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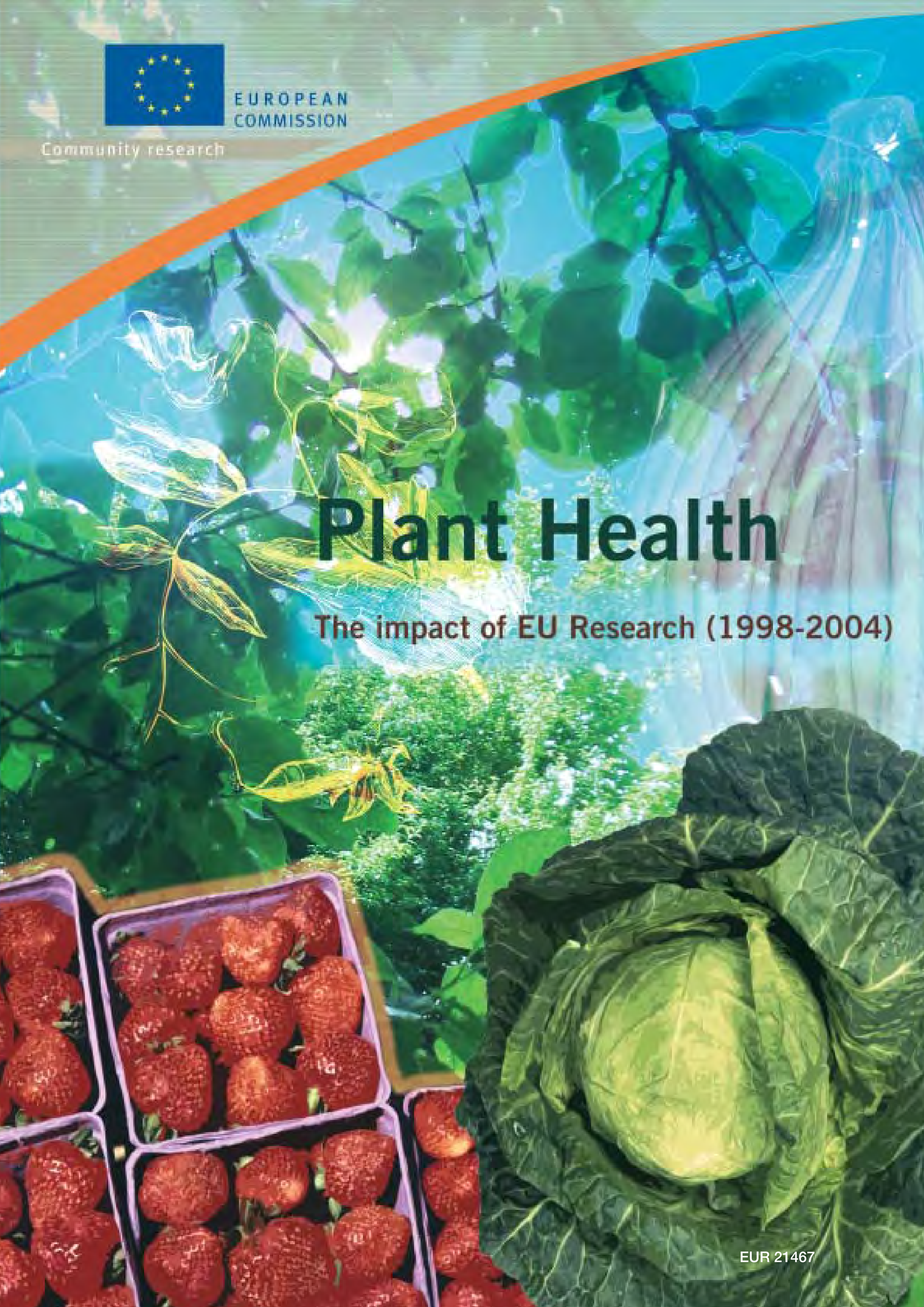

# Plant Health

## The impact of EU Research (1998-2004)

EUR 21467

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Cataloguing data can be found at the end of this publication.

Luxembourg: Office for Official Publications of the European Communities, 2005

ISBN 92-894-9026-8



*Printed in Belgium*

PRINTED ON WHITE CHLORINE-FREE PAPER


# Plant Health

## The impact of EU Research (1998-2004)

2005

Directorate-General for Research

EUR 21467

# Foreword

As Director of EU Biotechnology, Agriculture and Food Research it gives me great pleasure to present to you here the findings of the impact of Plant Health related research as funded by the European Union under the Fifth and Sixth Framework Programmes for Research and Technological Development.

Because of the importance of plant health and pesticides, not only for farmers but also for consumers, and for the environment, research on food chain issues related to crop protection, plant health, pesticides and associated biotechnology and genomics have always constituted an important part of the Framework Programme. The primary aim of this publication is thus to disseminate some of the plant health and pesticide results already obtained in completed and current projects. At the same time, the objective is to raise awareness of the opportunities open to academia and industry, especially small and medium enterprises, from both European and other countries in the ongoing and future Framework Programme.

Under the Fifth Framework Programme (FP5), which ran from 1998-2002, Key Action 5 addressed research issues of agricultural, fisheries and forestry with a budget of €520 M. The European Commission invited independent experts to carry out an extensive review of the impact of 47 of the most relevant plant health projects of the 400-plus projects funded in this key action. These 47 projects had a total operating budget of nearly €100 M and the review concluded that in most cases the projects carried out important multidisciplinary and complementary research which has provided very useful exploitable results for both industrial exploitation and which contributed towards EU policy support. The expert panel also identified future challenges for crop protection such as global climate change implications, a need for better understanding of agro-ecosystems as well as better ways to tackle consumer concerns over pesticides and GM crops. Eighteen of the 47 projects are reviewed in the publication as case study examples. Selected research projects under the Sixth Framework Programme (FP6), running from 2002 to 2006, have only begun but three of the most relevant selected projects are included in the eighteen.

