



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

Brussels, 4 September 2001

Secretariat

COST 276/01

DRAFT MEMORANDUM OF UNDERSTANDING

Subject : Implementation of a European Concerted Research Action designated as
 COST Action 852 "Quality Legume-Based Forage Systems for Contrasting
 Environments"

Please find attached the abovementioned draft Memorandum of Understanding.

DRAFT
Memorandum of Understanding
for the implementation of a European Concerted
Research Action designated as
COST Action 852

"Quality Legume-Based Forage Systems for Contrasting Environments"

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 by the Signatories.
2. The main objective of the Action is to increase the quantity and quality of homegrown proteins from regionally adapted legume-based forage systems.
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 EURO 31 Million in 2001 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 five 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.

Quality Legume-Based Forage Systems for Contrasting Environments COST 852

A. Background

In Europe there is currently considerable emphasis on low input, efficient agricultural systems that reduce production costs, promote environmental production policy and maintain a living countryside. The sustainability of these production systems relies on the cultivation of forage legumes. This is due to their ability to contribute to the nitrogen economy of swards through nitrogen fixation, their high feeding value and their ability to improve and maintain soil structure.

World demand for livestock products is expected to double in the next twenty years. Europe has a stable population, and a modest increase in consumption of livestock products is predicted. Animal products provide about 25% of the energy in the diet of people living in developed countries together with essential fatty acids, vitamins and minerals. Thus, by utilising forage legumes to their fullest extent, we have the opportunity to supply Europe with livestock products, produced from homegrown, traceable feeds of high quality and reduced environmental impact.

Within Europe half the annual requirement for feed is provided by grassland. However, although the EU is a net exporter of feed grain it is a substantial importer of protein and non-grain feed ingredients. The amount of raw material imported for feed corresponds to the production from 10 million ha of land. The current production of meat, eggs and milk relies on the importation of non-forage protein and this represents 27% of the total amount of protein consumed by the animal. Although non-forage proteins of vegetable origin are available, much of the 'by-pass proteins' have traditionally come from animal by-products and fishmeal. However, the effect of the BSE crisis has meant that most of these animal products, including fish meal, are now excluded from ruminant feeds and as a result there is an increase in the demand for high quality plant protein. This has been particularly prevalent in the dairy sector where supplementation has been regarded as necessary to sustain yields. Imported feed-components have high transportation costs, high environmental

impact and their quality and safety can be highly variable. A greater reliance on 'home-grown' legume-based protein sources would improve the traceability of the feed, enhance consumer confidence in the final market product and promote ecologically sound farming systems.

As farming within the north-western European countries moves towards less intensive forms of agriculture, it has been predicted that there will be a growth in intensive agricultural systems in the Baltic States and other Central and Eastern European countries in order to supply consumer demand in central EU countries. However, the growth of industrial forms of livestock production has been associated with serious environmental and safety problems. Consequently, forage legumes, adapted to a wide range of soil types, climatic conditions and management systems, will become increasingly important components of sustainable agriculture production systems in Europe.

Agricultural development over the past 50 years has heavily depended on chemical and resource-intensive agriculture. Even though modern reforms to European policies encourage a more holistic approach, many environmental and social problems still exist. The recent BSE crisis has served to underline the risks that people associate with conventional farming practices. It is no longer sufficient to adopt new technologies simply because they guarantee greater profit margins or higher production levels. In future it will be essential to take into account the opinion of the consumer in order to avoid further crises of confidence.

Conventional agriculture is subject to steadily increasing costs, uses large amounts of fossil fuels and creates increasing concern over environmental issues. It is inconceivable for European agriculture to continue along this route. Legume-based systems are known to contribute towards sustainable, environmentally sensitive and energy efficient agriculture and are likely to assume an increasing importance. However, the use of legumes in grassland systems has not yet increased markedly. Worldwide, the estimate for annual N₂ fixation on agricultural soils is about 90Mt of N, of which 56% is fixed by legumes. However, N₂ fixation in European countries is estimated to be much less. UK grassland, for example, receives less than 10 kg N ha⁻¹ annum⁻¹ from N₂ fixation. This not only indicates the trivial contribution which legumes are currently making to the N economy of grassland systems but also emphasises the scope that exists to exploit N₂ fixation within the European community.

