European Cooperation in the field of Scientific and Technical Research - COST -

Secretariat

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COST 263/06

MEMORANDUM OF UNDERSTANDING

Subject : Memorandum of Understanding (MoU) for the implementation of a European Concerted Research Action designated as COST Action 870 From production to application of arbuscular mycorrhizal fungi in agricultural systems: a multidisciplinary approach

Delegations will find attached the Memorandum of Understanding for COST Action 870 as approved by the COST Committee of Senior Officials (CSO) at its 165th meeting on 27/28 June 2006.

MEMORANDUM OF UNDERSTANDING
FOR THE IMPLEMENTATION OF A EUROPEAN CONCERTED RESEARCH ACTION
DESIGNATED AS

COST ACTION 870

From production to application of arbuscular mycorrhizal fungi in agricultural systems: a multidisciplinary approach

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 document COST 400/01 'Rules and Procedures for Implementing COST Actions', or in any new document amending or replacing it, the contents of which the Signatories are fully aware of.

2. The main objective of the Action is to take a multidisciplinary approach to increase the knowledge needed for implementation of arbuscular mycorrhizal fungi in agricultural systems, in order to reduce agricultural inputs and reduce losses to the environment.

3. The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at approximately EUR 60 million in 2005 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 four years, calculated from the date of the first meeting of the Management Committee, unless the duration of the Action is modified according to the provisions of Chapter 6 of the document referred to in Point 1 above.

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COST ACTION 870

From production to application of arbuscular mycorrhizal fungi in agricultural systems: a multidisciplinary approach

A. ABSTRACT

Arbuscular mycorrhizal (AM) fungi are beneficial soil organisms which form a mutually beneficial symbiosis with most plants, enhancing the acquisition of nutrients and water from soil by the host plant. The main objective of this COST Action is to take a multidisciplinary approach to increase the knowledge needed for the practical implementation of AM fungi in agricultural systems, in order to reduce agricultural inputs, and reduce losses to the environment.

First, the COST Action focuses on the combination of different scientific fields ranging from plant breeding, (low input) arable farming and applied mycorrhizal research. The synergism gained by combining the scientific areas of plant breeding and mycorrhizal research will be unique and will lead to new research breakthroughs.

Second, the COST Action is strongly focused on an integrated approach to scientific research and its implementation. A novel approach will be taken by bringing together representatives of parties from all links in the chain of production to application of AM fungi.

Third, this COST Action will bring scientists, SMEs and quality-mark organisations together for the development of an independent quality control system for the production of AM fungal inoculum. A strong focus will be on the use and development of (novel) molecular techniques for tracing and tracking of AM fungi.

Keyphrases: combination of diverse scientific fields: plant breeding, (low input) arable farming and applied mycorrhizal research; integration of science and implementation; development of quality control for production of AM fungal inoculum.

B. BACKGROUND

Currently, the majority of crops are grown in agricultural systems with significant input of chemicals, including chemical fertilisers and pesticides. This results in environmentally damaging losses to the environment, and growing crops in more sustainable low-input systems with reduced chemical inputs is gaining ground. Sustainable cropping systems can lead to the production of healthier food which benefits the consumers and reduces health risks.

Plant strategies for sustainable systems, such as low-input organic agricultural systems, have been outlined by Lammerts-Van Bueren (2002). The main requirements for crops to achieve high and profitable yields in such sustainable systems are to scavenge for nutrients and to cope with unpredictable and varying levels of soil nutrients. The application of beneficial microorganisms can enhance the growth of crops and increase their yields. Arbuscular mycorrhizal (AM) fungi are a key group of beneficial microorganisms that play a vital role in the acquisition of mineral nutrients from soils and facilitating plant development, particularly in agricultural systems with low inputs of chemical fertilisers and fungicides. Also, AM fungi can suppress the development of below- and above-ground plant pathogens, resulting in better crop performance.

In the last few decades, many scientists in Europe have been working to increase the knowledge about the role of AM fungi in agricultural systems because harnessing the beneficial functions of these organisms in agricultural systems shows enormous potential to reduce inputs and contribute to increased sustainability.