Finally, strategies for the Seventh Framework Programme are currently being developed and debated across the European Union and this publication can be viewed as an important input to the process of drafting suitable future research topics for coverage under the annual work programme. In addition, the results in themselves have created a significant base for the further development of pesticide and plant health research in Europe with important implications for the consumer and farmer alike.

Christian Patermann
*Director of Biotechnology,*
*Agriculture and Food Research*

# Contents

# Introduction

This brochure presents the results of an evaluation of 47 research projects on plant and crop health that were funded under the EU's Fifth Framework Programme for Research and Technological Development. The evaluators' chosen top 15 projects are described in more detail in "Success stories" (pp 15-24). The results of nine of these projects were also presented at a seminar entitled 'EU-funded Pesticide Related Research' at Crop Science and Technology 2004 (Glasgow, UK, 1-3 November[1]). The lessons and the recommendations resulting from the Evaluation and the seminar discussion are summarised on pages 25-27. Finally, pages 28-31 offer a glimpse of the research projects on plant and crop health in the current Sixth Framework Programme and the future possibilities.

## In a nutshell

Agricultural research is the oldest of all research activities supported by the European Commission. It has been instrumental in securing Europe's supply of home-grown food, boosting agricultural productivity and reducing food prices across Europe. Today, EU agriculture faces new challenges. To ensure European competitiveness in the global market place the agricultural sector must be responsive to EU consumer demands, producing food and non-food products that are affordable, and that meet high standards of safety and quality. The products have to exploit local advantages and added values, and the production systems must be sustainable and environmentally friendly, making appropriate use of European rural heritage and natural resources. Research can contribute significantly to these new objectives of the Common Agricultural Policy, by providing a sound knowledge base and high-performance technologies exploitable by farmers, industry, policy-makers, regulatory bodies, and consumers.

## EU-funded plant health research

Farmers and the whole agri-food sector need healthy plants and crops and high-quality plant-derived materials. Crop health is essential to productivity, food and feed safety, and the quality, competitiveness, and exportability of agricultural products. Hence, research on important plant pests and diseases was already part of an EC-sponsored programme (AGRIRES 2C, 1979-1983) even before the launch of the First Framework Programme for Research and Technological Development (FP1, 1984-1987). From FP1 to the ongoing FP6, plant health research has continued to play an important role.

The 47 plant health projects covered by this publication were supported under the European Union's Fifth Framework Programme (FP5-1998-2002); Thematic Programme 'Quality of Life and Management of Living Resources' (QoL); Key Action 5 'Sustainable agriculture, fisheries and forestry, and integrated development of rural areas, including mountain areas'; Action Line 5.1, 'New and sustainable systems of production, including breeding methods and exploitation in agriculture, fisheries and aquaculture, taking into account profitability,

1) *http://europa.eu.int/comm/research/agriculture/events/conferences.html*

the sustainable management of resources, product quality and employment as well as animal health and welfare'. All QoL research projects were mission-oriented, with the overall aims of enhancing European citizens' quality of life and improving the competitiveness of European industry.

The plant health research addressed the challenges mentioned above of European competitiveness, sustainability and response to consumer demand.

- **Maintaining competitiveness**
  - Improving conventional, organic, and integrated farming systems;
  - Linking genetic research in plants with the exploitation of desirable characteristics (e.g. pest or disease resistance);
  - Using specific disciplines (e.g. biotechnology) for improved health of crops in various farming systems;
  - With regard to organisms especially harmful or difficult to control or posing a threat to free movement of goods and services:
    - studying their effects
    - developing new methods, tools, and solutions for their detection, prevention, control and/or eradication, for their classification and forecasting, or for risk assessment.

- **Sustainable use and management of resources**
  - Developing environment-friendly, added-value management of agricultural wastes;
  - Reducing levels of chemicals such as pesticide residues;
  - Studying the effect and fate of agrochemical inputs;
  - Exploring defence mechanisms of plants and ecosystems for breeding purposes or for biological control of pests, diseases, and weeds.

- **Meeting consumer needs and demands**
  - Analysing the impact of crop protection methods on the environment and food chain;
  - Replacing health- and environment-threatening substances and methods;
  - With regard to genetically modified organisms: developing technical solutions to avoid gene flow and unforeseen risks; measuring the persistence and effects of DNA in the environment.

Research on plant health has continued in the Sixth Framework Programme FP6 (2002-2006) with emphasis on the European Research Area (ERA) transcending national borders and promoting optimal synergy of Europe's top scientists and research centres. A special feature of FP6 Thematic Priority 5, 'Food Safety and Quality', is its integrative 'fork-to-farm' approach, which aims to inject safety/quality-boosting innovation into each key link of the food chain. Healthy crops in a healthy environment are one major part of this vision.

# Projects under the microscope
## Fifth Framework Programme

**In July 2004, independent experts appointed by the European Commission's Directorate-General for Research evaluated 47 plant health projects funded under QoL Key Action 5, Action line 5.1 (KA5.1), some already completed and others still progress. There were 33 RTD projects, one Demonstration Project, two Combined Projects, eight CRAFT (SME projects), and three Concerted Actions.**

The evaluation was based on a pro-forma focusing mainly on project management, KA5.1 objectives, industrial involvement, outputs, dissemination and training activities, result transfer to economically active end-users, potential longer-term impacts (scientific, economic and societal), and policy implications (support to policy, legislation, standards and information-based strategies). With a view to selecting projects for presentation at the Crop Science and Technology 2004 event, the experts shortlisted the top 15. The following presents an overview of the 47 projects.