The interest in ecological forms of agriculture has increased substantially in recent years and presently organic farming accounts for 2.9% of agricultural land within the EU. Many EU countries are actively encouraging the uptake of organic farming systems and this will inevitably increase farmers' reliance on legumes. Recent results also suggest that elevated levels of CO₂ in the atmosphere and increasing temperatures associated with global warming will improve the ability of legumes to fix atmospheric nitrogen. This is likely to substantially increase the effectiveness of legume-based systems.

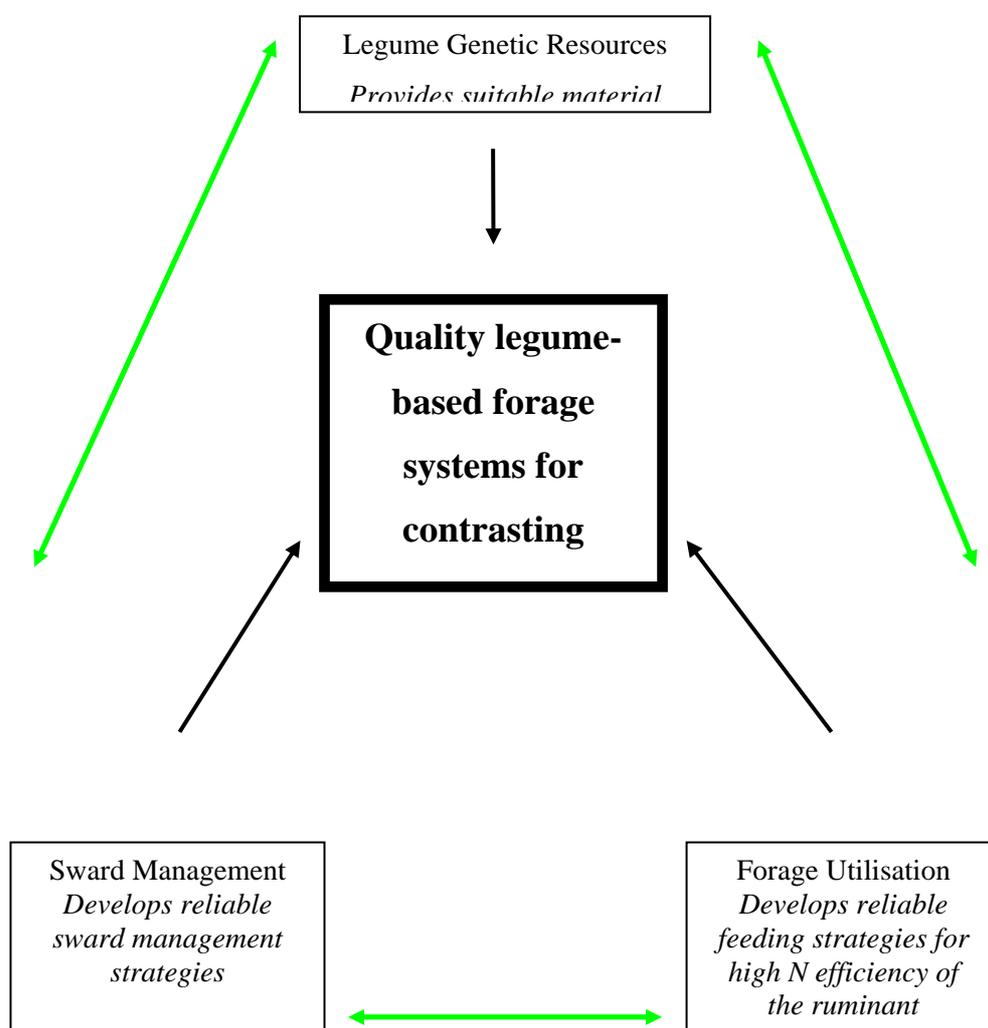
Yet major challenges still exist. Temporal and spatial variation in legume performance occurs and this restricts the confidence of farmers in legume-based systems. If reliability is to be improved and the range of forage legumes extended in Europe we will require understanding of the constraints of environment, the reasons for divergence between species' potential and actual performance, the causes of yield variability and lack of persistence, the mechanisms controlling diet selection in animals and the role of management.