As a consequence, the interest in production of AM fungi for application in agriculture has grown over the last decade. Several SMEs in Europe have started commercial production of these fungi for application in agricultural systems. This has resulted in availability of AM fungal inoculum on a large scale. However, AM fungal inoculum is mostly available in low diversity mixes comprising a small number of species. This results in general-use purposes with relatively low specificity. Since AM fungi show niche differentiation and functional diversity, it will be economically advantageous to develop inoculum of AM fungi tailored to meet the needs of specific crops, soils and management regimes.

Another possibility is to breed plants for more optimal colonisation by AM fungi. Considering the functions attributed to AM fungi, cultivars with high responsiveness to AM fungi, which result in enhanced colonisation of roots, are desirable. De Melo (2003) investigated the possibilities of breeding onion (*Allium cepa*) cultivars for enhanced development of the AM symbiosis within root systems. In particular, De Melo (2003) used molecular techniques to describe the genetic variation controlling AM colonisation of roots in various onion cultivars, and laid a basis for further breeding of onion cultivars to enhance colonisation by AM fungi to improve yield. More research on plant breeding is needed to increase the responsiveness of crop cultivars to AM fungi.

Another issue that has to be addressed is how to produce AM fungal inoculum with an independent standard quality control. Appliers, such as (potting) soil companies and farmers are highly interested in producing and receiving a high quality product. However, methodologies and techniques need to be developed for the tracing and tracking of AM fungi in inocula. Molecular techniques such as quantitative PCR and multiplex DNA techniques may be useful for monitoring the composition and quality of AM fungal inoculum.

C. OBJECTIVES AND BENEFITS

The main objective of the Actions is to take a multidisciplinary approach to increase the knowledge needed for implementation of arbuscular mycorrhizal fungi in agricultural systems, in order to reduce agricultural inputs and reduce losses to the environment.

In previous COST Actions (821, 838), considerable amounts of knowledge and insights on AM fungi have been developed. This COST Action focuses on the use of this obtained knowledge in practical systems.

The COST Action is novel in that it takes a multidisciplinary approach by bringing together diverse scientific areas ranging from applied mycorrhizal research, plant breeding and (low input) arable farming. The synergism that will occur by combining the scientific areas of plant breeding and mycorrhizal research is of particular importance. Plant breeding programmes have resulted in crops that have higher levels of resistance to pathogens, but they seem to show a reduced responsiveness and colonisation of AM fungi. More research on plant breeding is desirable to detect the plant genes involved in mycorrhization with the objective of developing crops with enhanced responsiveness and colonisation of AM fungi, leading to enhanced use of mycorrhizal resources in agriculture, and thereby increasing the sustainability of agriculture.

The secondary objectives of the COST Action are the following:

- To increase application of AM fungi in agricultural systems ranging from low- to high-input systems.
- To identify plant genes which control the responsiveness of crop plants to AM fungi. The aim will be to focus on crops that are of economic value in the participating countries.
- To facilitate the development of AM fungal inoculum with specificity for specific crops under different soil conditions and fertilisation regimes.
- To develop an independent quality control system for AM fungal inoculum.

Benefits

The main outcomes of the COST Action will be integration of different scientific disciplines to deliver increased implementation and application of AM fungi. The present network will contribute to strengthening the utilisation of AM fungi in practical growing systems. Exchange of information, young researchers and material as well as sharing research facilities through short-term scientific missions (STSMs) will contribute to a significant improvement of knowledge and to a much more efficient use of national research funds. Young scientists will be trained in the novel research lines generated by the COST Action. This will thus lead to highly synergistic effects through multidisciplinarity, enhanced complementarities, mutual specialisation and better coordination.

Demonstration sites should provide the participating countries, SMEs and advisers with data for future recommendations for the application of AM fungi in practical systems.

The COST Action will also contribute to the success of SMEs producing and supplying inoculum of AM fungi and to users of AM fungi (e.g. farmers, potting soil companies) and advisers in arable farming involved in the application of AM fungi. In addition, the COST Action will enable improvement in scientific and technological cooperation throughout Europe including the new EU member states. It represents a real transnational and multidisciplinary collaboration, for which the SMEs in each individual country cannot provide the necessary finance, personnel and competence.

For the scientific community, the COST Action will result in increased knowledge on plant genes involved in symbiosis with AM fungal inoculum. This provides great opportunities for plant breeding programmes to develop crops that currently associate poorly with AM fungi. Such breeding programmes are novel and may be of great economic value for the European agri-business.