## Scope and objectives

The 47 projects covered pathogens, pests, and pesticides. The shared common aim was to keep crops healthy while reducing or replacing inputs. Conventional, organic, and integrated farming were all covered (34%, 25%, and 41%, respectively).

Scientific targets were quarantine organisms (4 projects) and other harmful organisms (34), reducing levels of polluting agrochemicals (28), using advanced technology to improve plant health (23), understanding/exploiting plant and ecosystem defence mechanisms (19), and replacing harmful compounds/methods (13).

Twenty-one projects specifically aimed at the transfer of results to economically active end-users, 24 at implementation in other ways and seven at studying the cost/acceptability of new solutions or of complementary and multidisciplinary effects. Six projects included improvement of well-being and three covered contributions to the international dimension.

## Outputs and impacts

Outputs – achieved or anticipated in the short term – were diverse. Experts noted new knowledge (42 projects), patent applications (up to 4 projects), and innovations in the form of new tests/methods (24), prototypes/products (17), software (4), production processes (8), services (6), and standards (3).

**The reviewers also highlighted likely longer-term impacts on:**

- **science:** validation of previous research (28 projects), generation of cutting-edge knowledge (23), improvement of existing communication (12), and instigation of further research (13);
- **policy/legislation** at EU (14) and national (7) levels and harmonisation of standards (8);
- **strategy:** eight projects were expected to lead to the development of information-based strategies;
- **producers/industry:** changes in practices or processes (22), new products (18), new uses/markets for existing products (3), improved raw materials (3), and improved profitability (19);
- **society:** environmental improvements (28), enhanced viability of rural communities (5), new access to information (5), and better working conditions (2).

## Farming systems, sustainability, and research

Conventional farming in the EU relies heavily on the use of fungicides, pesticides, weed-killers, and fertilisers. The use of these agrochemicals contributes substantially to production costs and may sometimes lead to the accumulation of residues in the environment and, potentially, in food. Here the sustainability imperative translates as pressure to reduce these inputs or replace toxic ones. This is a focus for research.

In organic farming, certain agrochemicals and practices used in conventional agriculture are banned. Research is needed to enhance the range of 'natural' alternatives and to establish the economic viability of this growing sector more firmly.

Integrated farming does not exclude *a priori* any practice or technology, provided it contributes to an environmentally sound, economically viable, and socially acceptable system. Integrated farming thus welcomes novel cost-effective and environment-friendly plant health solutions.

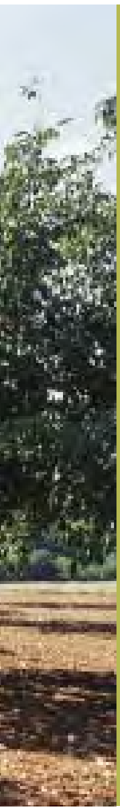
## Management and achievements

Most of the projects were judged to be well managed. The quality of progress monitoring and communication among partners was rated "excellent" (10 projects), "standard" (32), or "poor".

Progress was measured against deliverables and milestones listed in each project's technical annex. In the main, delayed deliverables (26 projects) reflected scientific problems, technical bottle-necks, or external factors (a late start, bad weather for field trials...). Deviations from the initial work plan were also noted. In most cases, delays and changes did not prevent the output of valuable science and promising technology. Changes of consortium were noted in 5 projects. Some changes were judged a hindrance to progress, others an enrichment (added competence).

The following section "Zooming In" provides a more detailed area-by-area look at the projects, starting with those concerned with production systems.

# Zooming in



## Area 1 – Production systems

The projects within Area 1 (see list below) focused on farming practices. Nine projects explored ways to limit or avoid the use of pesticides or weed-killers. Three aimed to recycle plant wastes into environment-friendly, plant-health-promoting products. The objective of one project, a Concerted Action (CA), was to collate and analyse all available knowledge on asparagus decline, a major threat to the profitability of asparagus production. Scientific objectives included environment-friendly waste management, reducing agrochemical residue levels, dealing with harmful organisms, understanding and exploiting plant defence mechanisms, and replacing harmful substances or methods (all key objectives of KA5.1). As to results:

- a prototype multisensor platform for early detection of disease in crops (permitting localised early treatment);
- a map-based 'intelligent' precision sprayer for orchards (taking tree shape and foliage volume into account);
- packaged biocontrol agents;
- plastic films for photocontrol of pathogens and optimal plant development;
- pathogen-free composts and methods for their standardised production;
- potentially, model-based intercropping strategies for organic farming.

One project had yielded a patent application. Notable outputs of the CA included a database, a handbook for growers, quality assurance and resistance-breeding guidelines, and a proposal for joint research.

Five consortia included SME partners and three had outside industrial contacts. Transfer of results to economically active end-users was judged to be good in ten cases. Evaluators predicted favourable economic impacts through new practices (8 projects), new products/new uses for existing products (8), improved raw materials (3), and increased profitability (7), although in one case there appeared to be no clear exploitation plan. Other expected benefits were: generation of cutting-edge knowledge (3 projects), validation of previous findings (7), improvement of pre-existing communication (5), environmental improvements (7 projects), better working conditions (2), enhanced viability of rural communities (1), better access to information (the CA), and instigation of further research (3). Potential impacts on policy, legislation, or standards were also highlighted (5). Management was judged satisfactory in all cases. Despite delayed deliverables in six projects, the achievability of project objectives was questioned in only one. Five projects included training, while eight boasted dissemination activities: demonstrations, publications, conference presentations, good websites, etc.

Two projects in this area received a rather low overall rating. In one case, the partners had omitted an important early step in their methodology to ensure that the results of different teams would be comparable. In the second case, an evaluator pinpointed 'exaggerated' secrecy leading to isolation and poor reporting.

A noteworthy originality in Area 1 was the presence of a highly successful 'project cluster' consisting of two projects addressing different aspects of the same goal: development of plant-health-promoting composts. The rationale for project clustering is that it should favour optimal synergy and research integration (the project clusters of FP5 prefigure the new instruments FP6).

