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16 agricultural success stories under the FAIR programme

EUR 21714

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Impact of EU Research

16 agricultural success stories under the FAIR programme

Area 4 - Agriculture and Fisheries, including Agro-industry, Food technologies, Forestry, Aquaculture and Rural Development

A review of research projects selected by Impact Assessment of Area 4

2005

Directorate-General for Research

EUR 21714

Foreword

This booklet presents short descriptions of successful agriculture, forestry and rural development projects funded under Area 4 of FAIR in the Fourth Framework Programme (FP4). FAIR was one of 18 specific programmes adopted by the Council in April 1994 for funding during the period 1994-1998. The FAIR programme had an overall budget of €680 million of which €199 million went to support the Area 4 sub-areas.

These projects have been drawn from the larger impact evaluation of the 239 projects the programme supported. The project coordinators were contacted and many of them completed an impact assessment questionnaire. This enabled an analysis to be performed on a large sample (103 replies).

We have selected 16 interesting projects on the basis of their performance in the impact analysis of the programme. They include the two best randomly selected projects from social cost benefit (CBA) and socio-economic analyses (SE). All the projects represent work that offers some of the best potential to deliver significant benefits. In this booklet we have used the word "Benefits" rather than "Impacts" to describe the useful outcomes of the work. Success stories are those where most of their impacts produce actual benefits.

The FAIR programme encompassed a wide range of research projects and studied subjects that affect many different types of products, industries and communities. The objective grading of research impact has an obvious and immediate value. It was produced using up-to-date methodology and within a strict timescale. Those interested in the fuller details of the assessment methodology will find this, and more, in the full report of the impact assessment which can be downloaded from the Agri-Net website.

Chrsitian Patermann
Director of Biotechnology, Agriculture and Food Research

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Introduction

FAIR is an acronym for the specific FP4 RTD programme 'Agriculture and Fisheries (including Agro-industry, Food technologies, Forestry, Aquaculture and Rural Development)'. The FAIR specific programme was launched by the adoption of the Council Decision on 23 November 1994, with the first call published on 15 December 1994 – deadline 15 March 1995. A further six calls were launched which resulted in over 3 300 research proposals submitted to the programme, of which 620 were finally funded. In parallel, seven separate calls were organised for training measures and SME CRAFT projects. The FAIR programme was broken down into six distinct areas:

(1) Integrated production and processing chains
(2) Sealing up and processing technologies
(3) Generic science and advanced technologies for nutritious foods
(4) Agriculture, forestry and rural development
(5) Fisheries and aquaculture
(6) Concertation activities.

The success stories in this booklet have been drawn from the 239 selected projects across the six sub-areas that go together to make up Area 4. Area 4 received up to €199 million or 30% of the total €680 million FAIR budget. Area 4 projects span a very wide subject area and include identifiable success stories, such as instrumentation that enables water saving but maintains crop quality; silage systems that use less fertiliser, composting systems that overcome the problem of waste husks from olive pressing, and information to improve the welfare of chickens. Some very important rural development issues are addressed from sub-area 6 of the programme. This is a small selection of some of the best projects as selected by the impact assessment methodology used for the study. It presents 16 fascinating and useful projects. More comprehensive details of agriculture and food-related EU research programmes can be found on the following websites: FAIR (www.cordis.lu/fair) or AGRINET (http://europa.eu.int/comm/research/agriculture /index en.html).

The main impact assessment technique relied on research workers completing a questionnaire. We received responses from 103 of the 239 projects in the programme. The projects listed on page 7 are the highest rated projects in each sub-area, with the number of projects selected reflecting the overall number of projects in each sub-area. A typical FAIR research project involved six different European partners, lasted for three years and had an annual budget of €1 million of which 60% was EU funding.

The response rates to the questionnaire mirrored the distribution of projects across the whole of Area 4.

Some projects were randomly selected for social cost-benefit analysis (CBA), and for socio-economic analysis (SE). Two additional projects,

Percentage of sample and all projects as project type, and sub-area

	Survey Sample	All 239 projects
Type		
Shared Cost	73	79
Concerted Action	27	21
Sub-Area		
Reformed CAP	22	20
Quality Policy	9	8
Diversification, New Land Uses	9	10
Animal & plant health, Animal Welfare	42	40
Multifunctional management of forests	14	15
Rural Development	5	6

the best of these two groups, are also included. These are 'A' rated projects, i.e. those with technology or a message with clear evidence of adoption and actual impact.

The value of impact evaluations of research may be tempered by the fact that the timescale of research impacts is often much longer than when the research was first envisaged. The first successful genetic modification (GM) of plants was achieved around 1983 but, due to public resistance to the technique, the full benefits accruing from the research have – 20 years after the initial research – yet to be passed on to European society at large. Nonetheless, GM technology and knowledge is being used by many European industries and the importance of the use of this technique should not be underrated.

Impact analysis is further complicated by the fact that effects frequently result from the activities of people often working in many different situations. The wide coverage of participants in both shared cost and concerted action projects show this breadth of coverage. We hope that when reading the report you will be able to appreciate both the participative nature of the research and the wide range of situations covered by those benefiting from the work.

Assessment methodology

A team of people with experience in evaluating projects, and research and government policy agreed a set of 28 impact factors, grouped into six main areas. As these factors had different impacts they needed to be weighted before combining them to produce a single impact index – the score out of a maximum of 280. The weightings were produced following a carefully designed consultation process which sought the views of a series of experts. This process obtained a reliable group opinion while simultaneously minimising the less desirable aspects of group interaction, such as social pressure of majority opinion, forceful persuasion, or the desire to stand by publicly expressed opinion or company policy.

The weightings were used to rank the questionnaire responses received from the 103 respondents to the impact evaluation survey. The weighted values attributed to each of the 28 impact factors, and the maximum score that could be achieved in the six main areas are shown below:

Type of impact	Weight
Legislation and Policy	**19**
Influence on EU/National/Local government policy	19
Science	**60**
Validation of previous research findings	7
Instigation of other research project(s)	7
Attraction of funding for further research	6
New contacts between research centres	11
Improvement in pre-existing communications between research centres	10
New contacts between research centres and industry	10
Improvement in pre-existing communications between research centres and industry	9
Agricultural industry	**82**
Changes in agricultural practice/processes	14
Introduction of new crops/varieties/breeds	10
Identification of new uses/markets for agricultural products	11
Reduction in losses due to pest/disease	11
Improvement in profitability of primary producers	12
Improved communication among primary producers	8
Improved communication between primary producers and their customers	8
Improved communication between primary producers and their suppliers	8
Other industry sectors	**47**
Changes in practice/processes	11
Identification of new uses/markets for existing products	10
Patent(s) applied for	8
New products launched	9
Improvement in profitability of businesses in the sector	9
Consumer relevance	**48**
Improved viability of rural communities	16
Environmental improvements	16
Food safety/nutritional benefits	10
New access to information (for consumers)	6
Training and development	**24**
Students trained as part of project	8
Primary producers trained as part of project	10
Others trained as part of project	6
Total	**280**

Coincidentally, after the weightings were agreed the 'ideal project' turned out to be one that influenced policy at EU to local level, from which changes in practice should arise that improve the environment and the viability of rural communities. This would provide training for farmers and would change the downstream practices of other industry sectors. As this essentially outlines the underpinning philosophy of the CAP and its reform processes, it adds considerable weight to the value analysis.

Although successive evaluations of similar research programmes using the above process may come up with similar weightings, depending on the panel's assessment, no two evaluations can be expected to be exactly the same.

