Biotechnology of soil: monitoring, conservation and remediation

Fact Sheet

Project Information

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IC-COST

Overall budget
€ 0

EU contribution
€ 0

Coordinated by
N/A

Italy

Objective

A. BACKGROUND

A. 1. Current state-of-the-art of research in the field

Soil biotechnology, which can be defined as the study and manipulation of soil microorganisms and their metabolic processes to optimize crop productivity, is a branch of soil science of evergrowing importance in the last years. The interest of the scientific community on soil biotechnology has recently increased due to its enormous potentiality of improving availability of plant nutrients, physical properties, degradation of xenobiotic compounds, waste management, plant beneficial symbiosis and the control of soil-born plant pathogens. Biotechnology has been supposed to play a role in forest and range soils.
In the last decade soil biotechnology has been proposed for monitoring the environmental impact of pollutants of different origins.

Pollutants or environmental stresses that cause small or transient changes in the activity and composition of soil microflora should be distinguished from those that have more persistent and presumably more serious effects.

Soil biological parameters, such as total biomass, C and N mineralization, biological N2 fixation and those reflecting specific activities such as enzyme activities of soil, can be used as parameters of environmental impact.

Traditional methods for the identification of micro-organisms depending on isolating and culturing them, allow the study of a small portion of the total bacterial population. New application of molecular biology has considerable value to soil studies. More rapid techniques, such as nucleic acid amplification and hybridization, allow the monitoring and identification of micro-organisms in different environments on the base of specific DNA sequences. In fact, even uncultivable microbial species can be detected from a pool of heterogeneous DNA amplifying or hybridizing total soil DNA with specific oligonucleotides.

So far, problems linked to DNA extraction from soil were related to the possibility to obtain both Gram positive and Gram negative microbial DNA and to separate the DNA of living micro-organisms from the free DNA present in soil.

Recently, during the 7th International Symposium of Microbial Ecology held in Santos, Sao Paulo (Brazil) in 1995, it has been clearly demonstrated that nucleic acids extraction from soil can be currently used for the study of soil biodiversity.

A.2. Why the cooperation should be carried out within the context of COST

The need of a multi-disciplinary and collaborative approach to soil biotechnology and of coordination of the scientific knowledges for a better understanding of the complex phenomena investigated are the main reasons for carrying out the proposed project of research in the framework of a COST Action.

A main constraint in the development of this discipline in its practical applications is, indeed, the lack of connections among different laboratories. In order to set up, validate and standardize biochemical and molecular biology methods it is necessary to establish strong relationships between groups of research. The organization of workshops, training courses, exchange visits and the elaboration and diffusion of manuals, for scientific and divulgative purposes, to the national, European and international institutions are guaranteed only under the COST Action network.

This Action would effectively promote the necessary coordination and allow a more
efficient use of national and European funds.

B. OBJECTIVES AND BENEFITS OF THE ACTION

The main objectives of this Action are the following:

- to improve the effectiveness of microbial and molecular biology methods so as to have a better monitoring, conservation and remediation of soil;

- to use new microbial parameters as better indicators of the environmental impact;

- to use biotechnological approaches for restoring chemical, physical and biological properties of degraded soils.

Benefits coming from the implementation of this Action are the following:

(a) to give the possibility of elaborating routine assays for soil monitoring, conservation and remediation;

(b) to help early detection of any fertility decline of natural ecosystems by the setting up of efficient and rapid methods of soil pollution diagnosis and of biochemical techniques for the study of soil structure stability.

C. SCIENTIFIC CONTENT

The Action will cover four main areas.

C.1. The role of polysaccharides in the rhizosphere

The knowledge of the effects of plant exudates on soil microbial biomass has been the objective of many researches on the ecological meaning of microbial biomass measurements.

In particular the programme of research in Slovenia and in Italy is complementary since Slovenia will be studying the soil microbial community structure while in Italy the priority will be given to studies on microbial biomass and on soil-plant relation in the rhizosphere.

The study will be completed by the contribution of the group of research of the United Kingdom which will analyse the role of polysaccharides in ion transport in the rhizosphere.

This area of research is important because the molecules produced by microorganisms in the rhizosphere may influence directly and/or indirectly the growth of
C.2. Effects of algal inoculation on poorly structured clay soils

Crusting and degradation of soil structure in the superficial layer are common problems affecting erodibility of soils, seedling emergence and general productivity of the land. A rapid decline of chemical fertility, as a consequence of cultivation, due to mineralization and/or loss of soil organic matter and major nutrients, particularly nitrogen, is another common problem. In view of the considerable areal extent of such problems, it is urgent to develop new sustainable management practices in order to improve soil productivity using, as much as possible, renewable resources. From this point of view the cyanobacterial inoculants could play an important role in a sustainable agriculture. Some cyanobacterial strains from soil produce large amounts of extracellular polysaccharides. The superficial development of these micro-organisms has been proved to cause retention of silt and clay particles and to have a positive effect on soil structure.