Understanding the mechanisms underlying nutrient flows in ruminants fed on legume-based diets is an essential prerequisite for the achievement of high animal performance coupled with high efficiency and reduced environmental impact. Such information is essential for an improvement in nitrogen use efficiency.

The complexity of the issues requires collaboration among scientists from diverse fields of research (genetics/plant breeding, physiology, agronomy, pathology, microbiology, animal nutrition, and systems modelling). These will be drawn from various institutes across Europe and they will participate in the three Working Groups of the Action.

B. OBJECTIVES AND BENEFITS

The main objective of the Action is to increase the quantity and quality of homegrown proteins from regionally adapted legume-based forage systems. The potential for legumes to contribute to sustainable agricultural development relates to their ability to (a) reduce the requirements for inorganic N fertilisers derived from non-renewable sources of energy; (b) reduce losses of nitrogen to the environment, (c) reduce the need for imported concentrates, and (d) maintain and improve soil structure and fertility. To achieve the overall objective, the Action will be broken down into three subject areas, each with its specific objective as shown in the diagram.



The Action will supply benefits for **society** by providing high quality agricultural products coupled with reduced environmental impact. It will provide information to policy makers on the pertinence of using legume-based systems. There will also be an added benefit of increased self-sufficiency from agricultural production within Europe.

The benefits to the **farming industry** will centre on the development of more reliable systems. The action will improve the selection of appropriate legume species/cultivars and the development of regionally adapted pasture management practices in contrasting environments of Europe. This will ultimately lead to more secure and sustainable systems for forage and livestock production.

The benefits to the **scientific community** will include stimulation of active communication between scientists involved at all levels of research on the development and utilisation of forage legumes in Europe. This will promote a multidisciplinary approach to the study of complex agricultural systems. It will also provide researchers with access to a range of climatic environments, which may occur in any individual country but not reliably enough for experimental purposes.

C. SCIENTIFIC PROGRAMME

To achieve the objectives of the Action work will be divided up into three working groups.

Working Group 1. Legume Genetic Resources

The three main areas covered by WG1 will be:

1. Mechanisms of adaptation of the legume plant and its associated micro-organisms.
2. Study of the genetic basis of adaptation.
3. Breeding of plants/micro-organisms (including both traditional and molecular techniques).

The aim of this WG is to facilitate the uptake of legume-based forage systems by the European farming community through the provision of suitable legume cultivars. There is a wide range of climates in Europe, and climatic zone will strongly influence the type of legume used in forage systems. For example, in the Mediterranean environment the most successful legume species might be winter annual-types, which will germinate with autumn rains, grow actively during the winter and produce seed prior to the onset of summer drought. Further north, winter survival becomes the dominant requirement and various mechanisms are adopted to achieve this. In all environments we need an understanding of the factors affecting the survival and productivity of legumes. Such factors include the presence of various abiotic stresses, competition from other species in mixed swards, the type of sward management imposed, and relationships between the legume and its microbial symbionts (*Rhizobium* bacteria and vesicular-arbuscular mycorrhizae).

It is envisaged that this Action will progress through the use of multi-site experiments involving a range of legume species, some of which will be common to many sites. By this means it will be possible to identify mechanisms of adaptation and their genetic bases. Molecular techniques are now available for research into the molecular and genetic bases of many environmental stresses. The effects of novel traits on legume performance in contrasting environments will be determined through the use of unique germplasm available to the participants.

Working Group 2. Sward Management

The main areas covered by WG2 will be:

1. The study of mechanisms resulting in successful sward establishment.
2. The study of the mechanisms affecting competition and complementarity in mixed swards.
3. Sward dynamics.
4. Nitrogen flow in legume-based systems (efficiency-losses).