In addition, two groups of ten projects were randomly selected from the 239 projects in the programme. The available information from these were subject to cost-benefit or socio-economic analysis and the projects rated as A, B or C. Projects with an A rating showed real evidence of tangible economic or socio-economic benefit. The two best projects from these randomly selected groups are also presented, along with the cost-benefit or socio-economic rating.

Selection of successful projects

The assessment methodology and the selection process produced the sample of projects listed below in order of ranking within each of the programme sub-areas.

Sub-area	Contract N°	Project	Type
1	CT95-681	Water management method for non-closed crop production.	SC
1	CT96-1832	Low input animal production based on forage legumes for silage.	SC
1	CT95-702	Local European beef breeds for producing quality meat.	SC
2	CT97-3648	Quality of stored grain: a decision support system for management and control of quality malting barley.	SC
3	CT97-3620	Composting of husks produced by two-phase centrifugation olive oil milling plants.	SC
4	CT97-3761	Engineering rice for resistance to insects.	SC
4	CT98-4105	Biocontrol of important soil dwelling pests by improving the efficacy of insect pathogenic fungi.	SC
4	CT98-4239	Lower application of insecticides by the production of insect-resistant crops using novel protease inhibitor genes.	SC
4	CT98-4311	Resistance genes to Salmonella carrier-state in fowls.	SC
4	CT97-3576	Feather pecking: solutions through understanding.	SC
4	CT97-3898	Reducing chemical input in apple production in response to consumer and producer environmental concerns by increasing the durability of natural disease resistance.	SC
5	Ct98-4421	Best harvesting practices of Mediterranean forest residues considering economic and environmental constraints.	CA
5	CT96-1341	A handbook and training course for choosing, propagating, protecting and utilising the Cypress Tree in Mediterranean regions.	CA
6	CT98-4162	Dynamics of rural areas.	SC

SC = Shared Cost, CA = Concerted Action

The best[1] randomly selected projects were:

Sub-area	Contract N°	Project	Type
2	CT97-3940	Factors affecting hide and skin quality: Development of strategies for improving the raw material of the leather industry.	CA
4	CT95-0654	Control of Esca and environemental benefits.	SC

Each project is presented with its impact ranking and score; a short 'Objectives' section which outlines what the work was trying to achieve and why; a description of some of the useful 'Outcomes', and a short section of 'Benefits' that will help both the industry sector involved and the wider community.

1) Highest scoring means both projects were 'A' rated by the cost-benefit or socio-economic evaluation, and were high scoring in the main impact evaluation, along with the projects listed in the table.

Sub-area 1. Reformed CAP

CT95-681

WATER MANAGEMENT METHOD FOR NON-CLOSED CROP PRODUCTION – WATERMAN

Overall Ranking: 3

Impact Score: 190

Objectives

In southern Member States of the EU there is an enormous lack of water. To use water as efficiently as possible one must have accurate data of the soil moisture status, and an adequate method of calculating the water requirements necessary to satisfy crop needs without producing leaching and pollution.

The objectives of this work were to develop sensors for measuring soil water content, pressure head and electrical conductivity. These were to be used to provide data for a two-dimensional hydraulic model for water movement in unsaturated soil, and irrigation algorithms that indicate when and how much water should be supplied. The computer model and the sensors combine to make the WATERMAN system.

Outcomes

This system consists of a decision support system, an irrigation controller and sensors for water related parameters. It operates in greenhouses as well as in outdoor situations and has three operating modes: semi-arid conditions with deep water tables, wet conditions with shallow water tables, and situations with an intermediate water table.

Some of the soil sensor equipment developed by the WATERMAN team

Three types of soil sensors were developed: a three-pin dielectric soil moisture content sensor (WET-sensor) based on the frequency domain (FD); a sensor for pore water EC (Sigma-probe); and a production model dielectric tensiometer.

The WET-sensor measures soil moisture content, bulk electrical conductivity (EC) and temperature. Some of these sensors have been developed commercially.

In addition, soil moisture and pressure head sensors of acceptable diameters were designed, and hardware was developed to interconnect sensors with PCs along with supporting software.

Using input from the sensors, the WATERMAN system can operate in three different operating modes: to enhance water use efficiency under Mediterranean conditions for field crops; to minimise leaching under north European conditions in greenhouses, assuming suitable targets for water content can be defined; and when a significant part of the plant water consumption comes from ground water and modelling of the hydraulic properties of the soil becomes necessary.

A 'pollution index' for the total amount of salts and their concentration leaving the root zone can be created and measured.

Benefits

- The WATERMAN system minimises water use and prevents leaching by replenishing the equivalent amount of water evaporated from plants and soil.
- One of the major spin-offs of the project was based on the ability of the sensors to measure not only the water content but also the bulk electrical conductivity (EC) of the soil. These findings suggested new applications for fertilisation practice and for pollution control based on these measurements.
- Water saving can be achieved without losing product quality.
- The system can also create a dry buffer layer underneath a wet root zone, and so minimises leaching.
- Regimes using WATERMAN irrigation become more profitable and environmental degradation due to leaching is reduced.
- In the rankings, this project was one of those scoring maximum points for science impacts.

CT96-1832

LOW INPUT ANIMAL PRODUCTION BASED ON FORAGE LEGUMES FOR SILAGE – LEGSIL

Overall Ranking: 4

Impact Score: 189

Objectives

The objective of the project was to provide the technical basis for economically efficient, less intensive animal production for northern EU countries, based on the use of forage legumes for silage. To date, such systems have had little impact because of poor productivity and persistence of the varieties and species available.

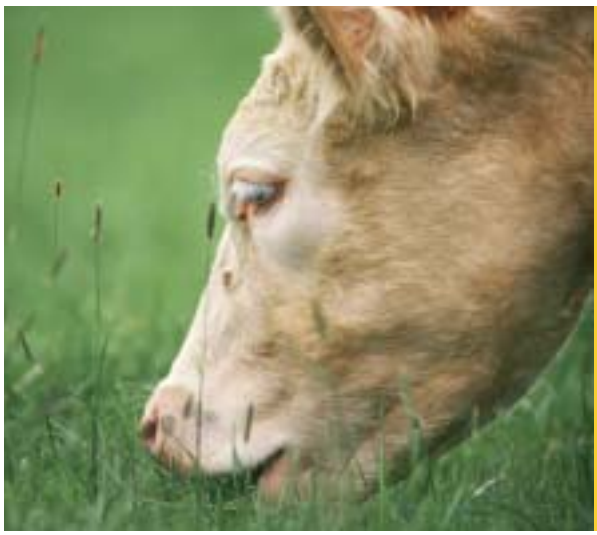
This project also investigated low input and environmentally sustainable systems using forage legumes which have the potential for better protection of the environment through reducing nitrogen losses.

Outcomes

The LEGSIL trials showed that forage legumes, either alone or with grasses, can be used to produce high-quality silage that supports higher levels of milk production than grass silages. Where grazing is also part of the system, grass-white clover mixtures are the most suitable.

Across Northern Europe there is potential for red clover (*Trifolium pratense*) and, to a lesser extent, white clover (*Trifolium repens*) and lucerne (*Medicago sativa*) to produce higher profits per hectare than grass-based systems using high levels of inorganic fertilisers.

In some situations, Galega (*Galega orientalis*) and lotus (*Lotus*) can compete economically with fertilised grass swards, although they are not the forage legume of first choice.



Legumes can be successfully ensiled in bunkers and as big bales when wilted to 25% dry matter (DM) with acid additives, and when wilted to 35% DM with either acid or an effective inoculum.

