Brussels, 30 October 1998

COST 298/98

DRAFT

Memorandum of Understanding

for the implementation of a European Concerted Research Action designated as COST Action 838

"Managing arbuscular mycorrhizal fungi for improving soil quality and plant health in agriculture"

The Signatories to this Memorandum of Understanding, declaring their common intention to participate in the concerted Action referred to above and described in the Technical Annex to the Memorandum, have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of the document COST 400/94 "Rules and Procedures for Implementing COST Actions", the contents of which are fully known to the Signatories.

2. The main objective of the Action is to gain pre-competitive theoretical and applied knowledge essential for the use of arbuscular mycorrhizal fungi in improving plant health and fitness, production of high quality food and in conservation of natural resources.

3. The overall cost of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at ECU 13,5 million at 1998 prices.

4. The Memorandum of Understanding will take effect on being signed by at least five Signatories.

5. The Memorandum of Understanding will remain in force for a period of six years, unless the duration of the Action is modified according to the provisions of Chapter 6 of the document referred to in Point 1 above.

COST ACTION 838

Managing arbuscular mycorrhizal fungi for improving soil quality and plant health in agriculture

A. BACKGROUND

1.1. State of knowledge

Societal expectations in relation to human health require the production of high quality food without environmental damage. Concerns about the undesirable side-effects of agrochemicals have highlighted the contribution made to plant health by soil microorganisms such as arbuscular mycorrhizal (AM) fungi. These mutualistically symbiotic fungi play a crucial role in plant nutrient acquisition and in plant protection from plant pathogens and environmental stress.

Most of the major plant families are able to form mycorrhiza, the AM association being the commonest mycorrhizal type involved in agricultural systems. AM biotechology is feasible for some crop production systems. Given the effects of AM inoculation on plant growth and health, as biofertilisers and bioprotectors, it is accepted that an appropriate management of this symbiosis would permit a satisfactory reduction of chemical fertiliser and pesticide inputs, key aspects for sustainable agricultural plant production. Maximum benefits will only be obtained from inoculation with efficient AM fungi and a careful selection of compatible host/fungus/soil combinations. The mechanisms involved in symbiosis development and function deserve further research for acquiring the scientific background necessary for manipulating this symbiosis in agriculture. AM inoculum production techniques need to be improved for the effective application of AM biotechnology in commercial agricultural plant production systems.

Two previous COST Actions have provided considerable insights into the biology and function of this plant-fungal interaction and have provided the vehicle for the establishment of a European Bank of AM fungal germplasm. This enabled European scientists to develop a "critical mass" and become leaders in the field of arbuscular mycorrhizal research through the development of a pan-European network of research laboratories. In line with the guidelines for the Fifth Framework it is now an opportune time to exploit this resource for improving employment through developing the use of inoculum in agriculture, and in harnessing AM benefits for preserving the environment and promoting the quality of life and health.

1.2. Need for a new COST Action

A new COST Action is required

- to extend the knowledge of the genetics, physiology and control of the AM symbiosis

- to understand the influence of AM symbiosis in plant/agroecosystem dynamics especially in improving both plant fitness and soil quality

- to transfer this knowledge into commercial practice and to make plant breeders aware of the AM potential

- to providing a European framework to develop regulatory guidelines for the use of AM inoculum.

1.3. Why COST is the most appropriate vehicle for this aim

Because of its complexity, mycorrhiza research requires a multi-disciplinary approach that can only be achieved by combining scientific expertise and resources from several Member States. This proposed COST Action will effectively promote such coordination resulting in more efficient use of both Community and national funds in order to develop a European approach in mycorrhizal technology. For this an essential element will be the training of young scientists and the exchange of information to such an extent that pan-European standarisation of AM inoculum production techniques and regulations can be achieved.

B. OBJECTIVES AND BENEFITS

The main objective of the Action is to gain pre-competitive theoretical and applied knowledge essential for the use of AM fungi in improving plant health and fitness, production of high quality food and in conservation of natural resources.