## Area 1 – Project list

- QLK5-CT-2001-70473, Grape must and distillery waste disintegration for agricultural use by low impact technologies (AMBITECH)
- QLK5-CT-1999-3086, Asparagus: integrating research on decline in Europe (ASPIRE)
- QLK5-CT-1999-01065, Development of biocontrol agents for commercial application against post-harvest diseases of perishable foods (BIOPOSTHARVEST)
- QLK5-CT-2001-70484, Development of an environmentally friendly protection of sweet pepper and strawberry (BIOPROTECT)
- QLRT-CT-2000-01442, Management of soil health in horticulture using compost (COMPOST MANAGEMENT)
- QLRT-CT-2000-01967, Fate and toxicity of allelochemicals (natural plant toxins) in relation to environment and consumer (FATEALLCHEM)
- QLK5-CT-2002-02352, Intercropping of cereals and grain legumes for increased production, weed control, improved product quality and

prevention of N-losses in European organic farming systems (INTERCROP)
- QLK5-CT-1999-01280, Development of an optical detection system for diseases in field crops with a view to reducing pesticides by targeted application (OPTIDIS)
- QLK5-CT-1999-01630, Tree shape and foliage volume-map guided precision orchard sprayer (PRECI-SPRAY)
- QLRT-CT-2000-01458, Recycling horticultural wastes to produce pathogen suppressant composts for sustainable vegetable crop production (RECOVEG)
- QLK5-CT-2001-70496, Development of greenhouse foils and additives to optimise plant growth and disease inhibition through control of photomorphogenesis (SPECTRAFOIL)
- QLK5-CT-2002-02239, Seed treatments for organic vegetable production (STOVE)
- QLK5-CT-2000-01418, Strategies for weed control in organic farming (WECOF)

## Area 2 – Fungal and bacterial diseases

The Area 2 projects (see list below) focused on bacteria and fungi responsible for crop diseases, post-harvest losses, and/or the presence of toxins in food. The objectives and scientific objectives were, for the large part, the same those of Area 1, except that, the emphasis was more molecular – biotechnology for plant health was much more prominent (7 projects), and waste management was not addressed. Area 2 projects stressed risk assessment, diagnostics, alternatives to pesticides, and breeding for resistance to pathogens. The latter concentrated on tools for marker-assisted selection (MAS), i.e. selective breeding on the basis of genetic markers associated with desirable plant features. Resistance deployment and management were also dealt with because evolving pathogens can eventually 'break' plant resistances.

The evaluation showed that these projects were actively yielding knowledge (9 projects) and new methods/tests (7), prototypes/products (3), and standards (1). A new service was on the horizon, based on diagnostic chips for quarantine potato pathogens (not limited to bacteria and fungi). One consortium had unravelled a complex biochemical pathway, paving the way for commercialisation of at least one novel environment-friendly plant protector. A prototype device for quantifying a disease agent in soil, breeding/selection tools, and mathematical models were other notable outputs. A patent application was also mentioned.

Predicted longer-term impacts included cutting-edge science (7 projects), better access to information (2), an improved environment (3), improved viability of rural communities (1), and a boost to the production sector or industry through increased profitability (3), changed practices (2), new products (1), and/or new uses for existing products (1).

Three projects in this group had a policy focus. One was developing diagnostic chips for the implementation of EU Plant Health Directive 77/93/EEC. Another was addressing the future EU ban on copper-based fungicides in organic farming (concluding that it may be premature). And the third, pinpointed by the evaluators, was assessing the risk that karnal bunt, a disease affecting wheat crops in other parts of the world, might spread to Europe. This raises policy issues such as: are trade barriers justified in this context? What preventive strategies can the EU adopt? If the disease should appear in Europe, are there measures that can be taken to contain/eradicate it?

Seven consortia included industrial partners and three were transferring results to economically active end-users. Dissemination was under way in all projects and training in three.

## Area 2 – Project list

- QLK5-CT-1999-01065, Development of a systems approach for the management of late blight in EU organic potato production (BLIGHT-MOP)
- QLRT-CT-2000-02270, Feasibility of an EU plant health directive (77/93/EEC) diagnostic chip (DIAG-CHIP)
- QLK5-CT-1999-01583, Induction of pathogen resistance in fruit trees by transiently altering the flavonoid metabolism with specific enzyme inhibitors (ERWINIA)
- QLK5-CT-2002-00971, Potato Late Blight Network for Europe (EUCABLIGHT)
- QLRT-CT-2000-02044, Novel tools for developing fusarium-resistant and toxin-free wheat for Europe (FUCOMYR)
- QLK5-CT-1999-01554, Risks associated with *Tilletia indica*, the newly-listed EU quarantine pathogen, the cause of Karnal bunt in wheat (KARNAL BUNT RISKS)
- QLK5-CT-2002-00914, Exploiting the genomes of diverse Pseudomonas biocontrol strains for sustainable agriculture, to protect the environment and to improve human health by production of healthy food (PSEUDOMICS)
- QLK5-CT-1999-31517, Sustainability, product safety and quality in cereals: development of novel quantitative models for risk assessment for mycotoxigenic Fusarium species (RAMFIC)
- QLK5-CT-2002-01813, Stem canker of oilseed rape: molecular tools and mathematical modelling to deploy durable resistance (SECURE)
- QLK5-CT-1999-01523, Verticillium wilt in tree species: developing essential elements for integrated and innovative management strategies (VERTICILLIUM WILT IN TREES)

## Area 3 – Viral diseases

Viruses cause important plant diseases. Many are established in Europe; and there are many others which might arrive. Currently, there are no quick, sensitive, reliable detection methods for many of these viruses.