The higher protein content of legumes means they should generally be fed with concentrates or forages of low crude protein content in order to reduce losses of nitrogen in faeces and urine.

Benefits

- LEGSIL provides the basis for economically viable extensive and/or organic livestock systems. This gives greater flexibility of choice in changes to land use, stocking rate and intensity of management.
- Increased farm self-sufficiency, better quality silage leading to better quality milk and meat for consumers.
- Protects food production from the impact of the rising cost of fossil fuel and fertilisers.
- Four books in different languages were produced for farmer audiences. This widely promulgated knowledge has enabled reliable legume-based production systems to be used by more farmers.
- The formation of a European group of expertise on legume-based systems for livestock production. Many of the partners are still working together having developed good relationships.
- The work provided good scientific underpinning for livestock extensification policies.
- In the rankings, this project was one of those scoring maximum points for science impacts.

CT95-702

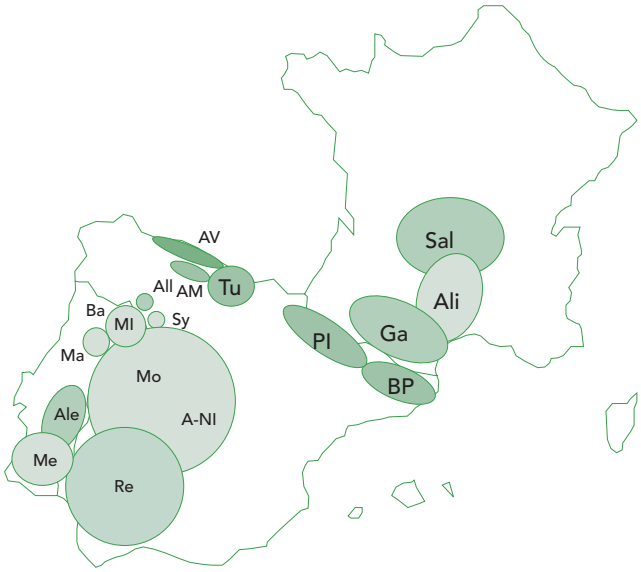
CHARACTERISATION AND ASSESSMENT OF GENETIC APTITUDES OF LOCAL EUROPEAN BEEF BREEDS FOR PRODUCING QUALITY MEAT – LOCAL BEEF BREEDS ACROSS EUROPE

Overall Ranking: 7

Impact Score: 173

Outcomes

Farmers in Spain and Portugal were interviewed to characterise their production systems. In Spain, they were grouped into 'dehesa' (meadow) (A-NI, Mo, Re) and mountain herds (AM, AV, Tu, PI and BP breeds), and in Portugal into north (Ba, Mi, Ma) and south (Ale, Me) herds. The meadow and south groupings had larger herd sizes. The Spanish systems were analysed to show the economic benefits for breeding improvements. An increase of one day in calving interval reduced the economic value by € -1 to -1.7 per cow per year. This was very small compared to the benefits from increased prolificacy, where twins increased the value by €450 to €700. Increased growth rate of 100g per day yielded benefits of €5.4 - 13.6 per cow per year. Large variations between the production systems in north and south Portugal suggested that programmes for breeding and conservation should also be different.



Au: Aubrac
Ga: Gasconne
Sal: Salers
Ali: Alistana
AM: Asturiana Montana
AV: Asturiana Valles
A-NI: Avilena-Negra Iberica
BP: Bruna dels Pirineus
Mo: Morucha
Pi: Pirenaica
Re: Retinta
Sy: Sayaguesa
Tu: Tudanca
Ale: Alentejana
Ba: Barrosa
Ma: Maronesa
Me: Mertolenga
Mi: Mirandesa

Objectives

The objective of this project was to evaluate the genetic diversity of several local beef cattle breeds from France, Spain and Portugal, as well as their ability to produce quality meat in extensive conditions. This was achieved through the characterisation of the production systems; the study of the genetic structure of breeds and their relationship through molecular genetic markers; and the analysis of growth performance, carcass and meat quality traits.

In France, after a decline in numbers in the late seventies, cattle numbers and herd sizes have increased, especially in the Au and Sal breeds. In Spain, there are considerable differences between breeds in numbers and consequent breeding activity. In 1995, there were 6 310 calves recorded in the AV breed, but only 64 for the Say herds. Effective recording schemes are essential where breeding activity is low due to small herds and low stock numbers. The Mi and Ba breeds in northern Portugal had shown evidence of an ageing breeding population (which can lead to

extinction), but EC support for breeds in danger of extinction and successful beef certification programmes have helped reverse this trend.

As breed structures are variable, so is the level of inbreeding. In the Au and Sal breeds in France, only three herds provided one-quarter of the genes found in the last calf crops monitored. Some of the Spanish populations studied have a small effective genetic size. In consequence better analysis of breed genetic structure and mating policies are needed. Most breeds, like Av, BP and Mo need recording effort to monitor inbreeding; the state is critical in the BP breed. Some breeds, like Ali and Say are too small in size and need a well programmed mating policy to avoid deleterious inbreeding in future. In Portugal, incomplete pedigree information meant inbreeding estimation was not possible for some breeds like Ma and Mi. In some situations inbreeding may be high.

Microsatellite marker analysis suggested the most important breeds to be preserved are those included in two clusters: one formed by the Mi and Ali breeds, and one made up of the Say and Tu breeds.

French and Spanish breeds were used to assess growth performance and carcass characteristics. There were clear differences between French and Spanish breeds, but in both cases fattening and slaughter weight followed a pattern which fitted the usual production system. Spanish breeds fattened on high-energy diets put on over 1.6 kg per day, whilst French breeds on lower energy diets gained between 1.25 and 1.37 kg/day. The coefficient of variation for the liveweight gain data was higher for the Spanish breeds. The content of lipids, dry matter, pigments, collagen and muscle fibre size were positively related to carcass fatness, whilst the opposite was true for protein content.

Overall, the large differences between the breed-systems observed may justify specific designations or meat quality marks.

Benefits

- The numbers of some breeds have been shown to be below the minimum recommended for long-term survival. The project has identified where recording practices by administrators, breeders and breed societies should be improved to protect and enhance the security of the breeds at risk.
- The study has provided objective data on the quality of meat produced by specified breeds and feeding systems that may contribute to the developing and/or enhancing meat labelling and specific brands.
- Within a breed-system, meat quality is independent of a wide range of growth rates and confirmation scores. So selecting for growth and confirmation will not have detrimental effects on meat quality.
- The production systems described meet the priorities of CAP directives encouraging farm activities in areas which need the maintenance of the social fabric and the environment.
- Thriving beef production and processing industries should contribute to the development of rural areas and new employment opportunities.

Sub-area 2. Quality Policy

CT97-3648

QUALITY OF STORED GRAIN: BUILDING A DECISION SUPPORT SYSTEM FOR MANAGEMENT AND CONTROL OF QUALITY MALTING BARLEY – QUALIGRAIN

Overall Ranking: 14

Impact Score: 190

Objectives

A reformed CAP and more liberal trade conditions have lead to increasingly competitive world markets. In this situation the requirement of quality grain for end-users or for export is ever more important. The objective of this project was to build a computer expert system (ES) in order to assess, monitor and control the quality of stored malting barley. In addition to improving knowledge on the storage of malting barley, the project helped to reduce losses and enhance cereal food safety.

Outcomes

Definitive models were produced for predicting the impact of heat treatments on germination capacity and dormancy break of malting barley. An algorithm was developed for the prediction of the time required to reach the maximum germination rate, and the moment when germination rate reaches the 95% lower limit. The model was successfully tested and validated.

