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FINAL REPORT

**Nitrogen Exchange Between Organic and
Inorganic Pools in Soil-Organic Residues
Systems**

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Title: Nitrogen Exchange Between Organic and Inorganic Pools in Soil-Organic Residues Systems.

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A. ABSTRACT

Two contrasting hypotheses were considered to describe the flow of soil N and C between organic, inorganic and microbial forms: (1) direct assimilation of low molecular weight organic N compounds (direct hypothesis); or (2) immobilization of NH_4^+ while organic N is completely mineralized (MIT hypothesis). Evidences for the occurrence of both processes were obtained. The approach used was to compare the observed dynamics of ^{15}N partitionment between inorganic and organic fractions to the ones computed with the simulation model NCSOIL structured to represent the hypotheses. The direct hypothesis was the major process for N assimilation by substrate specific microbes (zymogenous population), while the MIT operated at the level of the soil organic matter with the autochthonous microbial population. Simulation of N turnover under the MIT hypothesis called for a microbial efficiency factor ranging from .2 to .6. After 32 weeks of incubation, rates of $^{15}\text{N}\text{-NH}_4^+$ incorporation in the soil organic fraction were still high.

Parameters for the decomposition of cellulose and wheat straw (C/N ratio of 14.5) were obtained by optimization of the model NCSOIL against ^{15}N data documenting NH_4^+ immobilization concomitant to cellulose decomposition and ^{15}N mineralization from wheat residues. Optimal specific rate for cellulose decomposition was $.015 \text{ d}^{-1}$, and wheat had to be divided into 3 components (soluble fraction: 3.0 d^{-1} ; cellulose like, 62 per cent of the insoluble fraction: $.015 \text{ d}^{-1}$; and insoluble, resistant fraction: $2.2 \cdot 10^{-8} \text{ d}^{-1}$).

The competition between NH_4^+ and NO_3^- for N turnover under aerobic conditions was studied. A distinction was made between NO_3^- exogenously added, or formed by nitrification of added or mineralized NH_4^+ . Experimental data documenting changes in the partitionment of $^{15}\text{N}\text{-NO}_3^-$ between NH_4^+ , NO_3^- and organic N were obtained for soil incubations lasting for 28 days. Exogenously added NO_3^- was not immobilized, but NO_3^- formed by nitrification of mineralized NH_4^+ may be involved in N turnover. A conclusion will be reached after the data have been compared to those computed by a model which explicit the added transformations and scenarios linked with NO_3^- immobilization during the MIT process. The model, NCSOIL6, has been devised but analysis of the data remains to be performed.

Other studies were performed in the context of this research as support to the work on N and C transformations. It included (1) a study about the determination of soil microbial biomass nitrogen and ^{15}N with a high background of labeled mineral N; (2) the elaboration of an algorithm derived from the Marquardt approach to optimize multidimensional ecological models; (3) a modification of the model NCSOIL to distinguish between autochthonous and zymogenous microbial populations, and to include NO_3^- immobilization during the MIT process; and (4) a study on the contribution of clay fixed NH_4^+ to KCl extractable nitrogen using ^{15}N as tracer.

B. OBJECTIVES

The overall objective of the research was to improve the quantitative description of N exchange between inorganic and organic pools; to determine the forms and kinetics of N assimilated by the soil microbial population.

Specific objectives were:

1. To test whether the soil microbial biomass obtains its N from organic N (the direct hypothesis) or whether assimilation always uses soil inorganic N (the mineralization-immobilization turnover - MIT - hypothesis).
2. To compare, under net mineralization or net immobilization conditions, the extent of turnover of various forms of inorganic N:
(1) NH_4^+ added vs. NO_3^- formed from NH_4^+ in situ by nitrification.
3. To determine the fraction of decomposed soil organic N recycled into the microbial biomass (the efficiency factor) and its variation with changes in the biomass size during soil incubation.
4. To determine the N turnover during the decomposition of plant residues and composted organic wastes in relation to their composition, and the soil type.

C. RESEARCH REPORT

The research report consists in 9 separate contributions of which four are in the form of reprints, and five are presented as manuscripts.

D. DESCRIPTION OF COOPERATION

The respective contributions of Israeli and US laboratories to the project can be identified by looking at the senior authorship of each research report. In reality, each research report is the result of an intense cooperation facilitated by the excellent communication linkages provided by BITNET electronic mail and FAX.

Many of the reports called for a comparison of simulated to experimental data. This process was greatly facilitated by BITNET which gave us the opportunity to exchange in ASCII characters, Fortran source codes, input and output files in a form ready to be used.

The project supported a postdoctoral position at the University of Minnesota for Dr. Philip Barak from the Hebrew University of Jerusalem, Israel; and, hosted the scientific participation of Dr. Sabine Houot from the Institut de la Recherche Nationale (INRA), Paris France.

E. EVALUATION OF RESEARCH ACHIEVEMENTS

The aim of the research was to improve the quantitative description of N exchange between inorganic and organic soil pools. The approach was (1) to document N exchange between soil pools by the use of tracer ^{15}N added either as inorganic or organic forms; and (2) to compare experimental data to those computed by simulation models designed to quantify various concepts of N and C transformations. Results were of two kinds: (1) a confirmation of speculated N and C processes in soil; and (2) a quantification of these processes by the assignment of values or range of values to parameters of the model.

Concern about rising production costs, declining soil fertility and environmental deterioration have increased interest in alternative farming systems which reduce the level of chemical and energy inputs. Results presented in this report will assist in the management of residues, organic amendment, and N fertilization for productive agriculture and reduced nitrate pollution of ground water.

F. LIST OF PUBLICATIONS

Aviva Hadas, M. Sofer, Sala Feigenbaum, J.A.E. Molina, and C.E. Clapp. 1989. Analysis of soil microbial biomass nitrogen and ^{15}N with a high background of labeled mineral N. Commun. in Soil Sci. Plant Anal., 20(9&10):923-933.

Barak, P., J.A.E. Molina, Aviva Hadas, and C.E. Clapp. 1990. Mineralization of amino acids and evidence of direct assimilation of organic nitrogen. Soil Sci. Soc. Am. J., 54:769-774.

Barak, P., J.A.E. Molina, Aviva Hadas, and C.E. Clapp. 1990. Optimization of an ecological model with the Marquardt algorithm. Ecological Modelling, 51:251-263.

Molina, J.A.E., Aviva Hadas, and C.E. Clapp, 1990. Computer simulation of nitrogen turnover in soil and priming effect. Soil Biol. Biochem., 22:349-353.