This will be reached by:

- understanding the role of AM fungi in sustainable crop production
- understanding and improving biological balance of microorganisms in the rhizosphere of AM plants: the mycorrhizosphere
- analysing the genetic, physiological, cellular and molecular basis of the functioning AM symbiosis
- establishing technologies for AM inoculum production
- developing regulatory guidelines for the application of AM technology.

The expected benefits will be an increase in the efficiency of crop production, reduction of agrochemical inputs, and an evaluation of the safety and bioethical aspects in relation to public acceptability. This will accelerate the development of technology in an area where Europe has become pre-eminent in terms of research. The exploitation of this research base is best accomplished through a dialogue between scientists and end-users and this will be facilitated by this proposed COST Action.

C. SCIENTIFIC PROGRAMME

The work programme is divided into four working groups representing four research areas that will attract significant interest in the future.

Working Group 1: population biology

Aboveground plant development is influenced by below ground microbial activity. AM fungi represent a major component of the microbial community in the soil, and act as both a reservoir of nutrients and as a conduit for exchange of materials between the plants and the surrounding soil. Thus the fungi are an important determinant in plant productivity. We now realise that considerable diversity exists both within and across the currently-recognised concept of AM fungal species. An understanding of the range of diversity is essential to establish predictive models of population dynamics and the effect of AM fungi on soil quality and plant responses.

- Functional diversity – Research in this Working Group will focus on the influence of the mycorrhizal symbiosis on plant-soil interactions, and the role of AM fungi in nutrient cycling, stress alleviation, increasing plant fitness and reproductive success. Because different species of AM fungi differ in the type of benefits they confer (i.e. improving aggregate formation, nutrient cycling, biological control ...) it is considered important to catalogue the AMF according to their functional activities.

- Fungal ecotyping – Ecotyping of fungal isolates from various European agrosystems will provide new knowledge on the genetic and physiological diversity within individual species complexes. This will supply the information necessary to exploit this biological resource more widely in both agroecosystems technology, and in the management and conservation of natural resources. The information will be integrated into the developing pan-European databases established in the previous COST Action.

Working Group 2: plant health

Arbuscular mycorrhizal fungi are known to influence plant nutrition and health. They can act as biocontrol agents, biofertilisers and phytostimulators. AM fungi interact with many other soil microbes in achieving these activities and this can influence mycorrhiza formation and function. AM fungi also affect rhisophere colonisation by other soil microbes, thereby developing the so-called mycorrhizosphere. This Working Group will address:

- Microbial dynamics – The better use of AM fungi needs a more mechanistic understanding of the biological balance between microorganisms in the soil, microbial diversity, dynamics and interactions. For this, research will be encouraged into the mechanisms involved in ecophysiological, cellular and molecular aspects of AMF-microbe interactions.

- Resistance mechanisms – Knowledge of the microbial interactions (e.g. between AM fungi, pathogenic fungi and PGPR) which underlay bioprotection will facilitate more sustainable crop management systems. The Group will develop research on the mechanisms involved in the protective role of AM symbiosis (e.g. changes in rhizosphere populations, elicitation of plant defence mechanisms, development of endophytic bacteria).

- Tolerance mechanisms – Emerging evidence indicates that AM plants show enhanced tolerance to pathogenic and environmental (e.g. drought) stresses. The Group will bring together those investigating ecophysiological mechanisms, e.g. phytohormone balance, in order to increase understanding of the influence of AM fungi on the developmental physiology of plants.

- Nutrient acquisition – AM fungi usually positively influence the acquisition of nutrients by plants. This is vital in nutrient-limited situations. The Group will study processes of nutrient acquisition linked to interactions of AM fungi with rhizobia (e.g. using ^{15}N methods) and phosphate-solubilising bacteria (e.g. using ^{32}P dilution techniques). The role of hyphal networks in nutrient capture, improvement of soil structure and modifications in root functioning will be investigated.