Three of the projects in this area (see list below) were developing improved diagnostic tools for detection of plant viruses or their vectors, another three projects focused on plant resistance to viral attack and one was exploring an interesting form of biocontrol countering virulent viruses with mild ones.

The plant-resistance projects embodied two different strategies: developing tools for MAS (2 projects) and genetic modification (GM, 1 project). The latter had the innovative goal of engineering grapevines (and rootstock) so as to produce antiviral antibody fragments normally produced by animals.

The projects were judged to be actively yielding knowledge (all projects) and innovations (five projects). Full sequences of viral genomes, molecular tools for virus and vector detection, and the discovery of a new 'resistance gene' in barley were among the notable achievements. Other KA5.1 objectives were also achieved: reducing environmental pollutant levels, understanding plant defence mechanisms, and replacing harmful substances and methods.

Reviewers noted potential economic benefits from all projects in this area, mainly in the form of new products. Five Area 3 projects included industrial partners but only two scored highly for their efforts to reach economically active end-users. The absence of industrial involvement in one project was seen as a potential obstacle to result transfer. In another case, the development of prototype diagnostic kits had provided proof of concept for an interesting approach, but it was felt that the emergence of a competitive, high-performance commercial product was still a long way off.

Other predicted impacts included: creation of cutting-edge knowledge (2 projects), validation of existing knowledge (4), instigation of new research (1), environmental improvements (4), and enhanced viability of rural communities (1). Interestingly, one evaluator also highlighted 'improved animal welfare' because the project in question aimed to develop a substitute for diagnostic tests based on antibodies produced by animals. Policy or regulatory implications were highlighted in three projects.

Overall management was judged satisfactory in all cases except one. Detailed problems included delayed deliverables (4 projects) and major work-plan changes (4). In two projects, evaluators acknowledged substantial achievements but regarded the given final objectives as overambitious.

Scores for training (4 projects) and dissemination (all six) were high, but the evaluators were not satisfied with any of the Area 3 websites (five projects visited). In one case dissemination was limited to a website which one evaluator described as 'empty'. One consortium was praised for active dissemination outside the scientific community, notably to growers.

## Area 3 – Project list

- QLK5-CT-1999-01116, Standard test kits incorporating novel antibody fusion proteins to detect harmful viruses (AFPTEST)
- QLK5-CT-1999-01471, Development of diagnostic tools and host plant resistance to control the rapid spread of lettuce big-vein and ring necrosis disease in leafy vegetables (DISCOVAR)
- QLK5-CT-2002-70996, Biological suppression of severe plant viruses (POTYPROTECT)
- QLK5-CT-2001-01183, Engineering durable pathogen resistance in grapevine: A novel strategy for integrated disease management to overcome environmental impacts of pesticides (RESISTANCE IN GRAPEVINE)
- QLK5-CT-2002-71855, Improved utilisation of new genetic resources in resistance breeding against soil-borne viruses in barley and wheat by the use of molecular markers (VIRRES)
- QLK5-CT-1999-01553, Improved diagnostic tools for the certification of strawberry propagation material (VIRUS DETECTOR)

## Area 4 – Pests and pesticides

Animal pests that threaten crops include insects and arachnids, and nematode worms. They are often controlled with potent pesticides. They also have natural enemies that infect, prey on, or parasitise them, thereby constituting potential biocontrol agents. The projects of Area 4 (see list below) dealt with pests, pesticides, and alternative means of control.

There were two distinct groups among these projects. The first (2 projects) focused on predicting the (eco-)toxicity of new pesticides, with a view to facilitating their development and registration. Both received a high overall rating. One consortium aimed to create and validate new software capable of predicting toxicity on the basis of quantitative structure-activity relationships. The second sought to develop a standardised framework for choosing and using probabilistic risk assessment methods, with guidelines for reporting on results.

This group reflected KA5.1 objectives through its focus on the effects of chemical inputs and on the transfer of tools to end-users (pesticide companies and regulatory authorities). Outputs were useful new knowledge and new methods and software. Both projects had potential regulatory implications and seemed likely to benefit the pesticide industry (facilitated registration, increased profitability) but the evaluators were less confident that environmental or consumer benefits would arise from this work. They felt that research should also address the question: which risk assessment strategy is safer, the use of prediction tools or an approach based on case studies and experimentation? They also expressed disappointment that the projects targeted their

dissemination at a rather narrow group of end-users (companies and regulatory bodies). They called for measures such as free public access to project outputs (websites, software, databases, assessment results, etc.), contacts with environmentalist NGOs, and presentation of this research at the Crop Science and Technology 2004 event. The aim should be transparency. In fact one of these projects was indeed presented at the event.

The second group (7 projects) focused on environment-friendly pest control strategies. The range of options explored was wide: biocontrol, mating disruption, luring and trapping, preventing egg-laying, examining the potential of a fungal insecticide, and producing pest-resistant plants by MAS or genetic modification. These goals correspond well with KA5.1 scientific objectives. Generation of useful new knowledge, notably on pest behaviour, ecological aspects, and plant-pest interactions, was intense in this area.

Examples of emerging innovations (five projects) included: new biocontrol agents, traps/lures, a data package for registration of a natural pesticide, a mating-disruption system, resistant cultivars, useful genetic material, and a geographical information-system-based tool for predicting the effectiveness of control. The area scored well as regards potential economic benefits (new products, changed processes, increased profitability). Five consortia counted industrial partners and four were addressing transfer of results to end-users.