The COST Action is of great value for scientists in different scientific areas as it allows applied mycorrhizal research, plant breeding and (low input) arable farming to be brought together. Scientists in these various research fields and working in different European countries will be brought together enhancing cooperation and scientific development. In addition, this COST Action enables scientists from countries with less-well-developed scientific infrastructures to connect with scientists from countries with highly developed science. Young researchers will be trained in the combined fields of applied mycorrhizal research, plant breeding and (low input) arable farming.
In addition, the participation of advisers and SMEs, including inoculum producers and potting soil companies, in the COST Action, will be valuable in ensuring technology transfer. The issues, raised by the participating SMEs and advisers can be incorporated in the scientific programmes and projects, facilitating practical use of AM fungi.

For society, the Action contributes to the further development of sustainable agriculture. Conventional agricultural systems often use unsustainably high inputs of (chemical) fertilisers that result in high losses of nutrients to the environment. Considerable amounts of applied nutrients do not end up in the products. Low-input sustainable agricultural systems, including organic farming, which have reduced fertiliser inputs, show reduced productivity. The work will contribute to the use of beneficial microorganisms including AM fungi as substitutes for chemical inputs. Lower chemical fertiliser application rates will be possible by harnessing AM fungi to increase the availability of nutrients to plants, thereby maintaining crop yields and reducing nutrient losses to the environment. Also, AM fungi can suppress development of below- and above-ground pathogens enabling reduced input of chemical pesticides. The final results of the application of AM fungi in sustainable agricultural systems will be the production of healthier food.

D. SCIENTIFIC PROGRAMME

The scientific programme has been developed with input from scientists of different COST countries, to achieve the objectives set out in the Action. The activities will be divided into four Working Groups (WG), that will have links and interactions between them as follows:

- WG1: Plant breeding and colonisation of AM fungi
- WG2: Quality control of AM fungal inoculum
- WG3: Application of AM fungi in agricultural systems ranging from low- to high-input systems in Europe north of the Mediterranean regions
- WG4: Application of AM fungal inoculum specific for Mediterranean conditions

The COST Action will integrate different aspects:

- To optimise the responsiveness of plants to mycorrhizal fungi by studying the plant genetics involved in the mycorrhization process and by optimising the association of specific cultivars of crops with specific mycorrhizal fungi (WG1).
- To improve the application of mycorrhizal fungi by increasing knowledge about the development of AM fungi under different environmental and soil conditions (WG3 and WG4).
- The development of an independent quality control system for inoculum of AM fungi (WG2).

For this integration process by the four WGs, representatives of different parties in the chain from production to application of AM fungi will be involved, among which will be SMEs involved in plant breeding, AM inoculum production and supply of AM fungi, users of AM fungi (e.g. farmers, potting soil companies), and advisers in arable farming. Moreover, quality-mark organisations will participate in the Action enabling the development of a quality control system.

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WG1 Plant breeding and colonisation of AM fungi

This Working Group will enhance knowledge to breed plants for more optimal root colonisation of AM fungi by detecting plant genes involved in the responsiveness to AM fungi.

Sustainable agricultural systems are of high interest to the participating countries in order to promote the foundation of environmentally friendly production and a distribution chain of safer, healthier and more varied foods for the European consumer. This can be achieved by reducing inputs of fertilisers and the replacement of fertilisers and chemical pesticides by biological alternatives.

The recognition of a need to foster sustainable agriculture systems with reduced inputs of chemical fertilisers and pesticides is not new and has been made more imperative because of the recognition that highly specialised, capital-intensive and chemical-intensive agricultural methods that boosted production outputs to higher and higher levels, have a myriad of adverse effects on natural resources, environmental quality, human health,, food quality and safety. Therefore**,** increasing numbers of producers (i.e. farmers) in Europe have tended to move towards sustainable low-input agricultural practices, pushed by the cost-price squeeze of food production and the increased dependence on off-farm chemical inputs.

For a plant cultivar oriented to sustainable agriculture approach, Lammerts-Van Bueren (2002) noted that the main requirements are adaptation to soil fertility properties and reduced input of fertilisation. Recently, scientists from all over the world have started to understand that microbial biodiversity is a crucial factor regulating soil processes in sustainable agricultural systems (including low-input systems), and specifically in that portion of soil influenced by roots, .i.e. the rhizosphere. Within the rhizosphere, beneficial microorganisms are key active components of the overall biodiversity, assisting plant growth through their involvement in the processes of nutrient cycling and acquisition, antagonism of detrimental organisms, and enhancement of soil structure. An important group of these beneficial microorganisms include AM fungi. Numerous data report the beneficial impact of AM fungi on plant growth and disease resistance under controlled conditions.

