Effect of C-sources and Urea on the Carbohydrate Hydrolysing Enzyme Activities of Different Soils

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The material and methods of the study are presented in this volume /ANTAL et al., 1990/.

The various treatments influenced the quantity of soil microbes slightly - usually not overgrowing an order of magnitude -. It seems that the effect of different substrates caused changes rather in the composition than in the quantity of the microflora. Microbial communities became well-adapted to their environment, reflecting the changes of surroundings by their communal metabolism during the succession of the population.

Among the different microbial groups the most marked quantitative changes were observed in soil fungi /Fig. 1A/. The increase in the number of microbes due to the treatments was the highest in the sandy soil while quantitative changes were moderate in the brown forest soil.

The number of microbes in soil samples treated with C-sources and urea are generally higher than those treated only with C-sources.

The saccharase activity of the calcareous, slightly humous sandy soil treated with C- and N-sources decreased compared to the samples given only C-sources, with the exception of cellulose /Fig. 1B/. The beneficial effect on enzyme immobilization is probably due to the applied organic matters /C-sources/ which undergo a relatively intensive decomposition in the presence of urea as a N-source. The cellulose decomposition presumably resulted in advantageous conditions for the accumulation /adsorption and/or immobilization/ of this enzyme in soil. Wheat straw was the C-source inducing the most remarkable increases in the sandy soil's saccharase activity.

All C-sources, and especially C-sources applied together with urea, increased the saccharase activity in the chernozem soil samples /Fig. 1B/.

Changes in the saccharase activity over time in the chernozem soil can be characterized by several ascending and decending periods, fluctuation was observed particularly in the case of control and urea treatments.

Similar observations were made in the case of the brown forest soil, with a substantial difference, namely in the first 24 hours of the incubation period the original saccharase activity decreased to a lower value, which may be explained by an abiontic destruction or proteolytic decomposition.