Expected longer-term scientific achievements ranged from cutting-edge knowledge (6 projects) and validation of existing knowledge (5) to improved communication (3), better access to information (1), and instigation of future research (2). Six projects had potential implications for policy or legislation. Environmental improvement (all 7 projects) and improved viability of rural communities (1) also emerged as likely impacts. In Area 4, management was rated 'standard' to 'excellent' in six cases, 'poor' in one (where the coordinator had changed during the course of the project), and 'uncertain' in two instances. The latter reflected poor reporting. Five consortia had experienced difficulties and delays but none had substantially changed the work plan. Dissemination activities were mentioned for four projects and training for three. In one case, an evaluator recommended additional measures (e.g. specific grower training) to ensure optimal exploitation of results.

## Area 4 – Project list

- QLK5-CT-2002-00691, Development of Environmental Modules for Evaluation of Toxicity of Pesticide Residues in Agriculture (DEMETRA)
- QLK5-CT-1999-01110, Threat to European maize production by invasive quarantine pest, Western corn rootworm (*Diabrotica virgifera virgifera*): a new sustainable crop management approach (DIABROTICA)
- QLK5-CT-1999-01462, Durable resistance management of the soil-borne quarantine nematode pests *Meloidogyne chitwoodi* and *M. fallax* (DREAM)
- QLK5-CT-1999-01118, Protecting biodiversity through the development of environmentally sustainable locust and grasshopper control (ESLOCO)
- QLK5-CT-2002-01346, Concerted Action to develop a European Framework for probabilistic risk assessment of the environmental impacts of pesticides (EUFRAM)
- QLRT-CT-2000-01447, Integrated pest management strategies incorporating bio-control for European oilseed rape pests (MASTER)
- QLK5-CT-1999-01501, Making plants resistant to plant parasitic nematodes: no access – no feeding (NONEMA)
- QLK5-CT-2001-70693, Pesticide Reduction In Mushroom cultivation in Europe (PRIME)
- QLK5-CT-2002-71135, Replacement of insecticide treatment on apples by a pheromone based control approach for codling moth (NEW INSECT CONTROL)

## Area 5 – Breeding and genetic improvement

Plants have natural genetic resistance to pests and diseases. All the projects within Area 5 (see list below) aimed to exploit genomic findings for resistance breeding or for engineering resistance into plants. The KA5.1 scientific objectives covered were: dealing with harmful organisms, reducing pollutant levels, replacing harmful compounds, and measuring the persistence and effects of DNA in the environment.

This research followed four main lines. One consortium was constructing a physical and functional map of the potato genome. In another project, the idea was to gain knowledge of natural plant protectors by studying the effects of genetic modifications in a model plant (and to apply that knowledge to ornamentals). Four projects were developing plant populations and molecular tools for MAS. One of these, focusing on roses, stressed conservation of biodiversity among wild relatives of cultured varieties, seen as an essential source of resistance genes. The remaining three projects aimed to improve plants through genetic modification.

The 'genetic modification' projects in Area 5 illustrate the effort to make GM crops that will be acceptable to EU consumers and environmentalists, notably through environmental risk assessment and an analysis of socio-economic benefits and ethical issues. Scientists were working on strategies such as deriving 'payload' genes from the plant species to be modified, eliminating non-payload genetic material ('clean vector' technology), and avoiding gene flow by introducing payload genes into closed plant structures (to prevent their spread through pollination).

All projects were generating important new knowledge (resistance mechanisms, GM effects on soil ecology, genomic data, etc.). Three had yielded new or improved methods (e.g. for ecotoxicity testing). Two were developing new software (for instance, a rule-based model for assessing the economic value and environmental impact of GM plants).

Seven of the consortia included industrial partners and one had significant outside contacts with industry. At least three had taken steps to ensure transfer of results to end-users. Evaluators predicted economic benefits in the form of changes in practices, new products, and increased profitability. Other expected impacts included generation of cutting-edge knowledge (5 projects), validation of existing knowledge (5), improved communication (2), instigation of future research (3), environmental improvements (7), increased viability of rural communities (1), and better access to information (1). Two projects were noted as having policy implications.

Project management was generally satisfactory but reporting was sometimes poor. One project's output was judged rather slim. In another case, project achievements were qualified as 'interesting', but the project was considered 'too ambitious'. All projects had initiated dissemination activities and six included training.

## Area 5 – Project list

- QLK5-CT-2002-01849, Developing a physical achangend functional map of potato: creating new sources for molecular markers to breed cultivars with multiple resistances and quality traits (APOPHYS)
- QLK5-CT-2002-01666, Soil ecological and economic evaluation of genetically modified crops (ECOGENE)
- QLK5-CT-2002-02307, Faba bean breeding for sustainable agriculture (EUFABA)
- QLK5-CT-1999-01484, European rice: transgenes for crop protection against fungal diseases (EURICE)
- QLK5-CT-2002-01278, Genetic evaluation of European rose resources for conservation and horticultural use (GENEROSE)
- QLK5-CT-2002-01492, High-quality disease resistant apples for a sustainable agriculture (HiDRAS)
- QLK5-CT-2002-70866, Resistance breeding against the barley leaf spot complex, a new barley disease in Europe (BARRACUDA)
- QLK5-CT-1999-01479, Sustainable production of transgenic strawberry plants. Ethical consequences and potetional effect on producers, environment and consumers (TSP-EEES)
- QLRT-CT-2000-02445, Natural oxylipins and defence in ornamentals (NODO)

# Success stories
## (Fifth Framework Programme)

# In the BCPC showcase

Here are summaries of the nine KA5.1 plant health projects selected for presentation at the one-day seminar on EU-Funded Pesticide Related Research, one of six BCPC seminars constituting the core of the Crop Science and Technology 2004 event.

## EUFRAM
## Assessing environmental risk

Under EU Directive 91/414/EEC, Member States must assess the ecotoxicity of new pesticides before authorising their sale. Current risk assessment methods are predominantly 'deterministic', i.e. they use fixed values for toxicity, exposure, and risk. However, fixed values fail to reflect uncertainty and the variability of real situations. To compensate for this, deterministic assessments tend to use safety factors and worst-case assumptions, which could lead to overestimating the risk.