AM fungi contribute strongly to nutrient uptake in systems with low input of fertilisers and are essential for sustainable agricultural systems. However, poor responses of AM fungi to various cultivars of crops have been reported. Breeding programmes for agricultural plants have produced varieties or cultivars with a range of genetic differences. For instance, breeding of crops for resistance to fungal and bacterial pathogens have resulted in suppression of AM fungal colonisation and responsiveness. As a consequence, incompatible reactions between host plants and certain AM fungi may occur. Hetrick et al. (1993) noted that breeding of wheat cultivars may have resulted in a high dependency on fertilisers and non-responsiveness to AM fungal colonisation. Also, genotypes of other crops show a high level of variation in AM fungal colonisation and specific host-AM fungal relationships have been reported. One of these crops is onion and De Melo (2003) described to the possibility of breeding onion cultivars for enhanced development of the AM symbiosis within root systems. However, further studies are needed to unravel the genetic traits in the diverse crops that are of economic value for Europe, in order to optimise mycorrhization and result in higher yields and reduced development of plant pathogens in low input systems.

The objective of WG1 is to detect the genetic traits in plants involved in the mycorrhization process for the development of breeding programmes for modern cultivars with high mycorrhizal responsiveness. Therefore, populations of various crops that segregate for mycorrhizal responsiveness will be built up and molecular markers will be obtained for mycorrhizal responsiveness in these crops. This project will focus on crops that are of economic value in the participating countries.

A detailed study of the following aspects is proposed resulting in the following important milestones:

- Production of segregating populations of crops in order to obtain molecular markers for mycorrhizal responsiveness.
- F1 seed from pair-wise crosses between genotypes of various crops with a high and with a low mycorrhizal responsiveness.
- Bioinformatics to identify homologues of the various crops and design microoarray.
- Molecular linkage map for crosses between different cultivars of crops.
- Growth of various crops and establishment of plant-mycorrhizal symbioses; performance of microoarray experiments.
- Molecular linkage map for a cross between two plant genotypes differing in mycorrhizal responsiveness and detection of QTLs for mycorrhizal responsiveness.
- PCR, cloning and sequencing selecting differentially expressed genes.
- Full data analysis of differentially expressed genes.

Among the expected deliverables will be the identification of individual genetic traits for symbiotic associations with AM fungi in modern cultivars of various crops and their wild relatives, which will help to better understand the mycorrhization process. This will lay a basis for breeding programmes to develop modern cultivars with high responsiveness to AM fungi resulting in enhanced colonisation of roots. Moreover, another deliverable is the determination of molecular markers for mycorrhizal responsiveness and the identification of plant genes involved in mycorrhizal responsiveness.

The knowledge gained will provide a more integrated picture of how AM fungi associate with specific cultivars of crops in agricultural systems. An essential part is setting steps within this WG to unravel the plant genetics determining the mycorrhization process. These steps can be made quicker by the enhanced cooperation of research groups in plant breeding, applied mycorrhizal research and arable farming. Furthermore, insights will be enhanced about specific AM fungi that associate well with specific crops.

WG2. Quality control of AM fungal inoculum

This Working Group will focus on the development of a quality control system for inocula of AM fungi.

In the last decade, the number of new SMEs around the world producing inocula of mycorrhizal fungi has increased. This means that these producers see market opportunities for application of mycorrhizal fungi. Von Alten et al. (2002) have written that scientists investigating mycorrhizal fungi find that the promises made by the producers about the mycorrhizal products and the results seen by the end-users are worlds apart.

There are still great problems in bringing high quality and fit-for-purpose AM fungus products to target markets. Because AM fungi are obligate symbionts, the production of AM fungal inocula of the best quality is still challenging.

Companies have taken different approaches to their markets, ranging from products with single AM fungi for specific markets, to mixed products for general markets. However, there is an urgent need for better control over the production and storage of AM fungal products before selling them. Therefore, there is an increasing desire for a quality control system for AM fungal inocula. This system will need to determine the quantity and quality of the mycorrhizal fungi present in the products. Currently, the quantity of AM fungi in inocula is determined by the number of infection units using a MPN-estimation, the standardised most probable number estimation. However, the MPN-estimation is considered to provide a less constant and stable measure than that desired. Moreover, Dodd et al. (2000) have reported that the MPN methodology underestimates the inoculum potential of spores. Also, detection of contamination by plant pathogens is needed to ensure the quality of the AM fungal inoculum.