The value of ergosterol as a biochemical index of fungal biomass production was confirmed, and studies of the rate of biodeterioration of malting barley during storage allowed production of a model predicting the length of the safe storage period. Using temperature and moisture, this model predicts the safe thresholds for mould hazards in a large range of storage conditions.

The fate of and decrease in efficacy of several post-harvest organophosphate insecticides can be predictively modelled within the Qualigrain ES.

The correlation between a one-day rapid test (chitted grain at 24 h) and the Germination Index (three-day test) was improved by using an image analyser. A good correlation was demonstrated between the ELISA test and standard analysis (HPLC) for storage mycotoxin ochratoxin A.

The Qualigrain ES was refined after expert user comment and now incorporates information that enables storage costs to be optimised. An 'uncompiled' version of the DSS graphic user interface is available to research and trade organisations and other potential beneficiaries.

The study and development of an acoustic pest detection and identification system was started. This detects insects at very low density levels, identifies the species and the developmental stage, and estimates the density.

Benefits

- More reliable storage management for malting barley through use of a DSS for:
  i. Managing grain going into store;
  ii. Optimal storage conditions;
  iii. Monitoring of quality changes using developed models.
- Early pest detection using an acoustic probe for the detection of in-store pests, including identification of the insect species and developmental stages.
- Models of insecticide residue degradation during storage of malting barley, and of the influence of hermetic storage on germination enable grain to be kept in better condition.
- The benefits of good storage practice were promoted through a demonstration version of the DSS on the project CD-ROM and website.
- Better quality grain enabling producers to compete more effectively in open world markets.

Sub-area 3. Diversification, New land uses

CT97-3620

COMPOSTING OF HUSKS PRODUCED BY TWO-PHASE CENTRIFUGATION OLIVE OIL MILLING PLANTS – HUSK

Overall Ranking: 2

Impact Score: 228

CBA/SE rating: A

Objectives

New two-phase centrifuge technology dramatically reduces the problem of waste water from olive milling, but shifts it to husks which have higher water content and higher phenol concentration. This project tests two different composting technologies (composting pile and composting reactor, horizontal and vertical) to find an energetically and economically acceptable solution to the problem of husk disposal, by producing compost fertiliser. The selection of suitable microbial strains for composting was part of the work.

Outcomes

Following laboratory-scale experiments, two different technologies were adopted for husk composting.

Chemical, physical and microbiological tests ensured the carbon-nitrogen ratio and that the potassium and phosphorous concentrations were adequate for the composting technology. Chemical characterisation also included fat content and polyphenolic compounds with inhibitory activity. Nitrogen enrichment and nutrient balancing were different for each country and chosen in relation to the composition and availability of the sub-products in the areas, and low cost.

Physical characterisation included apparent density and free air space. The principal microbial groups were investigated. Generally, microbial counts were high, particularly the yeast numbers. Humid fresh husks showed high phenol toxic activity, although phenol-degrading micro-organisms (both bacteria and fungi) were found in all samples.

The more active microbials isolated from the husks themselves and from an initial composting experiment were selected in order to be used as inoculum in the pilot plants. In addition, materials rich in micro-organisms (animal slurries) were utilised as inoculum.

The methods were set up for determining the activity of a pool of 20 important enzymes to monitoring the process. Polymerase chain reaction (PCR) and other techniques were used to check the hygienic property of the compost for the presence of the most significant pathogenic micro-organisms.

Aeration by physical turning gave better results than the air injection, due to the high density and extreme lack of porosity of the olive husks. Forced aeration worked if raw husks were mixed with bulking agents. Aeration was very important because it influenced temperature and water content.

Composting static aerated piles without turning is most economic for small plant sizes. However, as the size increases and the annual utilisation period becomes longer, the higher technology plant solutions tend to be more advantageous. If husks were to be applied unprocessed to land

this would incur landfill charges and lead to adverse crop effects. Avoidance of these issues help to justify the higher operating costs of larger plants.

Benefits

- The processes devised are suitable for the Mediterranean countries with small, widely distributed olive milling plants, and give farmers a new way of disposing of olive husks in an environmentally friendly way.
- Compost is produced that can be used as organic fertiliser for horticultural plant cultures and is very suitable for soil organic amendment, especially in the harsh temperature conditions inside greenhouses.
- The process provides safe processing of a by-product that avoids soil and water pollution, odours and, in some cases, phytotoxicity.
- Improved economic efficiency of olive oil mills. Some experimental activities have begun at full scale.
- The composting technologies work well for the humid husks produced by two-phase centrifuge olive oil mill plants. Material from three-phase centrifuge plants can be composted after mixing with mill waste water and other materials.
- This project was ranked second overall and scored maximum impact points in the areas of science and consumer relevance.

Sub-area 4. Animal and Plant Health, Animal welfare

CT97-3761

ENGINEERING RICE FOR RESISTANCE TO INSECTS – ERRI

Overall Ranking: 1

Impact Score: 253

CBA/SE rating: A

Objectives

The goal of this project was to develop Striped Stem Borer (SSB) resistant rice through transfer of *Bacillus thuringiensis* (*B.t.*) genes, encoding insecticidal toxins and plant proteinase inhibitor (p.i.) genes, into the two rice varieties most widely used in Italy, Spain and France.

Such resistance would help to control SSB (*Chilo suppressalis*) which hitherto has required heavy chemical treatments as well as sprays with *Bacillus thuringiensis* insecticidal formulations. The use of these limited efficacy treatments will be decreased, thereby reducing environmental impact. Yield losses, which can reach 15-20% in Spain and France, will also be reduced.

Outcomes

The programme identified genes, and developed methodology and constructs for use in breeding programmes. This enabled the production of seven resistant lines that show resistance to Striped Stem Borer.

Commercial exploitation of the traits has yet to occur due to public resistance to GMOs in the EU, despite their considerable environmental benefits. During the course of the project there was little improvement in public opinion and legislation on GMO crops.

Patents issues could affect the commercial value of the findings, depending on the route used to produce the resistance.

In general, merchants, processors, and retailers remain disinterested in GMO crops because of consumer resistance.

Successful workshops were held for Spanish producers – GMOs are considered more acceptable in Spain.

Benefits

- Rice plants have been produced that show a high level of resistance to the Striped Stem Borer, thereby requiring much reduced pesticide use. These plants remain available for possible future use.
- If adopted, growers would save on pesticide costs (possibly offset by higher seed costs), and there would be reduced environmental pesticide loading.
- There is potential to save the 15-20% losses caused by the pests in affected crops, thus improving the returns for rice producers.
- Three PhD students and many Masters students had worked on the project producing a knowledge bank for use by the industry.
- The projects have been discussed at numerous public lectures, seminars in Spain, magazine articles, and TV shows. The project workers developed good relationships with the Spanish partners in particular.
- The project has had a lot of exposure and has been very much part of the GMO debate at local, regional and national levels, helping to support a rational basis for the discussion of GMO crops.
- The project was rated first overall and had maximum scores for potential impact in the areas of policy, science, industry and training.

CT98-4105

BIOCONTROL OF IMPORTANT SOIL DWELLING PESTS BY IMPROVING THE EFFICACY OF INSECT PATHOGENIC FUNGI – BIPESCO

Overall Ranking: 5

Impact Score: 187

Objectives

This project set out to develop and study environmentally friendly biological agents for the control of soil-dwelling pests. These harm fruit trees, pasture, crops and forest trees throughout Europe causing damage estimated at several billion euros. Biological control agents (BCA) could replace or reduce the input of chemical pesticides in European agriculture, forestry and horticulture. Damaged crops include soft and top fruit such as strawberries, blackcurrants, raspberries and apples, arable crops like cereals and potatoes, and forest trees like firs and Christmas trees.