To increase farmer confidence in the use of forage legumes it is necessary to have more reliable establishment techniques and to reduce the variability in legume contribution within and between years, particularly for legumes in mixed swards.

The arena in which establishment occurs is a mix of management, environmental and biotic factors. This short phase sets the scene for the future of the legume in the system. An understanding of the processes influencing the survival and growth of legume seedlings, whether in a re-seeded pasture, in a perennial sward or as a sown crop in competition with weeds, is a key to increased establishment reliability.

Managing for less variable legume performance requires a clear understanding of the factors behind fluctuations of mixed legume swards through the growing and rest seasons (cold winters/dry summers) and their long term dynamics over years. Recent new approaches to understanding competitive and complementary behaviour that utilise the strong relationships between successive phases of the life history of swards and mixed stands will help to develop this knowledge. The effect of animal grazing behaviour, the role of clonal and sexual reproduction and rules governing allocation to reproduction and seed and seedling survival in determining the long-term persistence of legumes in natural and sown grassland need further examination.

Improving the efficiency of utilisation of legume fixed N and reducing N losses to the environment increases the attractiveness of legume-based systems. Precise information on nitrogen flows and losses in both grazed and ungrazed systems will help to achieve these two aims.

Working Group 3. Forage Utilisation

The four main areas covered by WG3 will be:

1. Animal intake and grazing behaviour.
2. Quality of legume-based fresh and ensiled forage.
3. The mechanisms of N-flows within the ruminant (efficiency-losses).

In order to develop sustainable, legume-based livestock production systems we need to understand the complex relationships that exist between herbivores and the plants they consume. In addition, more information is required on the processes of energy transfer and nutrient loss from the system. This information is necessary to quantify and predict the performance of beef and dairy production systems, thus promoting their greater economic viability and compliance with environmental legislation. It is essential that such information be transmitted to the farmer if legumes are to be used in an appropriate way, thereby improving the efficiency of these systems.

It is well known that the presence of legumes in the sward encourages high level of forage intake by the grazing animal. However, an understanding of the link between grazing behaviour, dietary preference and animal intake would enhance the prediction of nutrient intake by the ruminant in pasture systems.

Nutrients and energy are lost during field-based harvesting and conservation processes. The extent of these losses is influenced by management practices, by the type of legume used and by its contribution to the sward. It is clear that models predicting nutrient turnover, particularly during forage conservation, need to be formulated and validated. These models must take into account the species composition and legume content of the sward in order to provide reliable estimates of nutrient intake by the animal.

Understanding the mechanisms underlying nutrient flows in ruminants fed on legume-based diets is an essential pre-requisite for the achievement of high animal performance together with high efficiency and reduced environmental impact. New approaches based on the nitrogen/energy ratio in the ruminant diet will improve our understanding of the process of digestion. Information on the role of specific plant constituents (e.g. tannins), known to affect rumen by-pass protein, can be related directly to the legume content of the diet and will improve nitrogen use efficiency coupled with reduced nitrogen losses to the environment.

INTERNAL LINKS BETWEEN WORKING GROUPS

To achieve the overall objective of the Action the working groups cannot function in isolation. The following links between groups will therefore be encouraged.

Links between WG1 and WG2 will focus on:

- Adaptation and management.
- N-fixation efficiency.
- Breeding for improved reliability in mixed swards.
- Improvement of adaptation to limiting factors in marginal areas.

Links between WG1 and WG3 will focus on:

- Grazing behaviour and plant characteristics.
- Adaptation of protein quality for the ruminant.

Links between WG2 and WG3 will focus on:

- Grazing behaviour and sward dynamics.
- N-flows and environmental impacts.
- Sward dynamics and quality of herbage.

EXTERNAL LINKS WITH THE INDUSTRY

Numerous links occur within research projects in the individual countries. These include links with the seed industry (e.g. Germinal Holdings, UK; Barenbrug, The Netherlands; DLF-Trifolium, Denmark; SvalöfWeibull, Sweden), fertiliser companies (e.g. KalitSalz-Germany) and producers of inoculants (e.g. Elomestari Oy, Finland). In addition, every country involved has strong links with the farming community. This works at a number of levels from ministry policy makers through technology transfer services to farming co-operatives and ultimately individual farmers.