- Transgenic rhizosphere – Transformation technology has led to the production of genetically modified crops. There is therefore a need to understand how current and future transgenic crops can be used to optimise key rhizosphere processes.

Working Group 3: genetic and cell programmes

Arbuscular mycorrhizal fungi can alter patterns of gene expression, cellular programming and organ development of host plants, but advances in knowledge about these have been mainly hampered due to a lack of appropriate molecular methods and to AM fungi being obligate biotrophs. The conceptual framework for research in this domain is now mature and modern molecular techniques are now adapted for more precise analyses of this unique biological system. This Working Group will bring together expertise from European laboratories to address major unsolved questions concerning the genetic, molecular and cellular basis of symbiotic interactions.

- Symbiosis genes – Identification and characterisation of plant and fungal genes required for the symbiosis. Use of legume species as model systems will be encouraged in the European network since mutants and gene expression analyses have provided evidence of similarities between nodulation and AM symbiosis formation.

- Genetic archives of the fungi – Provision of molecular and genetic information about AM fungi. Very little is known about the organisation and functioning of the glomalean genome. Increasing inputs will be acquired through establishment of nucleic acid libraries, proteomes and isozyme profiles, and identification of genes encoding metabolic functions.

- Symbiosis-related cell programmes – Impact of the fungal genome on the host cell programme. Reorganisation of the host protoplast and acquisition of new cell functions lead to the creation of a symbiotic interface. Developing research into membrane proliferation, chromatin structure, cytoskeleton organisation and cell signals will give more mechanistic insight into cell compartments involved in symbiotic processes.

- Morphofunctional integration – Deciphering the reciprocal influence of plant and fungal genomes on partner morphogenesis. The AM fungus modifies root system architecture and the plant genotype can control fungal differentiation. Mycorrhizal plant mutants and genetically different fungal isolates will provide tools for a more accessible analysis of the integrated AM complex.

Working Group 4: mycorrhizal technology

The use of arbuscular mycorrhizal fungi in plant biotechnology differs from that of other beneficial soil microorganisms because the fungi involved are obligate symbionts and therefore recalcitrant to pure culture. Thus specific procedures are required to culture and handle them; specific tools have to be developed and provided to European biotechnological producers.

- Inoculum technology – Plant inoculation with AM fungi results in the formation of a mycorrhizosphere with selective consequences on other important soil microorganisms. Therefore the use of AM fungi in plant production needs an appropriate inoculum technology compatible with those used for other beneficial soil microorganisms. Development of second generation inocula, derived from mixing AM fungi with other inocula, will be the main activity. The use of such inocula will improve plant fitness, and soil aggregation and stability so increasing yield by biological means. A further application would be in bioremediation processes to restore soil fertility.

- Inoculum registration – Ecological, biosafety and bioethic concerns have created the requirement for microbial inoculants to be approved and registered. This Working Group will provide the guidelines for AM fungi-specific European standards of inoculum use.

- Quality control – Specific protocols for quality control of AM fungal inoculum will be developed and standardised for application all over Europe. This is essential not only as a guarantee for European producers and users but also for the protection of ecosystems.

- Technology transfer – The product concept for AM fungal inoculum is particularly suitable for SME. Scaling up of production and use of AM fungal inoculum is only economically feasible for SME if structures to run concerted field experiments all over Europe are available. This will be offered by Working Group 4 through case studies in the areas of horticulture, fruit production and revegetation of deserted ecosystems.