An alternative strategy is to replace the fixed values representing toxicity, exposure, and risk by probabilistic distributions. This is called 'probabilistic' risk assessment. In 2001, a workshop supported by the EU on 'probabilistic risk assessment for the environmental impacts of plant protection products' concluded that this approach could be useful for pesticides, within a context to be determined by further study. These conclusions prompted support, within QoL KA5.1, for a 'Concerted Action to develop a European framework for probabilistic risk assessment of the environmental impacts of pesticides' (EUFRAM, January 2003-December 2006).

EUFRAM objectives include investigation of the role and outputs of probabilistic assessments, methods of uncertainty analysis, and probabilistic methods for typical datasets. Other issues examined are reporting and result dissemination, validation of probabilistic methods, evaluation of software and databases, and how to improve access to existing data.

The project is divided into two phases: an initial stage leading to production of a draft framework document on the basis of nine preliminary papers, and a phase in which end-users (pesticide companies and regulators) will test the probabilistic approach in their own work. Three seminars will punctuate this second phase: one for end-user training, one for sharing experiences, and one for feedback and document revision.

The EUFRAM partners are also establishing a network which anyone who is interested is invited to join by accessing the project website.

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# DIABROTICA
## Invasive pest prevention


The Western Corn Rootworm (WCR) is a beetle larva. It can devastate maize crops. Long known in America, it made its first European appearance near Belgrade in 1992. Since then it has spread to more than 15 European countries, as far west as Northern Italy, Switzerland and France. In order to develop effective pest management and containment strategies, it is important to know more about WCR persistence and spread in the European agricultural context. This was the aim of a project entitled 'Threat to European maize production by the invasive quarantine pest, Western Corn Rootworm (*Diabrotica virgifera virgifera*): a new sustainable crop management approach' (DIABROTICA). The project partners studied many aspects of WCR behaviour and ecology, notably in relation to agricultural practices. They also examined the costs/benefits of containment strategies and the likely economic consequences of further dispersal.

The project has yielded a useful tool (an improved trap for WCR monitoring) and a wealth of new knowledge. For instance, findings suggest that resistance breeding should be feasible. On the other hand, it appears that the pest can feed on a variety of grass species and lay its eggs on crops other than maize. This probably enables the beetle to persist at low population density even in areas where corn is not grown. Yet it would seem that selective pressure on the beetle to adapt to new hosts is low.

Project partners have identified high-risk areas and have estimated economic losses in case of an invasion. In simulations they have shown that containment measures should reduce the rate of spread considerably. A cost-benefit analysis reveals that a one-year eradication programme near key airports (airports are points of entry for stowaway beetles) would cost about €185 000 compared to predicted economic losses totalling €35 million over the ten-year period following WCR establishment.

Furthermore, research indicates that because the generational mortality of WCR (99%) is offset by high fecundity, a further third of the survivors would have to be killed in order to stop population increase. Biocontrol might be the answer, but the pest appears to have no natural enemies in Europe. A parasitic fly found in Mexico shows potential as a biocontrol agent, but further study is needed before envisaging its release in Europe.

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# BIOPOSTHARVEST
## Developing biocontrol agents

Post-harvest losses due to contaminating fungi are a major problem in the EU and worldwide. Traditionally, fungicides are used to control post-harvest 'diseases', but society is calling for the development of environment-friendly alternatives. A promising new approach is biocontrol, i.e. the use of microbial antagonists of the organisms that cause post-harvest spoilage. This was the focus of the project 'Development of biocontrol agents for commercial application against post-harvest diseases of perishable foods' (BIOPOST-HARVEST).

The consortium consisted of seven universities, four research centres, eight small and medium-sized enterprises (SMEs), two agrochemical companies, and six packing houses. Its general objective was to develop commercial biocontrol agents for citrus, stone and pome fruits, and moist cereals. The starting point was a set of four agents (a bacterium, a mould, and two yeasts) known for their biocontrol properties. Project tasks included developing molecular markers of these agents (for tracking their fate in the environment), studying their mode of action, optimising their production and formulation, and conducting pilot and commercial trials combining their use with physicochemical treatments (heating and treatment with non-toxic compounds).

The project was highly successful in terms of both knowledge generation and concrete outputs. Reliable, simple, low-cost production processes and convenient packagings were developed for all four biocontrol agents (BCAs). In experimental trials, optimal protection of citrus fruits against penicillium moulds was achieved by combining two post-harvest treatments: heating at 40°C in 3% bicarbonate, and treament with the BCA *Pantoea agglomerans*. The best treatment for peaches and nectarines appeared to be chemicals at flowering and BCA treatment (*Epicoccum nigrum*) before harvest. Wheat was effectively treated with the yeast *Pichia anomala*, and the biocontrol agent *Candida sake* proved as effective as fungicides against fungus-induced spoilage of apples and pears.

The partners have publicised their findings on a website (www.biopostharvest.org), and in 20 research papers, seven magazine articles, 36 oral communications and 15 posters (at conferences, workshops, symposia). An international workshop was held in the framework of the project, and the book of abstracts from this event is downloadable from the project website.

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# RECOVEG - COMPOST MANAGEMENT
## Composts for plant health

Plant-based composts are used, notably in horticulture, as a nutrient source and for soil amendment. They also display plant-disease-suppressing properties. In addition, composting can be a good way to recycle plant-based wastes. To promote the optimal use of composts in horticulture and vegetable production, two KA5.1 plant health projects are pursuing common objectives: to identify composting conditions required to eradicate pathogens from organic wastes, and to explore the mechanisms whereby composts suppress soil-borne plant diseases. These projects are RECOVEG (Recycling horticultural wastes to produce pathogen suppressant composts for sustainable vegetable crop production) and COMPOST MANAGEMENT (Management of soil health in horticulture using compost).