During the last decade, molecular techniques have been developed which enable the description of specific AM fungi in soils. These molecular techniques allow qualitative and quantitative description of mycorrhizal fungi in soil and roots, including fungi that have been applied as inoculum. This was a big step forward and enabled the Applied Plant Research Organisation to describe the below-ground communities of AM fungi colonising onions in different cropping systems in the Netherlands. Such molecular tracing techniques are of crucial importance to determine the quality of mycorrhizal products. Also, the efficacy of the applied mycorrhizal fungi to colonise the plant roots can be determined by molecular tracing techniques. These techniques enable tracing of mycorrhizal fungi that have been applied. However, quantitative molecular tools have been developed only for a limited number of AM fungi. Further development of molecular techniques for quantification of individual strains of AM fungi is desired for tracing the effectiveness of AM fungal inocula. This may include the development of multiplex DNA techniques for tracing soil organisms. Also, contamination of inoculum by plant pathogens can be monitored using related molecular techniques.

The objective of WG2 is to develop an independent quality control system for the application of AM fungi. Novel molecular techniques will be developed as part of this quality control system.

Therefore, a detailed study of the following aspects is proposed:

- Sequence analysis of specific regions of (ribosomal) DNA of AM fungal isolates used in mycorrhizal products.
- Identification of specific primers for monitoring and quantification of AM fungi resulting in the development of qRT-PCR.
- Optimisation of DNA isolation from propagules in mycorrhizal products and from roots of field grown plants.
- Sequence analysis of regions of ribosomal DNA of major plant pathogens to allow detection in mycorrhizal products.
- Identification of specific primers for monitoring of plant pathogens in AM inocula.
- Testing of the efficacy of the AM fungal products in the field by determining the colonisation dynamics of individual AM fungal isolates by qRT-PCR.
- Development of multiplex techniques to monitor both AM fungi and plant pathogens.

Among the expected deliverables, novel methodologies will be developed for tracing and tracking of AM fungi. A strong focus will be on the development of novel molecular techniques to quantitatively trace specific AM fungi, and to study the efficacy of AM fungal inocula on different crops. This will lead to the development of an independent quality control system for AM fungi.

The knowledge gained will lead to an integration of knowledge to improve the production and performance of AM fungus inocula and to thereby promoting quality. An essential part is the further development of novel molecular techniques for tracing and tracking of mycorrhizal fungi during the production, storage and application stages.

WG3 Application of AM fungi in agricultural systems ranging from low- to high-input systems in Europe north of the Mediterranean regions

This Working Group will increase knowledge about the effects of different soil conditions on the development of AM fungi resulting in the development of more AM fungal products for specific soil conditions in Europe north of the Mediterranean regions.

Effects of AM fungi in agricultural and horticultural systems are almost exclusively beneficial. Evidence is increasing that AM fungi can enhance the development and yield of crops in the field. Important determining factors for the application of AM fungi are plant characteristics (see also WG1) and soil variables.

The vast majority of soils in the world contain AM fungi, but the diversity and abundance can vary. When undisturbed soil is brought into cultivation, the community of AM fungi usually changes. Two key factors drive such modification: change in the plant community from natural vegetation to a monocultural cropping system, and soil chemistry changing from a nutrient-poor system to a nutrient-enriched system. Some studies show that soil mineral content and structure can affect AM fungal communities. For instance, the study by Johnson et al. (1992) showed that the occurrence of six AM fungal species was influenced by soil type. However, systematic studies of the effects of abiotic soil variables on the development of AM fungi are lacking. The studies carried out thus far show that the development of AM fungi and their effects on plant growth are greater in soils with low nutrient content, in particular with low phosphorus. It is well known that fertilisation with phosphorus reduces development and root colonisation of AM fungi, but the magnitude of the effect is strongly affected by the fungi studied, the host plant and other environmental conditions. Also, the effects of differing pH under field conditions have received little attention thus far. Additionally, the effects of other soil components including nitrogen, potassium and magnesium on the performance of AM fungi, have received little attention.

