

Effect of C-sources and Urea on the Available N Content and Urease Activity of Different Soils

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Soil enzymatic investigations give valuable information on the conversion of organic compounds and have been used as additional indices in the determination of soil biological activities for a long time.

Authors investigated the effect of different C-sources and urea /as a N-source/ on the available N-content and activity of four enzymes in three different soils.

A soil incubation model experiment was set up to study the decomposition of cellulose, starch and wheat straw with and without applying urea.

Some physical, chemical and biological properties of the calcareous sandy soil /Órbottyán/, chernozem soil /Nagyhörccsök/ and brown forest soil /Keszthely/ are given in Table 1. Soil samples were taken from the ploughed layer and stored under air-dried conditions.

The quantity of added urea was estimated to reach a 20:1 C/N ratio in soil samples containing C-sources /220 ppm urea N/. For each treatment of the model experiment 1 kg air-dried soil was sieved through a 2 mm mesh and the moisture content was adjusted to 65% of water holding capacity. Incubation was carried out in 3 replications at 37 °C for 12 weeks. The determination of the available N-content, the enzyme activities and of the quantity of microbes was carried out at the beginning of the experiment and on the 1st, 2nd, 4th, 9th and 14th day of incubation, then weekly /number of microbes in every two weeks/.

The available N-content of the soil was determined according to BREMNER /VARGA, 1969/, the urease activity according to TABATABAI and BREMNER /1972/. To estimate microbial numbers, dilutions of soil samples were determined on agar plates of different media /SZEKI, 1979/. The activity of saccharase, amylase and cellulase was determined according to FRANKENBERGER and JOHANSON /1983/ with some modifications. The quantity of the formed reducing sugars was measured photometrically by a colour reagent. The data were evaluated by variance analysis with two variables.

Results on the N-content and urease activity of the investigated sandy soil were presented in detail in a previous publication by ANTAL et al. /1988/.

The experimental data of the chernozem soil are evaluated according to the treatment pairs, individually. Similarly to the sandy soil, a rapid

Table 1
Some main properties of the investigated soils

Soil characteristic	Calcareous sandy soil /Örbottyán/	Chernozem soil /Nagyhörcsök/	Brown forest soil /Keszthely/
Physical sand:clay, %	81:11	64:36	65:35
CaCO ₃ , %	3.3	1.8	-
pH/KCl/	7.6	7.1	6.7
Upper limit of plasticity /K _A /	24	37	37
Organic matter content, %	1.3	3.46	1.67
Available content of			
/mg/100g soil/			
N	2.4	2.0	3.3
P	0.8	1.1	0.6
K	5.7	21.2	9.8
Exchangeable content of			
/mg/100g soil/			
Ca ²⁺	187.2	583.4	269.4
Mg ²⁺	14.9	16.4	21.7
Urease activity			
/μg NH ₄ -N·g ⁻¹ soil·hour ⁻¹ /	3.53	1.81	21.7
Total number of microorganisms			
/logarithmic values/			
Bacteria	6.65	6.96	7.0
Actinomyces	6.60	7.26	7.64
Fungi	4.00	4.74	4.98

hydrolysis of the added urea without C-sources was observed and the relatively high NC₃-N content was stagnant up to the end of incubation. The untreated /control/ soil sample had a low available N-content and no significant change had been registered.

In the cellulose and starch treatments without an N-source the tendency is similar to the above described. Added together with cellulose or starch, urea underwent a rapid hydrolysis, but after a relatively short time the available N-values clearly indicated the immobilization of N.

In our incubation experiment wheat straw proved to be the most difficultly decomposable organic matter, also in the case of the chernozem soil.

Comparing the urease activity of the chernozem soil and sandy soil, we found some differences. The most substantial difference was that the urease activity of the control samples was lower than that of samples only urea-treated, but this difference was significant only in the 96th hour of incubation. The application of C sources - in general - caused a marked increase in the enzyme activity during incubation. It is likely that soil urease was trapped within the organic matter of soil. Evaluating the effect of the urea treatment, it can be stated, that - with the exception of wheat straw - urea decreased the urease activity in the soil samples.