The aim of this project was to use insect-pathogenic fungi to control scarabs and weevils. By so doing, the work was aimed at improving production and formulation technologies, and developing biochemical methods to monitor fungal virulence and its nutritional (carbon) requirements. After release, molecular techniques were used to characterise strains and to monitor the pathogen in the field. In addition, new application systems for effective targeting of the pathogen were tested to study the impact of the pathogens on target and non-target insects.

Field trials were used to demonstrate/evaluate the efficacy of the fungal biological control agents, and address some of the criteria for the registration of insect pathogenic fungi.

Outcomes

Fungal formulations with enhanced virulence and increased shelf-life were developed, as were new formulation techniques.

Improved knowledge of the spatial-temporal distribution of inoculum increased the understanding of how epizootics were initiated. This linked to information on pest and fungal ecology and the effect of environmental factors on host-pathogen interactions.

Fieldwork studied the persistence of the pathogens (*Beauveria brongniartii* and *Metarhizium anisopliae*) in the soil at sites where they had been used extensively for scarab and weevil control.

Beauveria brongniartii was registered as BCA in Austria in June 2000, and was the first effective propagule against *Melolontha* in the EU.

Benefits

- More profitable cropping, horticulture and forestry as a result of lower losses due to damage by scarab beetles and weevils. Improved rural businesses.
- Reduce environmental loading from pesticides.
- An effective alternative treatment to the CFC methyl bromide.
- Enhanced soil biodiversity through the use of specifically targeted pathogens rather than broader spectrum pesticides.
- Provision of a treatment for soil-dwelling pests that is acceptable for organic production systems, giving further support to rural businesses.

CT98-4239

LOWER APPLICATION OF INSECTICIDES BY THE PRODUCTION OF INSECT-RESISTANT CROPS USING NOVEL PROTEASE INHIBITOR GENES

Overall Ranking: 6

Impact Score: 176

Objectives

The overall objective of the proposal was to reduce the application of insecticides by producing crop plants with durable resistance to pest insects, by using transgenic plant biotechnology and genes encoding protease inhibitors (PIs). Insecticides are the most harmful pesticides to the environment and human health. Reducing their use will contribute to the development of an economically viable and environmentally sound European agriculture.

During the project the first objective was to select PIs with desired properties from novel sources. The second objective was to introduce the genes encoding novel PIs into important European crops to demonstrate that a reduction in the application of agrochemicals can be achieved; and the third objective was to target the most harmful pests.

Outcomes

As it had been demonstrated that dietary inhibitors in plants induce protease genes that are insensitive to them, it was necessary to find inhibitors that were effective against such 'resistant' enzymes. The two approaches used were the use of a phage display to generate novel structures by changing the folds of proteins, and an approach using inhibitors from the animal kingdom that showed activity against insect proteases.

Changing the folds of protein was not a realistic option, so the phage display approach produced limited success. However, it proved possible to select a chymotrypsin inhibitor which was five times more effective against pea and peach aphid than the parent trypsin inhibitor molecule.

Using inhibitors selected from the animal kingdom was an easier way of finding novel molecules with activity against insect pests. Equistatin was a particularly effective dual inhibitor from sea anemone. Bioassays *in vitro* showed it had good activity for blocking both cysteine and aspartic gut proteases. In practice, the combination of equistatins with a number of different cystatins proved to be much more effective against thrips, the cystatins protecting the equistatins from degradation by legumains. Greenhouse trials demonstrated that transgenic potato and chrysanthemums had fewer adult insects and 80% less offspring.

Selected assays also showed that protease inhibitors not only reduced the growth of larvae and the fecundity of adults, but also acted as a strong feeding deterrent to adult insects in a dose-dependent fashion. This dual mode of action should contribute to the field durability of the crop resistance to insects.

Benefits

- The programme provided a wide array of information on proteases and their efficacy in deterring insects from crop plants.
- Plants developed in the programme showed there is considerable scope for the reduction of insecticide use on crops, with benefits to the producers, consumers and environment.
- The project provided increased understanding of the high-level expression of proteins in plants, showing they are highly dependent on the protein-plant species sequence.
- The project produced patentable material, and advances in the knowledge bases in the subject through academic and commercial research.
- Like the other projects ranking in the top six, this one achieved a maximum science impact rating.

CT98-4311

RESISTANCE GENES TO SALMONELLA CARRIER-STATE IN FOWLS

Overall Ranking: 9

Impact Score: 171

Objectives

Poultry products are the main source of human toxi-infections, mainly because of asymptomatic carrier-state, i.e. persistence of Salmonella in apparently healthy fowls. Caecal salmonella leads to human disease through contamination of the egg shell at the oviposition and of the carcass during evisceration, whilst ovarian salmonella leads to yolk contamination. Major genes of resistance to infection have been identified, whereas genes controlling resistance to carrier-state are still unknown. The objectives of this work were:

1. To discover which genes control caecal carrier-state after inoculation with *Salmonella enteritidis*;
2. To find out to what extent these genes also control resistance to ovarian carrier-state after inoculation with *Salmonella enteritidis*; and
3. To study these genes' mode of action to help in their identification and their use for selection.

Outcomes

Of two genes, TLR4 and NRAMPI, known to have an effect on resistance to mortality in fowls, gene mapping showed that TLR4 and the region surrounding it are linked to resistance infection with *Salmonella typhimurium* and probably to resistance carrier-state. TLR4 was expressed at approximately the same level in all tissues tested. NRAMPI appears to underlie the first Quantitative Trait Loci (QTL) controlling *Salmonella enteritidis* clearance during the late phase of infection.

Inbred lines resistant or susceptible-to-resistance to carrier-state were identified in fowls and crosses obtained. Animals were measured for intestinal colonisation, faecal excretion and caecal contamination, and elective genotyping was achieved. Among the nine QTL identified, seven could be involved in the determination of resistance to salmonella in chicken. Resistance to colonisation appears to be dominant, not sex linked, and seems to occur in two steps – the rapid elimination (within two weeks) of salmonella by an acquired immunity mechanism, and continued re-infection at a very low rate.

A simulation tool adapted to bacterial count was developed and showed linear regression and non-parametric methods to be the most useful means of anaylsing transformed data.

Studies of resistance to colonisation and the role of macrophage activity showed resistance was not expressed at the level of the gut but primarily in the reticulo-endothelial system. Respiratory bursts of activity of macrophages seem to correlate with resistance. Macrophages from resistant-line birds clear *Salmonella gallinarum* more quickly and efficiently. The role of immune response in resistance to infection appears to be small.

Significant differences were observed between the resistance of inbred lines to resistance carrier-state in adults or chicks, and the infection profiles of serotypes of *Salmonella agona* and *enteritidis* were more severe than those of *Salmonella typhimurium*. The work confirmed the efficacy of vaccination against carrier-state.

Benefits

- The work significantly increased the body of knowledge about the mechanisms of resistance to salmonella carrier-state in fowls.
- The work should contribute to the better breeding and husbandry of stock to reduce the overall salmonella burden in chickens.
- Application of the findings should help reduce the incidence of human toxi-infections arising from salmonella in fowls.