MEANS OF ACHIEVING THE OBJECTIVES OF THE ACTION VIA THE NETWORK

The elements of this work are based on existing research programmes within the individual participating countries. The range of expertise within the Action allows us to expand the effectiveness of these programmes by utilising a range of tools:

- Creation of unique material from multi-site experiments involving a range of species in order to study the basis of mechanisms for adaptation.
- The use of molecular techniques in order to recognise and manipulate key genetic elements.
- The use of common material and/or techniques in contrasting European environments to understand the effect of major environmental variables.
- Selection of standard methods for the estimation of N-fixation, quality parameters, etc.
- The use of models to quantify the biological, environmental and management processes and impacts.

D. ORGANISATION AND TIMETABLE

The Action is set up for five years. Five years is required for two reasons. Firstly, most of the research projects that contribute to the action are by nature long term. Secondly, creation of unique material from multi-site experiments and the use of common material for experimental purposes require a number of years to materialise. The three working groups will carry out the work of the action as described in Part C. The Management Committee will assemble scientists that represent areas covered by the working groups and provide leaders for the different groups. It will meet once a year to assess the progress of the Action. The Management Committee will organise three workshops on topics that emphasise links between the working groups (see Part E). A final conference will be organised at the end of the project period where the achievement of the different working groups will be reviewed and progress towards the realisation of the overall objective will be assessed.

The working groups will meet once a year. The meetings will be used to present results from experimental work in an informal and interactive way. Joint publication of results in conferences and international journals will be encouraged. Wherever possible working group meetings should coincide in order to stimulate exchange between the different groups and attempts should be made to let Management Committee meetings run concurrently with WG meetings.

The Management Committee will be responsible for the selection of participants for short-term scientific missions. These will be used to encourage bilateral exchanges between participating countries in order to enhance the aims of the Action and will provide opportunities to exchange expertise between working groups. Priorities will be given to visits of young scientists to established research teams.

Table 1. Overall timetable.

Event	Year 1	Year 2	Year 3	Year 4	Year 5
Management Committee	x	x	x	x	x
WG Meetings	x	x	x	x	x
Workshops		x	x	x	
Final conference and report					x
Newsletter	x	x	x	x	x

E. DISSEMINATION PLAN

The success of the Action relies on effective communication between individual partners, the working groups and the wider scientific community. This will be achieved by:

- The creation of the network
- Regular workshops open to the wider scientific community
- Short term scientific missions which lead to exchange of expertise
- Creation of a web site

A special Web site on the Internet will be set up for the Action. Each working group will be responsible for a contribution to a regular newsletter which will be published on the Web site and discussion groups will be set up for each working group in order to stimulate dialog and exchange of ideas between formal meetings.

Three workshops will be organised on topics that emphasise links between the working groups (Table 2). Proceedings from these workshops and the final conference will be published in a formal manner and referenced on the Web site. Results from working group meetings will be published in an informal report and on the Web site together with reports of short-term scientific missions and final reports of each of the working groups.

Table 2. Workshops.

	WG links	Topic
Workshop 1	WG1 x WG 2	Adaptation and Management - Strategies for improved reliability in mixed swards.
Workshop 2	WG1 x WG3	Adapting protein quality and plant characteristics of the legume to the demands of the ruminant.
Workshop 3	WG2 x WG3	Sward dynamics, forage utilisation and N-flows in legume-based systems.

F. ECONOMIC DIMENSION

The following 23 COST countries have actively participated in the preparation of the Action or otherwise indicated their interest: Austria, Belgium, Bulgaria, Croatia, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Lithuania, Norway, Poland, Slovakia, Slovenia, Spain, Sweden, Switzerland, the Netherlands and the United Kingdom.

On the basis of national estimates provided by the representatives of these countries the overall cost of the activities to be carried out under the Action has been estimated, at 2001 prices, at roughly Euro 31 Mio. for a five year period.

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