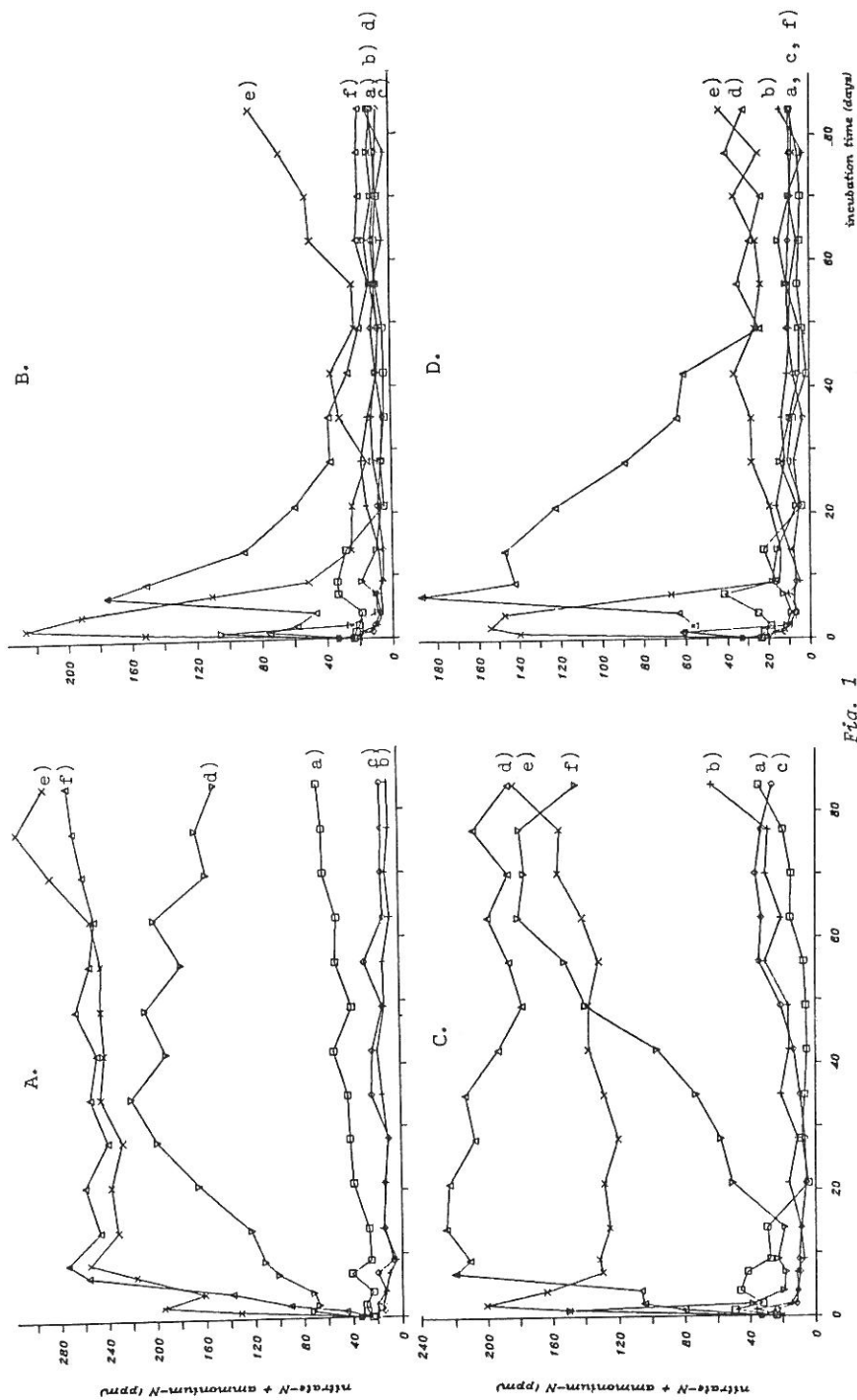


Fig. 1

Available N content of the sandy soil, chernozem and brown forest soil in different treatments. A. Control: a/ sandy soil; b/ chernozem; c/ brown forest soil; Urea treatment: d/ sandy soil; e/ chernozem; f/ brown forest soil. B. Cellulose: a/-c/: See A.; Cellulose + urea: d/-f/: See A. C. Wheat straw: a/-c/: See A.; Wheat straw + urea: d/-f/: See A. D. Starch: a/-c/: See A.; Starch + urea: d/-f/: See A.

In general, the above-mentioned conclusions may also be drawn in respect of the brown forest soil originating from Keszthely. Owing to this reason, we principally highlight the differences, which are caused by the physical-, chemical and mainly biological properties of this soil.

In the case of soil samples treated only with urea the hydrolysis of urea began later and it's rate was lower as compared to the investigated soils. The $\text{NO}_3\text{-N}$ values reached the maximum only in the 5th week, which was followed by a slow fluctuating decrease on a relatively high level. Under the effect of the slightly decomposable C-source /cellulose and starch/ a marked microbial immobilization of available N originating from urea was noted. This is in accordance with our results regarding the changes in the number of microbes. After that, no significant differences from the original values were measured in the value of available N till the end of incubation.