CT97-3576

FEATHER PECKING: SOLUTIONS THROUGH UNDERSTANDING

Overall Ranking: 12

Impact Score: 166

Objectives

The main objective of this project was to improve the welfare of laying hens by increasing our understanding of the internal variables originating within the bird, and external variables originating from its environment that underpin the development and reduction of Feather Pecking (FP).

Emphasis was on:

i) identifying individual behavioural and physiological characteristics associated with high FP;
ii) identifying inanimate stimuli (and their component features that elicit sustained pecking);
iii) identifying attractive properties of pecked birds, and detemining if FP spreads in a flock;
iv) evaluating methods that could be used to minimise FP in industry, and formulating recommendations.

Outcomes

The research revealed the factors affecting the young developing chickens play a role in the development of feather pecking. The introduction of pecking devices, like lengths of white polypropylene twine, was most effective when it was introduced from day 1 onwards. Thus, it is likely that strategies to prevent feather pecking in a flock are most effective from a very young age.

Tests used in the experiments, such as the runway test, crush cage test and corticosterone responses to manual restraint, have the potential to select feather peckers at an early age, and therefore to accelerate genetic selection against feather pecking.

In addition, the research showed which behavioural and physiological characteristics play an important role in the development of feather pecking and require further study.

Abrasion and damage of feathers by features in the housing system, such as food troughs or low perches, can lead to feather pecking, especially if the damage is on the back or rump of the bird. Designs that lessen the risk of feather abrasion will also help reduce feather pecking.

Preliminary results show that if a bird has been wounded by cannibalism it is likely to be cannibalised again when returned to its same group, even after the wounds have healed. So care is needed when reintroducing such birds.

The project held three seminars in Sweden, the Netherlands and the UK, and produced more than 20 scientific and popular articles about the work.

Benefits

- The housing and behavioural welfare of chickens will be improved by the findings.
- The design and construction of the housed environment can be improved to reduce feather abrasion that may lead to feather pecking.
- Bird and egg losses arising from feather pecking will be reduced, leading to better physical and financial performance.
- Stress levels in birds and overall health should benefit from better housing and less feather pecking.

CT97-3898

REDUCING CHEMICAL INPUT IN APPLE PRODUCTION IN RESPONSE TO CONSUMER AND PRODUCER ENVIRONMENTAL CONCERNS BY INCREASING THE DURABILITY OF NATURAL DISEASE RESISTANCE

Overall Ranking: 13

Impact Score: 163

Objectives

Durable disease resistance is one of the main objectives in apple breeding. Scab (caused by the fungus *Ventuna inaequalis*) and powdery mildew (caused by the fungus *Podosphaera leucotricha*) are the two major diseases of apple; they strongly affect apple quality and yield when they are not strictly controlled by fungicides. Against this background, the project was based on a close collaboration between geneticists, pathologists, breeders, pomologists and nurserymen, and involves several major objectives:

(i) characterisation of new apple cultivars carrying durable disease resistance;
(ii) assessment of the risks of new virulences appearing;
(iii) genetic dissection of polygenic resistance, taking into account pathogen variability;
(iv) development of new breeding strategies;
(v) marketing analysis of several new resistant hybrids.

Outcomes

In the characterisation of the resistance status of apples, nine cultivars with broad spectrum resistance to scab (*Venturia inaequalis*) were identified after greenhouse testing with 14 strains of the disease. Good resistance was confirmed in the field in two cultivars, Discovery and Dulmener Rosenapfel. The other varieties produced either intermediate or worse results in the field than in the greenhouse. A wide variability to ontogenic resistance (resistance related to the ageing of the leaves) was noted. The ranking of resistance according to ontogenic resistance was closer to field resistance than to the glasshouse test results.

Pathogenicity tests were carried out on eight cultivars for 39 strains of *V. inaequalis* from seven countries and 28 genotypes. The majority of strains were virulent to two or three cultivars, although seven strains showed virulence to five to seven cultivars. These seven all came from Germany or the Netherlands, with northerly strains tending to show more virulence. Once infected, there was no significant relationship between aggressiveness and virulence. The geographic distribution of *V. inaequalis* strains which are virulent to the *Vf* gene (from *Malus floribunda* #821) has been established for Europe. The presence of such strains in commercial orchards in France, the Netherlands and Denmark suggests there is a need for a special management strategy for cultivars with *Vf*-based resistance.

An in-depth analysis of the genetic base of scab resistance using QTLs highlighted the complexity of the apple x *V. inaequalis* interaction. A similar QTL analysis for powdery mildew showed interaction effects may be very important in explaining the observed resistance. Several of the markers used in the disease characterisation were used for marker-assisted selection procedures. This enabled crosses to be made that combined two or three major resistance genes (for scab or powdery mildew).

The project also conducted consumer preference testing in Switzerland and France. The work showed that analytical parameters, like firmness, total soluble solids and titrable acidity, are not valuable predictors of overall acceptability. However, the results demonstrated that disease-resistant apples have reached a fruit quality level which is comparable or even superior to established commercial varieties.

Benefits

- The characterisation of the genetic base for resistance to scab and powdery mildew in apples has supplied valuable information for apple-breeding programmes in the future.
- The results provide a good foundation for integrated disease management in European apple orchards.
- Such practices will enable reductions in fungicide use in apples and provide produce with better finish and lower storage losses.
- Reduced pesticide use in orchards will produce a better environment for the natural flora and fauna.

Sub-area 5. Multifunctional Management of Forests

CT98-4421

BEST HARVESTING AND/OR TREATMENT PRACTICES OF MEDITERRANEAN FOREST RESIDUES CONSIDERING ECONOMIC AND ENVIRONMENTAL CONSTRAINTS – MEDFORE

Overall Ranking: 20

Impact Score: 150

Objectives

The objectives of this Concerted Action project were to survey forestry management practices in Mediterranean countries, particularly as regards the disposal of forest harvesting residues.

From the results, the group was able to analyse the most innovative or interesting systems and equipment for forest residue treatment, and produce proposals for the integration of suitable treatment systems. Ultimately, these proposals will lead to better utilisation of forest residues and help reduce the risk of fire.

Outcomes

During the project, three meetings and a final seminar were organised with all the participants. The meetings produced protocols for handling forest residues and facilitated discussion on regional variations in practice.

Collection of information was difficult due to the diversity of forest management and the scarcity of available information on forest residue harvesting and/or treatment practices. Data on the efficiency and cost of standard and innovative systems, and the machinery used on forest residues was also difficult to obtain, as were details of environmental, social and economical impacts.

There was a lack of information on the characteristics, productivity and efficiency of equipment produced in Canada, United States and North Europe when used in the Mediterranean forest.

However, new interest was noted concerning utilisation of forest residues for energy production in the participating countries.

Benefits

- The protocol and glossary created for data collection will enable similar studies in the future to work from a common base.
- The work improved the understanding of 'best practice' in the management of forest residues in Mediterranean forestry.
- The project facilitated the introduction of common and innovative systems and specific equipment, as well as the development of new markets.
- It raised the importance of forest residue biomass work which has been the subject of several governmental discussions, and now has a prominent place in the Renewable Energy Resources National Programme.
- The Concerted Action gathered a group that will continue to work together to improve the utilisation of forest residues, and related issues.

CT98-1341

A HANDBOOK AND TRAINING COURSE FOR CHOOSING, PROPAGATING, PROTECTING AND UTILISING THE CYPRESS TREE IN MEDITERRANEAN REGIONS – CYPRESS

Overall Ranking: 25

Impact Score: 136

CBA/SE rating: A

Objectives

Cypress is an adaptable multipurpose tree for providing wood for a range of uses. Its evergreen habit and suppression of shaded undergrowth present a lower fire risk than some alternative species. This Concerted Action aimed to provide foresters, farmers, landscape managers and decision-makers with updated practical information on all stages of stand, windbreak and individual tree establishment, as well as guidance on the management of the cypress in Mediterranean regions.