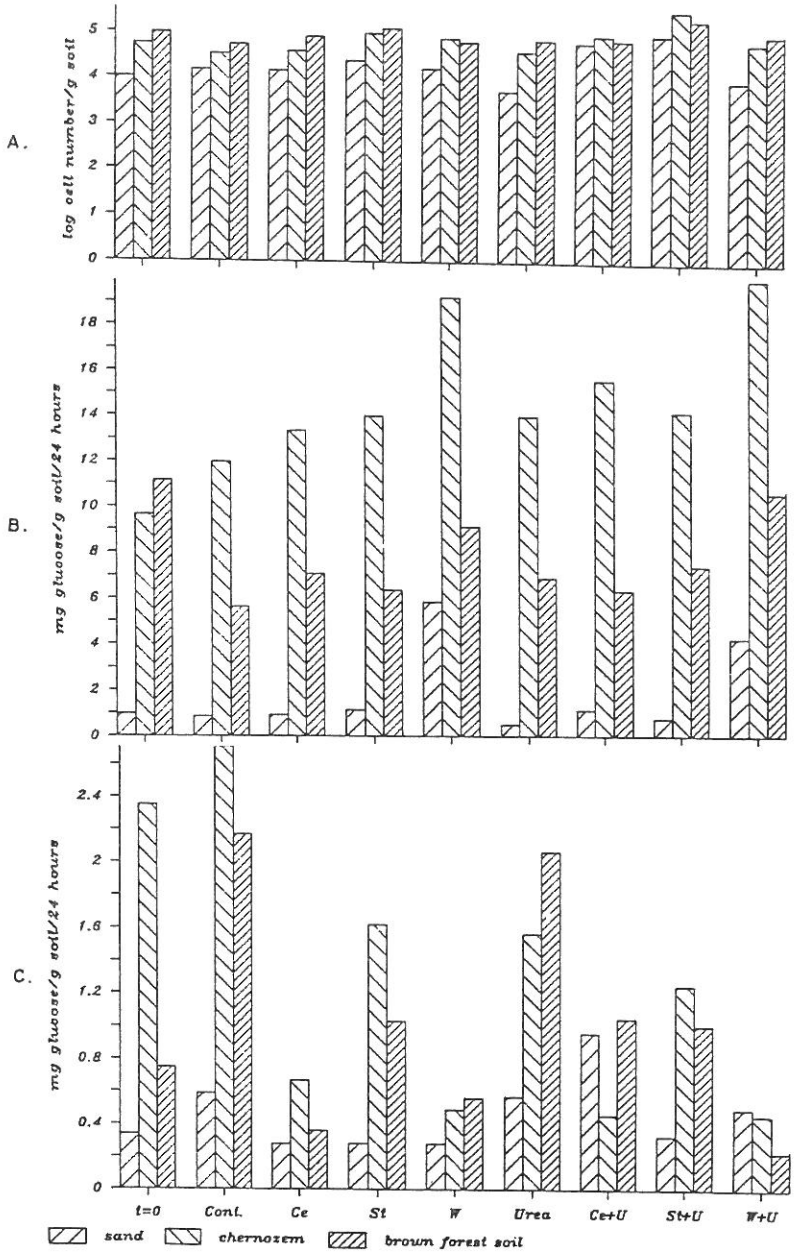

Fig. 1

The effect of different treatments on the quantity of fungi /A/, saccharase activity /B/ and cellulase activity /C/ of the sandy, chernozem and brown forest soil /averaged over time/. Abbreviations: Cont: control; Ce: cellulose; St: starch; U: urea; W: wheat straw

Generally, the highest cellulase activities were recorded in the control treatments of all three soils with the exception of the cellulose + urea treatment in the sandy soil /Fig. 1C/.

In the chernozem and brown forest soils cellulase activities are lower in the cellulose and wheat straw treatment than in those given starch /Fig. 1C/.

As other experimental data /ANTAL et al., 1990/ indicate an intensive cellulose decomposition in samples with low cellulase activity, the hypothesis is suggested that the catalysis of cellulose decomposition proceeds in the microenvironment of microbes /by enzymes attached to the surface of the cells/ rather than by diffusible "free" and accumulated enzymes. Another possibility is that the cellulolytic enzymes are trapped in a kind of enzyme-substrate complex in such a way that they are almost unavailable for the test substrate /carboxymethyl-cellulose, Na-salt./. These phenomena should be thoroughly studied "in vitro", that is, in simplified biochemical model system.

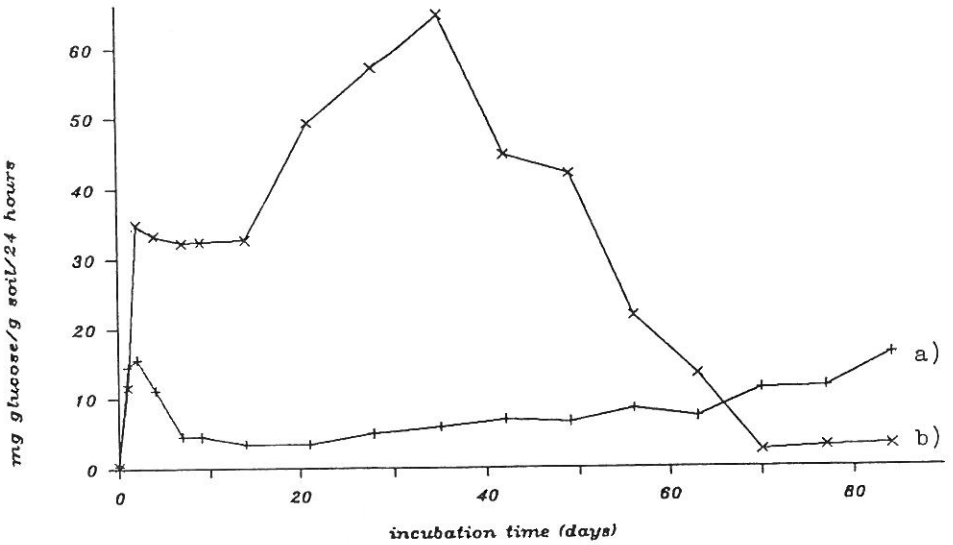

Fig. 2

Amylase activity of a sandy soil
Treatments: a/ starch; b/ starch + urea

During incubation a many-fold increase in amylase activity was noted as affected by starch C-source in all three soil types /Fig. 2/. This suggests a relatively quick decomposition of this substrate and/or the persistence of the enzyme.

The decomposition of starch was more intensive if urea /as a N-source/ was applied together with C-sources /Fig. 2/. This is in connection with the N-limitation of microbial growth in soil. The influence of the N-source is characteristic in the sandy soil and least specific in the brown forest soil.

An increment of amylase activity induced by cellulose and by wheat straw /C sources/ was observed in the sandy and chernozem soils while even the initial increase in the enzyme activity - as a result of the exogenous enzyme input of the wheat straw added to the brown forest soil - was eliminated after the first 24 hours of incubation /considering the destruction and/or decomposition of enzymes/. The enzyme activities of the chernozem soil are illustrated in Fig. 3.