The objective of WG3 is to increase knowledge about the effects of different soil conditions on the development of AM fungi. This will result in the development of a greater number of AM fungal products for specific soil conditions. Therefore, systematic studies to determine the effects of soil variables on the development of AM fungi will be set-up in Europe north of the Mediterranean regions.

Therefore, a detailed study of the following aspects is proposed:

- Different soil types in Europe north of the Mediterranean area will be selected.
- A selection of AM fungi will be added to a selection of host plants under greenhouse conditions.
- Development of AM fungi will be determined using the molecular techniques (see also WG2), and will be related to the chemical composition of the soil.
- A selection of AM fungi will be added to selected crops in field trials.
- In the field trials fertiliser amounts will vary from zero to conventional rates.
- This large-scale application of AM fungi will be carried out with adapted machines.
- Root samples will be taken and the development of individual AM fungi will be determined with the novel molecular quantitative PCR methodology (see also WG2),
- Fertiliser inputs will be measured and the chemical compositions of the soil will be determined.
- Growth and yield of crops, including onions, and development of AM fungi will be related to the chemical composition of the soil, particularly nitrogen and phosphorus as they are the main components of fertilisers.

Among the expected deliverables, systematic studies of the effects of soil variables on the development of AM fungi will result in optimisation of AM fungal products available on the market for use in European countries north of the Mediterranean regions. This will result in more optimal performance of the AM fungi in the commercial products. As a consequence, it is expected that this will lead to an enhanced application of AM fungi in agricultural systems with crops that are of economic value for Europe.

The knowledge gained will lead to production of AM fungal inocula for specific soil conditions. An essential part is the increase of knowledge on the effects of the soil variables on different AM fungi in a systematic way.

WG4. Application of AM fungal inoculum specific for Mediterranean conditions

This Working Group will increase knowledge about the effects of different soil conditions on the development of AM fungi in the Mediterranean regions resulting in the further development and application of AM fungal products.

In Mediterranean regions, characteristic climatic conditions include long, dry, hot summers, with scarce and erratic rainfall, while in winters torrential rainfall may occur. A considerable amount of land in the Mediterranean regions is arid or semi-arid and Barrow (1991) estimated that 50% of Spain consists of such drylands. In these regions, plants are exposed to considerable environmental stresses, including shortage of water resources for prolonged periods of the year. In fact, the factor most limiting to plant growth is water availability in semi-arid and arid environments. As a result of water limitation, plants' access to phosphorous is difficult, and therefore, can also be limited. It is well known that AM fungi can ameliorate the effects of water stress in (semi)-arid ecosystems and enhance the uptake of phosphorous. Furthermore, AM fungal inoculum can have stimulating effects on the development of crops in semi-arid regions. For instance, in a study in Israel, it was shown that inoculation of chive with an AM fungus inoculum based on *Glomus intraradices* resulted in increased production of crops classed as export grade quality. The efficacy of AM fungal inoculum can differ between crop species. For instance, in a study to investigate the effects of different AM fungi on citrus cultivation in Turkey, differences in plant growth and percentage of mycorrhizal infection occurred with different AM fungal species. On the other hand, AM fungal isolates that are effective in a given situation in the absence of water stress may not be effective under conditions of drought stress, which often occurs in the Mediterranean area.

However, the interactions between AM efficiency and other soil variables in the Mediterranean regions have been under-evaluated and systematic studies to investigate the effects of abiotic soil components on the development of AM fungi have not been carried out.

The objective of WG4 is to increase knowledge about the effects of different soil conditions on the development of AM fungi. This will result in the development of more effective AM fungus products for specific soil conditions in the Mediterranean regions.

Therefore, a detailed study of the following aspects is proposed:

- Different soil types in the Mediterranean regions will be selected.
- A selection of AM fungi will be added to a selection of host plants under greenhouse conditions.
- Development of AM fungi as determined with molecular techniques (see also WG2), will be related to the chemical composition of the soil.
- A selection of AM fungi will be added to a selection of crops in field trials.
- This large-scale application of AM fungi will be carried out with adapted machines.

- Root samples will be taken and the development of individual AM fungi will be determined with the novel molecular quantitative PCR methodology (see also WG2).
- Soil variables will be determined and related to the diversity and abundance of AM fungi

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Among the expected deliverables, systematic studies of the effects of soil variables on the development of AM fungi will result in optimisation of AM fungal products available on the market for use in the Mediterranean regions.