Outcomes

A practical handbook was produced in seven different language editions covering: the biology of the genus *Cupressus*; reforestation material according to site and use; production of planting stock; principal diseases with a special focus on bark canker and genetic control; principal insect pests; yield of natural and planted stands; and wood technology and use.

A training course in Italy was attended by 30 people, mainly technicians and practitioners, which was a considerable proportion of the target users and influencers.

Benefits

- The development and strengthening of networks for the future exchange of information within the Mediterranean forestry sector.
- Better information for regional, national and EU policy on species selection for afforestation in the Mediterranean area.
- Higher production through use of disease resistant cultivars, leading to more profitable woodlands.
- Possible expansion of planting due to better appreciation of the durability of cypress wood for a range of uses, and development of better windbreak applications.

Sub-area 6. Rural Development

CT98-4162

DYNAMICS OF RURAL AREAS – DORA

Overall Ranking: 21

Impact Score: 148

Objectives

The project aimed to find out why rural areas in apparently similar economic, social and environmental circumstances have markedly different performances over relatively long periods of time. This question is key to devising successful practical strategies and programmes for sustainable rural development.

The main aim of the work was to explain the differences between 'well performing' and 'less well performing' rural areas, and to assess the ways in which national and regional factors influenced development of rural areas in western Europe. From this, guidance was produced for strategic programming of public intervention in different types of rural area.

In addition, new data were to be proposed for the analysis of rural development at local levels which can be applied at EU level.

Outcomes

Ten factors were identified as influencing differential economic performance.
Tangible Factors: Natural Resources, Human Resources, Infrastructure, Investment and Economic Structures, and Organisation.
Less Tangible Factors: Market Performance, Institutions, Networks, Community, and Quality of Life.

Differences in economic performance between regions arose because of the impact of local cultural traditions and social conditions in coping with the shift from the state capitalism of the earlier part of the 20th century to more market-oriented economies.

Governance, institutions and investment cover a wide range of fiscal and regulatory activity that affects daily life and business at many levels. Entrepreneurship is often associated with strong local public institutions that co-operate well, and where there is sufficient autonomy to undertake investment adapted to local needs.

Economic structures and organisation that allow local development to thrive include relatively small-scale, locally owned, individual or co-operative enterprises; good governance, local initiatives combining private and public sectors, and a greater degree of independence in relation to institutional autonomy and ownership of land and capital.

The quantity and quality of human resources emerged as a common differentiating factor between areas. Thriving areas have more positive indicators in the fields of education, training and literacy.

From the above, eight policy recommendations were suggested to be addressed at the EU level:
1. The need for rural small business extension activities.
2. A more mobile bureaucracy that engages with people in local rural areas.
3. National and pan-European rural interest groups need to operate at national and EU levels.
4. Broadening the scope of development policies beyond economic growth and development.
5. The transfer of public resource from richer to poorer areas.
6. Greater flexibility and autonomy in national and regional development policies.
7. Joined-up approach; integration at a local level to ensure efficient delivery.
8. Separation of Rural Development Policy from the CAP.

Benefits

Benefits accruing from these types of studies depend on political and operational aspects of local and national administration. However, this project provided the potential benefits of:
- Better guidance at local, national, and EU level for rural policy development.
- Knowledge to redress differential economic performance between regions.
- Better use of public resources across differing regions.
- Greater equality of treatment and opportunity.
- More effective decentralised policies.

Randomly selected projects for cost-benefit or socio-economic analysis – the two best projects

CT97-3940

FACTORS AFFECTING HIDE AND SKIN QUALITY: DEVELOPMENT OF STRATEGIES FOR IMPROVING THE RAW MATERIAL OF THE LEATHER INDUSTRY – HIDE

Overall Ranking: 19

Impact Score: 152

CBA/SE rating: A

Objectives

Hides and skins account for about 10% of the value of an animal and are potentially important in the generation of income for producers. In attempting to specialise in producing high-quality and high-performance, the EU leather industry needs a good supply of quality hides. This, in turn, should bring benefits to the whole production chain from farmer, to abattoir, and to tanner by adding value to this important by-product.

This Concerted Action aimed to form a network of prominent researchers from all areas of hide and skin production; to make research efforts within the consortium complementary; and to produce a working document outlining the needs of the industries throughout the supply chain.

Outcomes

A sustainable network involving European Union partners in the hide and leather industries, and a web based information system were established. But even with these achievements, the project coordinator maintains "…there is much more to do".

The improved communication increased awareness of the effect of diseases and damage on the value of hides and skins, and promoted the adoption of improved control methods. This was supported by a series of leaflets describing the economically important skin diseases and damage, which were translated into the languages of the partner countries.

The development of a computer-aided training package helped the identification and control of the economically important diseases and damage that affect the quality of hides and skins.

A seminar involving partners in the project and key personnel from related industries was organised to discuss the priorities for further research. A newsletter was published to outline the current state of research, and the final report outlined research required to continue hide and skin improvements.

Benefits

- Improved communication between the industry and prominent researchers from all areas of the hide and skin production chain. Better access to information for all in the industry through a web-based information system.
- Improved documentation on the supply standards needed by the EU industry to remain competitive.
- Fewer damaged hides due to disease, and the adoption of improved control methods. Across the EU, the potential gross impact of the improvement could be worth around €150 million per annum, from bovine hides alone.
- A report outlining the future research required to continue the improvements in hide and skin quality should provide the route to further benefits.

CT95-0654

CONTROL OF ESCA AND ENVIRONMENTAL BENEFITS – ESCA

Overall Ranking: 33

Impact Score: 121

CBA/SE rating: A

Objectives

ESCA is a disease of vinestock wood which has affected vine production for a long time. It attacks the stockwood and kills slowly or quickly depending on the nature of the infection. The only effective pesticide was sodium arsenite, but its mode of action was not fully understood. This currently essential compound is toxic to both man and the environment.

The objective of this project was to provide the scientific and technical base necessary for the development of new environmentally friendly methods to control the disease, and to disseminate them so as to eliminate the use of sodium arsenite in vineyards.

Outcomes

The four main fungi involved in the ESCA disease have been identified and it has been shown there is little differences in fungi species present either in different vineyards, or in different forms of the disease.

Studies on the working action of sodium arsenite show that it affects the microflora present at wood necrosis with *Fomitiporia punctata* disappearing, variable effects on *Phaeoacremonium spp*, and enhancement of *Trichoderma spp*. Arsenic levels in the grapes were negligible.

Preliminary results on the biology of *Phaeoacremonium* have been obtained. A strain collection has been assembled and the genetic variability of the fungi involved has been studied through DNA amplification techniques.

A PCR test for *Eutypa lata* detection has been established. Biological tests have been used to evaluate the aggressiveness of fungal strains, and several toxins released by these fungi have been identified.

Preliminary data on the use of molecular tools for improving grapevine tolerance to ESCA and grey mould have been obtained.

Benefits

- The developments should lead to more profitable vineyards through reduced losses by the control of ESCA.
- Elimination of the use of sodium arsenite, and reduced environmental loading.
- More disease-resistant material for use in vine breeding programmes.