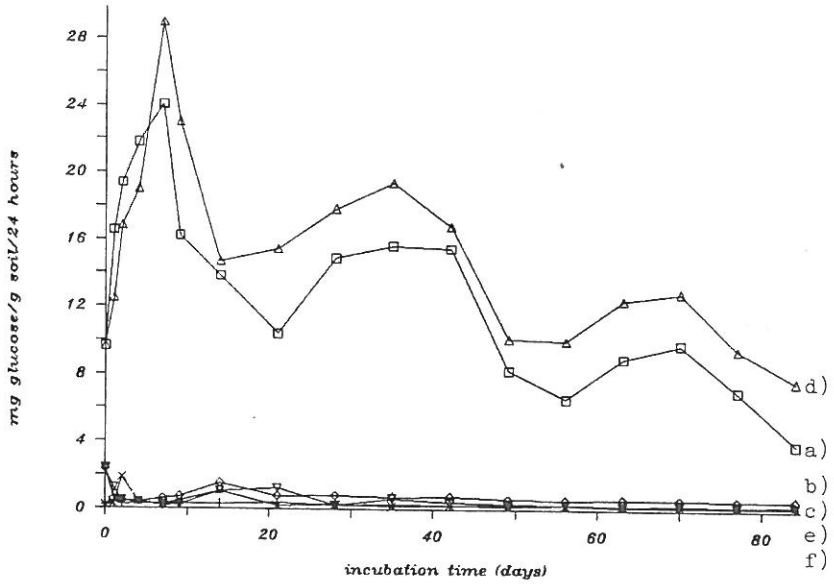

Fig. 3
Enzyme activities of the chernozem soil. In the cellulose treatment: a/ Saccharase; b/ amylase; c/ cellulase activity. In the cellulose + urea treatment: d/ saccharase; e/ amylase; f/ cellulase activity

The results of the studies on the dynamics of soil carbohydrases can be summarized as follows:

The cellulase and amylase activity - with the exception of the influence of starch treatment on cellulose activity - reached constant values after a week of incubation.

The saccharase activities of the sandy and the brown forest soil are well characterized by constant values. This cannot be stated for the saccharase activity of the chernozem soil.

The temporal sequences of the saccharase /and in some cases of the amylase/ activities are grouped into two or more parts, obviously in connection with the succession of microbial populations /Fig. 3/.

The most interesting finding on the stability of the newly synthetised enzymes was that almost the total surplus of amylase activity was eliminated during the incubation, in spite of the fact that this enzyme produced the greatest increases and persistence of the activity /Fig. 2/.

Some statements about the enzyme activities as biodiagnostic indices:

Cellulase activity seems to be unsuitable to detect and to indicate cellulolytic processes and their intensity. Amylase activity indicates the intensity of amylolysis due to its relatively high persistence in soil, and also reflects decomposition of cellulose and wheat straw. Soil saccharase activity seems to be a good biochemical index of several soil properties /organic matter content, quantity of organo-mineral complexes/ and microbial activity because of its accumulation and sensitivity to each treatment. This is due to the important role this enzyme plays in the extra- and intracellular microbial metabolism /Fig. 1B/.

On the basis of our experimental results, we can make some distinctions considering the three soil types with regard to the characteristics of organic matter decomposition.

Soil properties, as environmental factors, create the most temperate conditions for the soil microflora that are well-adapted to those in the brown forest soil. C-sources and urea had the least influence on the investigated variables in this soil sample. The decomposing processes are moderate and the microflora does not respond with extensive growth.

Influenced by nutrients, the microbial communities produced intensive proliferation in the sandy soil. The saccharase and amylase activities had a remarkable increase, which was followed by a relatively rapid decrease to a constant level. The microbial growth and metabolism are directly influenced by C- and N-supply and the adaptation of microflora to the environment proceeds rather by quantitative regulation than by the succession of microbial communities.

The investigated variables of the chernozem indicate that this soil type has transitional features between the sandy and brown forest soil. The temporal sequences of the enzyme activites can be characterized by more remarkable fluctuation and the changes of activities proceed for longer periods in the chernozem than in the sandy soil.

Reference

ANTAL, M. et al., 1990. Effect of C-sources and urea on the available N--content and urease activity of different soils. Agrokémia és Talajtan. 39. 399-403.