In the wheat straw treated soil, within the first 24 hours a rapid hydrolysis of part of the applied urea was observed on the basis of the available N-content. In the following 48 hours this available N-content decreased to its minimum, where it remained to the end of the second week of incubation. Later, the available N-content overgrew the first peak. As regards the N-supply, the differences between the brown forest soil and the other soils could be connected with the interaction of biotic and abiotic factors related to the soil properties.

The relationships of urease activity do not seem to be obvious. One of the essential differences is that the original urease activity was remarkably higher in the brown forest soil than in the others.

The tendencies of the changes in the available N-content caused by the different C-sources and the urea treatments in the experimental soils are demonstrated in Fig. 1 /A-D/.

Generally, the urease activity is higher in soils treated with C-sources than in soils without a C-input, either with or without urea /Fig.2/.

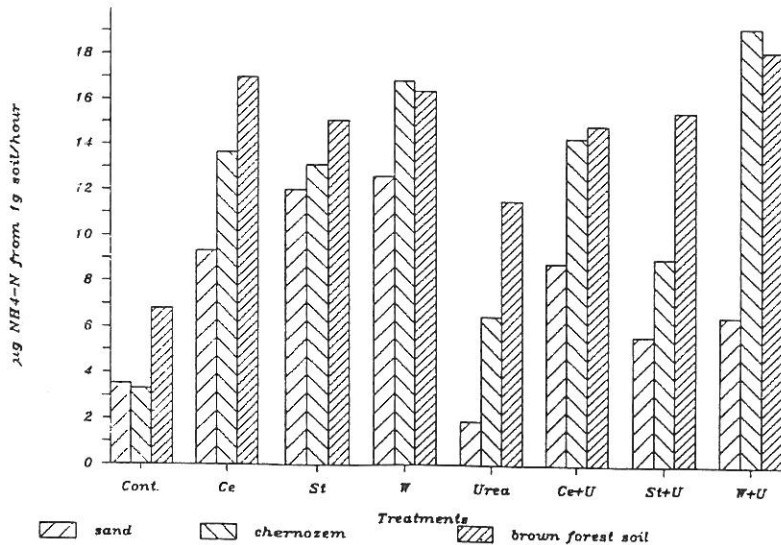


Fig. 2

Effect of treatments on the urease activity of the sandy soil, chernozem and brown forest soil /averaged over time/. Abbreviations of treatment: Cont.: control; Ce: cellulose; St: starch; W: wheat straw; U: urea

The highest N-content / $\text{NO}_3\text{-N} + \text{NH}_4\text{-N}$ / was found in the urea treatments in the case of all three soils, however N-immobilization is more facilitated in the brown forest soil. In the cellulase and starch treatments - in the sandy soil - the changes in the available N-content are in accordance with the considerably increasing microbial activity, due to the effect of urea at the beginning of the incubation.

In most treatments of the chernozem soil, proceeding urea hydrolysis the N immobilization is relatively rapid, but in the last 4 weeks part of the immobilized N starts to remineralize. It should be mentioned that the nitrogen in the brown forest soil remained in immobilized form from the 24th hour of the experiment up to the end of incubation.

The effect of wheat straw with and without urea application on the available N-content in the experimental soils is illustrated in Fig. 1/D/. The applied urea was hydrolyzed in the first week of incubation. The rate of N-immobilization was higher in the heavy-textured chernozem, than in the sandy soil.

In the brown forest soil the available N originating from urea, was very quickly immobilized by the microbial populations. The available N (mainly $\text{NO}_3\text{-N}$), formed later from microbial metabolism and urea hydrolysis, was unable to immobilize because of the relatively difficult decomposibility of the wheat straw. Under these conditions the N-mineralization processes came into prominence.

Recent works have indicated that different soils have different constant levels of urease activity, which is attributed by their ability to protect enzymes against microbial decomposition and other processes that lead to the destruction or inactivation of enzymes.

Based on our findings, it may be concluded that, depending on the soil type, the microbial biomass and enzyme activities increased after the addition of energy sources. Increases in urease activities coincided mainly with microbial growth increases and with the immobilization of nitrogen. No one, single measurement of activity is sufficient to interpret the microbial activity of the soil system. Each of the indices measured should be used to form an overall picture of a complex system like soil.

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