D. ORGANISATION AND TIMETABLE

1. Organisation

The Action will be divided into the following four new working groups:

I. Population biology

II. Plant health

III. Genetic and cell programmes

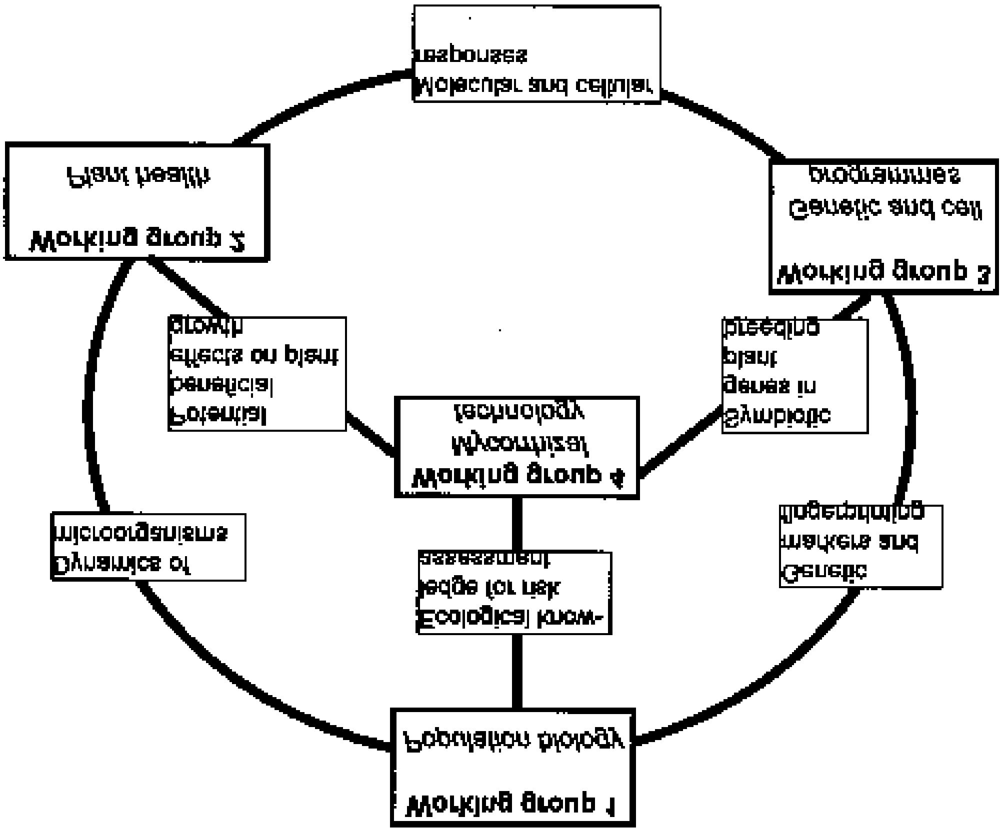
IV. Mycorrhizal technology

Coordinators of these working groups will be designated by the Management Committee.

The work of these working groups will include one annual workshop and smaller coordinating meetings. Several laboratories will be involved in more than one working group as the subjects of the working groups are broad and encompass a range of interrelated disciplines.

Interactions between the working groups are important, as several subjects should be studies using a variety of approaches (see Diagram 1). This will be done through inter-workgroup meetings.

Diagram 1: Interactions between the four working groups



Annual evaluation meetings (see Timetable) will be held:

⇒ to review the results achieved and will include non-European experts and members of the Technical Committee for Agriculture and Biotechnology

⇒ to finalise publications

⇒ to critically evaluate progress achieved in practical applications.

The Management Committee will meet at least once a year, if possible in conjunction with the annual meeting.

