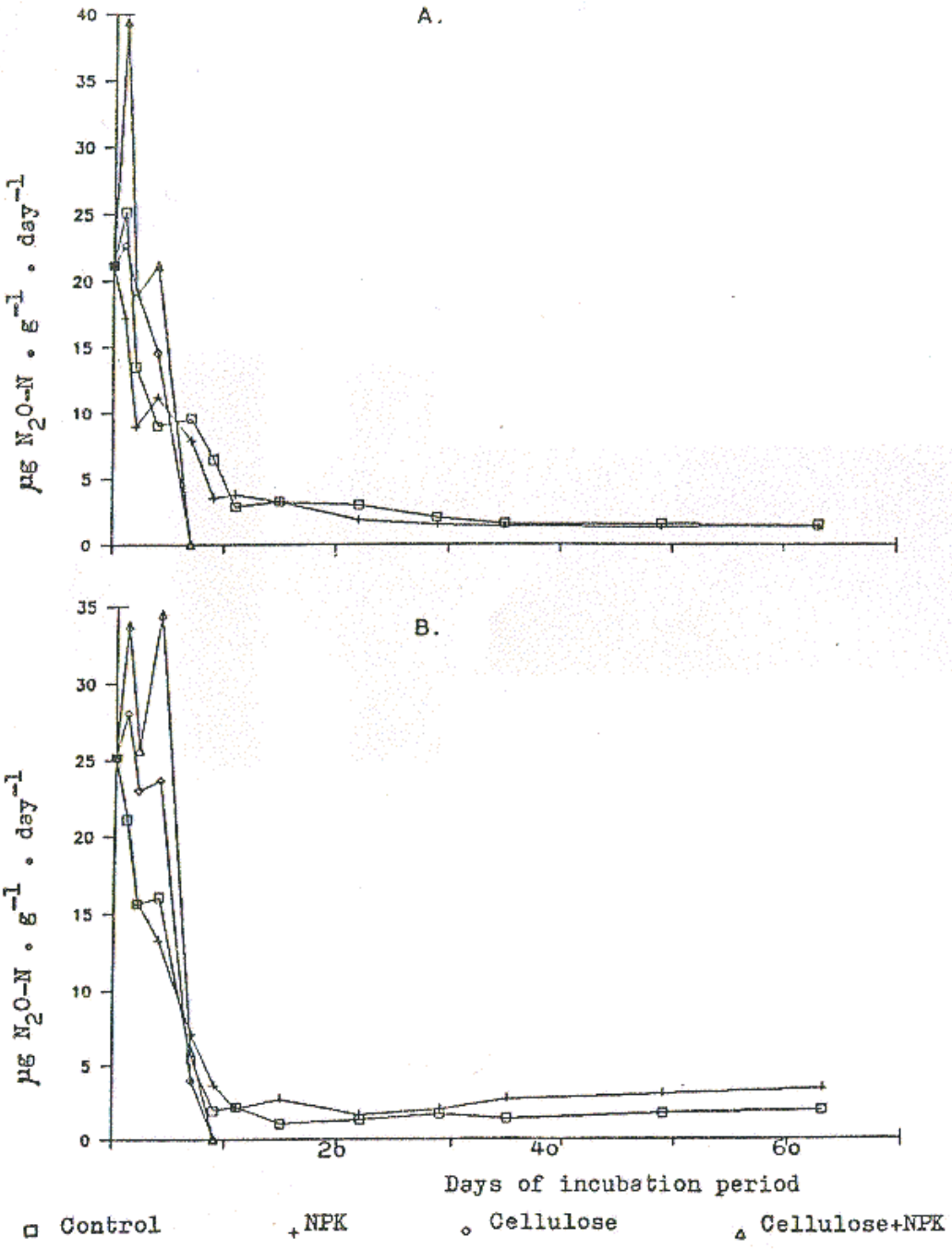

Fig. 5
Potential denitrification of the soil samples from Őrbottyán /A/ and Nagyhörcsök /B/.

Significant potential denitrification could not be measured after a week in the samples incubated with cellulose.

Summary

The process of respiration and the changes in the quantitative and qualitative composition of soil microflora are in accordance with the changes in inorganic N-forms of the soil. In case of cellulose application the original NO_3^--N and NH_4^+-N content as well as the N-content of NH_4^+-N fertilizer added additionally into the soil are immobilized during the first 10-12-day period of incubation. After this period the intensity of cellulose decomposition was controlled by the rate of organic-N mineralization.

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Potential denitrification was faster than aerobic soil respiration, which may be due to the higher electron donor demand for denitrification.