The knowledge gained will lead to an integration of knowledge to produce inocula of AM fungi and to maintain a certain level of quality. An essential part is the further development of novel molecular techniques for tracking mycorrhizal fungi during the production, storage and application stages.

It is expected that the interactions between many different European teams, SMEs, advisers and quality-mark organisations in the different fields ranging from plant breeding, applied mycorrhizal research and arable farming will lead to more demonstration projects, which are urgently required to provide recommendations and convince regulators, decision makers and the general public of the applicability of AM fungus products.

E. ORGANISATION

The Action will be managed by a Management Committee (MC). During the first MC meeting a chairperson, vice-chairperson and WG leaders will be chosen. The MC is responsible for planning and controlling the activities within the available budget.

The MC will integrate the reports of the WGs. The MC will take care of the annual reporting and evaluate regularly the activities and results in relation to the planned activities.

The MC will appoint a person responsible for generating and maintaining a dedicated web site for the COST Action.

The MC will be responsible for assessment of the STSM applications. The MC will take care that particularly younger scientists and scientists from less scientifically favoured areas will be involved in the STSM scheme.

An Executive Committee will be formed by the chairperson, vice-chairperson and WG leaders who will be appointed at the kick-off meeting of the COST Action.

The WGs will be responsible for organising the WG scientific meetings to meet their objectives and assess their progress. Moreover, the WGs will strive to achieve cooperation and exchange of novel insights. The aim is to set up joint research activities. The results of the activities of the WGs will be reported to the Action chairperson and Management Committee. Furthermore, within the different Working Groups, Short-Term Scientific Missions will be promoted. The exchange between the different organisations from the participating countries will strengthen cooperation.

F. TIMETABLE

The Action has a duration of four years. MC meetings will be held once a year. The WGs will organise separate meetings or in combination with other WGs. Moreover, activities will take place within the WGs. The planned activities are listed in Table 1:

Table 1. Timetable of the Action

Activity	*Year 1*	*Year 2*	*Year 3*	*Year 4*
Start – MC meeting	X			
Annual MC meetings		X	X	X
Separate or combined WG-meetings	X	X	X	X
Scientific activities within each WG		X	X	X
Final workshop and report				X
Annual report	X	X	X	

G. ECONOMIC DIMENSION

The following 20 COST countries have actively participated in the preparation of the Action or otherwise indicated their interest: Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Netherlands, Norway, Poland, Slovakia, Slovenia, Spain, Sweden, United Kingdom.

On the basis of national estimates provided by the representatives of these countries, the economic dimension of the activities to be carried out under the Action has been estimated, in 2005 prices, at approximately EUR 60 million.

This estimate is valid on 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.

H. DISSEMINATION PLAN

In this COST Action it is important that knowledge and data will be communicated to growers and advisers in arable farming. Also, it will be publicised that the Action takes a multidisciplinary approach resulting in a new paradigm in plant breeding: the development of cultivars that promote the economic and environmental sustainability of crop production through outstanding performance under reduced fertiliser inputs based on enhanced response to mycorrhizal fungi. Furthermore, implementation of practical use and sustainable management of beneficial microorganisms as a substitute for chemicals, including chemical fertilisers and pesticides will be promoted.

Therefore, the communication will consist of the following:

- A web site of the COST Action will be set up within the first three months after the starting date. This web site will be kept active by one designated person in this Action. The web site will be linked to the web sites of the participating institutions and web sites of advisers in arable farming.
- Press releases on the kick-off MC meeting in the participating countries.
- At least one publication per year in a professional journal for the participating countries.
- Flyers of one page (A4) will be produced on interesting results throughout the Action. The aim is to make at least four flyers per year (one per WG). These flyers are for the growers of crops, for advisers in arable farming, agricultural supply industries, suppliers of mycorrhizal fungi and breeding companies.
- Break-out technology workshops will be organised annually in one of the participating countries. These workshops are strongly focused on an integrated approach to science and its implementation within the chain of agricultural production. Representatives of different parties in the different research fields of plant breeding, (low input) arable farming and applied mycorrhizal technology will be invited to the workshops. This will include advisers in arable farming, agricultural supply industries, suppliers of mycorrhizal fungi, breeding companies and consumer organisations.

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