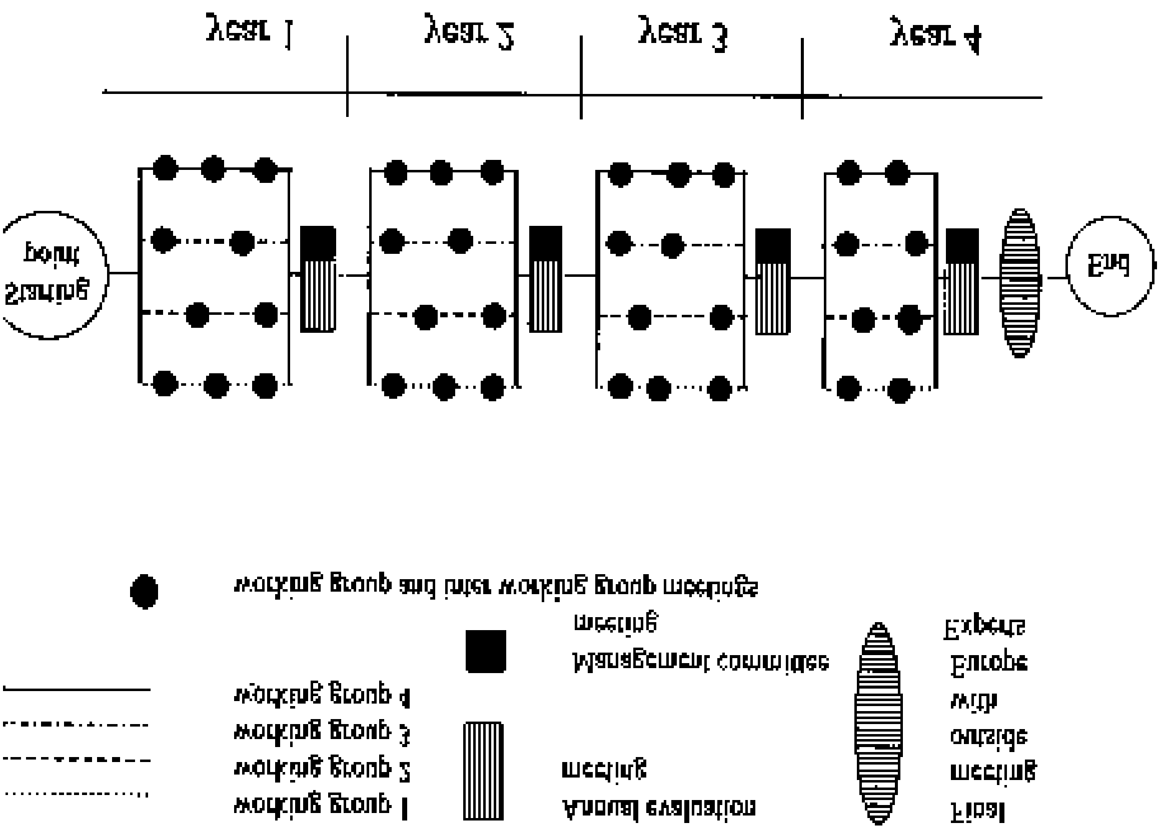
Based on the previous experience of COST 8.21, cooperation with other COST Actions (8.22, 8.23, 8.30, 8.31) will be established. Such cooperation will be promoted in coordination with the Technical Committee for Agriculture and Biotechnology.

2. Timetable

The time required to pursue the scientific projects will be four years. The evaluation of the progress of the Action will be carried out at annual meetings on specific subjects as indicated on the diagram.

A final meeting will be held for evaluating the achievement of this COST Action. International experts from outside Europe will be asked to participate and provide a critical analysis on the achievements.

<u>Diagram</u>



E. ECONOMIC DIMENSION

European Community	90 man-years scientific staff
(Except NL and L, but including CH and N)	90 man-years scientific staff
Central and Eastern Europe	20 man-years scientific staff
(Poland, Hungary, Slovenia, Czech Republic)	20 man-years scientific staff
TOTAL	220 man-years scientific staff

70 man-years x ECU 60 000	ECU 4,2 million
70 man-years x ECU 40 000	ECU 2,8 million
80 man-years x ECU 20 000	ECU 1,6 million
TOTAL PERSONNEL COSTS	ECU 8,6 million
Laboratory equipment and consumable	ECU 3,3 million
Overhead costs	ECU 1,6 million
TOTAL COSTS (*)	ECU 13,5 million

(*) assessment for 1997 on the basis of national estimates provided by the representative of countries listed above.

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