Groups of research in Italy and in the United Kingdom have shown that the inoculation of Nostoc strains are able to improve soil structure in structurally degraded clay soils. Their efforts, in the framework of the COST Action, will be coordinated in order to apply these micro-organisms in the field to evaluate their effect on clay soil structure as well as on the availability of major nutrients, organic matter turnover and dynamics of microbial populations. Moreover, this working group will study and evaluate the best method to distribute cyanobacterial biomass in the field (fresh biomass, dry inoculants, soil-based inocula) in order to improve the soil establishment of inoculants for an eventually large-scale employment of these micro-organisms.

C.3. Biochemical methods for isolating DNA bound to soil clay minerals

Isolation, purification and molecular characterization of nucleic acids (DNA, RNA) from soil samples have become a useful tool to study the factors involved in the interaction of nucleic acids with various components of the environment, especially clay minerals, to determine the fates of selected micro-organisms or specific genes under natural conditions and to monitoring gene transfer between bacteria. The importance of soil DNA and genotype analyses in soil sciences is documented by the recent development of several specific protocols. However information in this important area of investigation is still fragmentary and a further improvement is necessary. The establishment of a scientific collaboration among the laboratories (in Italy and in Holland) involved in this field will serve to overcome gaps in our knowledge and as such provide future direction to stimulate research in this area of environmental soil sciences.

C.4. Microbial properties as biological indicators of environmental impact
The relationship between microbiological properties and soil fertility has been studied for many years and has given, so far, important indication on soil management in sustainable agriculture.

The research groups involved in this area of interest will study the possibility of using microbiological parameters as indicators of degradation and depletion of soil quality.

The Italian group of research has set up biochemical and microbiological methods for the study of soil biological fertility and is able to analyse soil biological parameters in natural and stressed conditions. Besides, the Croatian researchers will develop in parallel with the Italians other biochemical and microbiological parameters for the soil-water quality.

In Ireland the field of interest is the use of white-rot fungi and bacteria in the bioremediation of xenobiotic compounds in soil, particularly polycyclic aromatic hydrocarbons (PAHs). The same objective of soil bioremediation is faced from another point of view by Hungarian researchers who will be involved in the study of recalcitrant soil contaminants, e.g. sulfanilic acid and other sulfonated compounds as well as halogenated substances.

The work of all groups of research is finalized to the evaluation of the efficacy of biochemical and microbiological methods as routine assays for soil monitoring, conservation and remediation.

D. ORGANIZATION AND MANAGEMENT

The Action will be divided into four working groups covering the main fields of research described above in the Scientific Content:

WG1: the objective of this working group will be to harmonize methodologies in use in different laboratories for studying the role of polysaccharides in the rhizosphere;

WG2: effects of algal inoculation on poorly structured soils;

WG3: molecular biology applied to soil microbial communities;

WG4: microbial properties as biological indicators of environmental impact. The aim of this working group is the elaboration of routine assays for soil monitoring, conservation and remediation.

The organization and the coordination of the COST Action will be ensured by the Management Committee (MC).
The MC will be composed of one or two representatives of each Signatory; its inaugural meeting will be held within six months after the entry into force of the MoU. The first tasks of the Management Committee will be the election of its president, the designation of the coordinators of the working groups and the choice of the research topics of each working group.

Each working group, under the supervision of the Management Committee, will organize its own working schedule to fulfil the proposed objectives and an annual workshop to be held in different participating countries.

Within the framework of the COST Action, annual evaluation workshops will be held for the following purposes:

to analyse the results achieved by the researchers. Officials from the EU Commission will attend the session;

to promote the cooperation among laboratories of different countries participating in the Action;

to evaluate the possibility of practical applications for the researches carried out.

The Management Committee will meet once or twice a year, possibly in conjunction with the annual workshop.

E. TIMETABLE

The time required to implement the scientific projects will be five years. The progress evaluation of the Action will be done usually every year during annual meetings on specific subjects; just in case the research topic intrinsically needs more time for updating results, the interval between meetings will be longer.

The final meeting will be held for the final evaluation of the results achieved during the Action. Scientists from outside Europe will be invited for a critical analysis of the results obtained by the four working groups.

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F. ECONOMIC DIMENSION OF THE ACTION

The following COST countries have actively participated in the preparation of the Action or otherwise indicated their interest: Belgium, Croatia, Italy, Holland, Hungary, Ireland, Slovenia, United Kingdom.

On the basis of national estimates provided by the representatives of these countries and taking into account the coordination costs to be covered over the COST budget
of the European Commission, the overall cost of the activities to be carried out under the Action has been estimated, in 1996 prices, at roughly ECU 3.8 million/year.

This estimate is valid under the assumption that all the countries mentioned above but no other countries will participate in the Action. Any departure from this will change the total cost accordingly.

Scientific staff: 30 man-years x ECU 60 000 = ECU 1.8 million  
Technical staff: 15 man-years x ECU 40 000 = ECU 0.6 million  
Doctoral student staff: 8 man-years x ECU 25 000 = ECU 0.2 million

Total staff: 53 man-years ECU 2.6 million

Laboratory equipment and consumables ECU 0.8 million

Overhead costs ECU 0.4 million

Total estimated costs covered from national sources ECU 3.8 million/year.

Programme(s)

Topic(s)

Funding Scheme

Coordinator

N/A

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