Conclusions

In total, Area 4 funding amounted to €271 million, with €199 million coming from the EU. One project alone – on improving the quality of European hides for the leather industry – could produce annual benefits of half this total if the technology is ever implemented throughout the EU. Across the whole programme there is vast scope for securing a payback of many multiples of the original investment. To do this, the findings and messages must be disseminated to potential beneficiaries in a sustained way over the long term, once the work has finished. There is plenty of scope for this among the projects described in this booklet.

In addition to financial returns, improvements in the environment and animal welfare add an ethical dimension to the benefits, improving the general quality of life.

Technology transfer

Methods for exploiting and promoting R&D findings develop each year. The present CORDIS activities in Innovation Relay Centres, the Technology MarketPlace, Gate-2-Growth, and the submission of Technological Implementation Plans help showcase some of the best results and provide a continual update on the process of reaping benefits from R&D.

In this analysis, some Concerted Action studies, such as the hide improvement studies, the improvement of cypress production, and forest residues utilisation groups, have left a working legacy of activity because the original commercial need for the work provided the long-term demand. Other work has developed applications for the market, such as the registration of *Beauveria* as a biocontrol agent, or improving the quality of stored grain. Like the highest rated project on engineering pest resistance in rice, these now depend on new commercial activity for their long-term success. In view of the forthcoming requirement that EU grain meets certain quality requirements, the Qualigrain project may well provide timely information for those storing grain.

A fair methodology

The Delphi process used in this evaluation employed a two-stage process. The weightings for the impact assessment were devised by an expert panel and were then used to rate the returns provided by the project coordinators through questionnaires. Although it could be argued that the composition of the panel could have been different, or someone other than the coordinators could have completed the questionnaires, the new impact assessment could also have drawbacks – the panel may be too focused to give a full view, or the questionnaire respondent may not be fully au fait with the work. Impact evaluation is not a black-and-white operation, as the many essays on the subject[2] clearly show.

The Programme Evaluation Standards of the American Evaluation Association have produced feasibility standards that suggest evaluations should be realistic, prudent, diplomatic and frugal, whilst accuracy standards should ensure that evaluations reveal and convey technically adequate information about features that determine the worth or merit of the work being evaluated. When commissioning R&D, the EC has a vigorous *ex-ante* appraisal which should ensure that, at least at the outset, all work is capable of contributing economic, environmental or quality of life benefits. This booklet and the main report show that most projects have indeed produced a range of useful benefits. One possible shortcoming of the Delphi assessment has been that the interpretation of some of the questionnaire queries differed between respondents, so some have either ignored or underestimated the impact of their projects in certain areas. A useful spin-off from this evaluation will occur if researchers learn to the see the wider impact of their work in areas outside their immediate target area. Indeed, the wider involvement of researchers in the evaluation process will influence future decisions.

Because of the inexact and variable methodologies that can be used for impact assessment, each list of scores is conditional and depends on the assumptions used in the evaluation process. The best rated projects from each of the sub-areas are listed in this booklet, but the assessment has made certain assumptions about the future uptake and benefits that will accrue to each project. If the assessments were made only on the impact to

2) A good collection can be found in Agricultural Systems 28 (2003).

date, the rankings and projects in this selection would be different – but would ignore potential future benefits.

Thus. the projects in this booklet are offered as a fair and realistic appraisal of Area 4 of the FAIR programme as carried out using the Delphi methodology. The two randomly drawn projects listed had good Delphi scores but were also rated highly when subject to scrutiny using cost-benefit and socio-economic measures.

Intermediate outputs

The outputs of research which do not create an effect on the wider world are referred to as *intermediate outputs*. These are distinguished from *final outputs* which are the technologies and information with the potential to affect industries and wider society. How to give fair weight to intermediate outputs remains a significant problem.

The Delphi process gave more credit to intermediate outputs than the cost-benefit analyses on the ten randomly drawn projects. The Delphi questionnaire recorded academic activities such as lectures, scientific papers and the number of research students involved, and they contributed to the impact score. The use of policy, science, agriculture, industry, consumers and training as categories for the responses ensured that the Delphi process covered a wide range of areas. Some of these were affected by intermediate outputs and some by direct outputs. As mentioned above, researchers need to be aware of the impacts and benefits of their research across the full spectrum of society and include both intermediate and final outputs when involved in evaluations.

Improving evaluations

Information gathered during an evaluation must be useful. The responses to the questionnaire show there is scope for project coordinators to have a fuller appreciation of the impact of their work in non-target sectors. To rate projects as having a zero impact on policy perhaps fails to give full credit to the rigour of research scrutiny carried out by policy-makers – although it may not be immediately apparent. Similarly, most projects will be capable of having some impact on the consumer sector, even if the immediate beneficiaries are the agricultural and industry sectors.

The mobility of academic staff, particularly rising young researchers, means expertise can move on very soon after work finishes. The impacts of this can be twofold. It deprives the evaluation teams of useful contacts and feedback, and it deprives the post-project technology transfer work of direct knowledge and generally high levels of enthusiasm. The EC initiatives mentioned under 'Technology transfer' above go some way to redressing this problem.

Recommendations

1. Given the only partial response to the impact survey, ways of encouraging participation of all EC research funding beneficiaries need to be investigated.

2. Involvement with the impact evaluation needs to be included as part of the initial project planning.

3. The period immediately after a project finishes is a time when the impact of continuing technology transfer can be lost, especially if staff move on to other work. Management of this period needs careful attention.

4. The Delphi process has proved itself to be a useful methodology, but there is scope for modifying the operation of expert panels and ensuring a shorter time frame for the iteration process.

5. Projects with a socio-economic element rely on the activities of administrators and politicians for their ultimate implementation. These should be included in the fabric of the projects in much the same way as farmers and commercial partners are involved in the development of science and technology studies.

Contributors

This project was carried out by ADAS (UK)

The following past and present members of ADAS Consulting contributed to the AGRI-IMP evaluation which provides the basic information for this report.

Adrian Armstrong	**Project co-ordinator to August 2003**
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In addition, the impact assessment panel was joined by Ciaran Mangan and Sjur Baardsen from the European Commission's Research DG. Their contributions were valued by the group.

List of publications

- Plant Genomics and Biotechnology for sustainable and competitive agriculture
  ISBN: 92-894-6374-0
- Plant Health: Impact of EU Research (1998-2004)
  ISBN: 92-894-9026-8
- The Forestry Wood Chain: The impact of EU research (1998-2004)
  ISBN: 92-894-8248-6
- Genomics research in livestock. What does it offer?
  ISBN: 92-894-7091-7
- Foot and Mouth Disease and Swine Fever: The impact of EU research (1998-2004)
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- New vision on European food and agricultural research. Summary of EURAGRI conference Athens, 8-9 May 2003
  ISBN: 92-894-6260-4
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The Success Stories in this booklet have been drawn from the six sub-areas that go together to make up Area 4 of the FAIR programme funded under the Fourth Framework programme. FAIR is an acronym for the fourth framework specific RTD programme "Agriculture and Fisheries (including Agro-industry, Food technologies, Forestry, Aquaculture and Rural Development)". The projects span a very wide subject area and include successes such as instrumentation that allows water saving but maintains crop quality; silage systems that use less fertiliser, composting systems that overcome the problem of waste husks from olive pressing, and information to improve the welfare of chickens. Rural development issues are addressed by a project 'Development of rural areas' from sub-area 6 of the programme. This is a small selection of some of the best projects as selected by the impact assessment methodology use for the study. It presents 16 fascinating and useful projects. The reader is referred to the web sites of FAIR (www.cordis.lu/fair) or AGRINET (http://europa.eu.int/comm/research/agriculture/index_en.html) where more comprehensive details of agriculture and food related EU research programmes can be found.

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