The specific goal of RECOVEG is to develop methods for recycling plant-based wastes into pest- and pathogen-free composts offering advantages for vegetable production. COMPOST MANAGEMENT is concentrating on suppression of soil-borne diseases in containerised crops. The two projects are 'clustered' for optimal synergy and research integration. One aspect of this collaboration is a focus on some of the same plant-based wastes. Selected green waste, spent mushroom compost, and olive waste have all been identified as promising materials for compost production.

Partners have successfully demonstrated disease suppression by compost addition in a number of plant-pathogen systems, but no single compost emerged as 'the best', as the magnitude of each compost's protective effects depended on the system studied. Studies have highlighted several chemicals potentially responsible for disease suppression, but in some cases a biological rather than a chemical mechanism is suspected. Teams have thus developed techniques for monitoring the species, structure, and dynamics of microbial communities associated with compost amendment. They hope to identify micro-organisms responsible for disease suppression. Partners are also studying the disease-suppressing properties of composts enriched with known biocontrol agents and suspected antagonists of plant pathogens.

This research has also yielded important information on composting conditions required to eliminate a range of plant viruses and pathogenic fungi. These results may help pave the way towards standardisation of compost processing at the EU level.

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## FUCOMYR
## Reducing mycotoxins in wheat

Wheat is Europe's most important cereal crop. An enemy of wheat growers is Fusarium Head Blight (FHB), a disease caused by fungi of the genus Fusarium. These organisms not only damage the developing wheat ear they also produce fungal poisons (mycotoxins) that accumulate in contaminated grains, threatening human and animal health.

Most wheat varieties currently grown in Europe are susceptible to FHB and no reliable, environmentally sound crop management or chemical control methods exist for the disease. Breeding for resistance may thus be the key to reducing mycotoxin contamination in wheat. The aim of the KA5.1 project 'Novel tools for developing Fusarium-resistant and toxin-free wheat for Europe' (FUCOMYR) is to produce efficient tools that will speed up development of new, FHB-resistant wheat varieties.

Genetic markers for marker-assisted selection of FHB-resistant germplasm are an important tool being developed within FUCOMYR. One line of research here focuses on 'candidate resistance genes', such as genes coding for detoxifying proteins or genes whose expression is stimulated by Fusarium infection. Another approach, called 'quantitative trait locus (QTL) mapping', involves correlating variations in FHB resistance within a wheat population with the variability of mapped markers on the wheat genome. This reveals 'quantitative trait loci', i.e. marker-delimited genome segments likely to carry gene variants contributing to resistance.

FHB resistance is a complex trait influenced by multiple genes and also by environmental factors. A prerequisite to QTL mapping was therefore to provide a detailed description of FHB resistance in wheat, based on a study of different resistance components (resistance towards initial attack, towards Fusarium growth, towards mycotoxins) and on measuring disease parameters in artificially inoculated plant populations (mapping populations and a screening nursery of genetically diverse wheat varieties). In addition, teams worked on characterising FHB resistance in the laboratory (development of a detached-leaf test).

FUCOMYR has yielded important results: better knowledge of resistance components and mechanisms, new resistance sources, new resistant breeding lines, a consensus map of FHB resistance in wheat, a promising *in vitro* strategy for resistance testing, a yeast-based system for identifying wheat genes conferring mycotoxin tolerance, etc. Breeders within the project consortium have already begun to incorporate FUCOMYR findings into their work.

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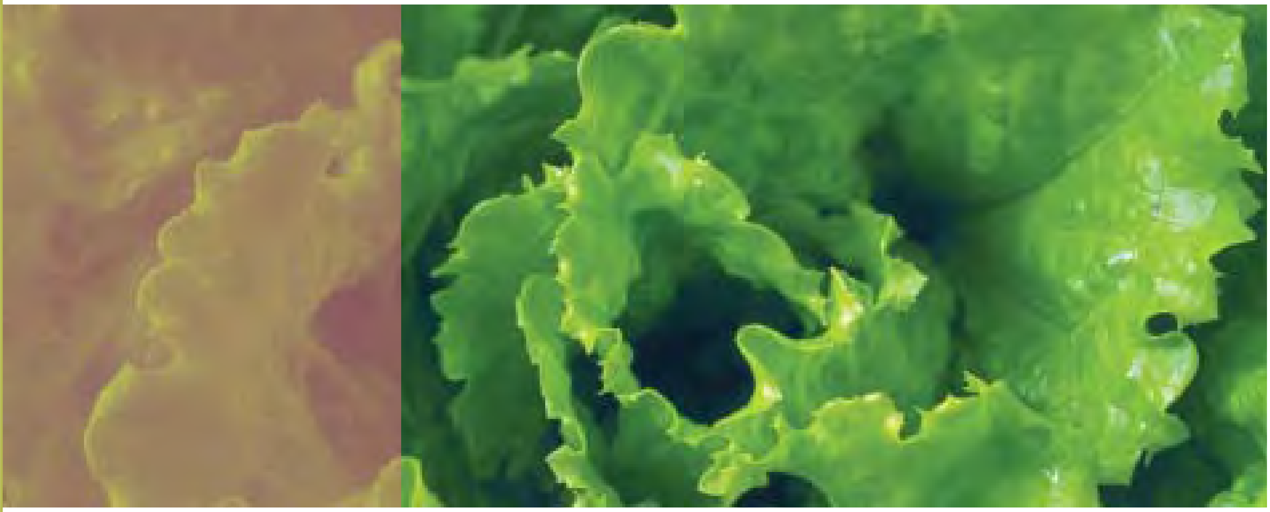
# DISCOVAR
## Lettuce viruses under attack



The project 'Development of diagnostic tools and host plant resistance to control the rapid spread of lettuce big vein and ring necrosis disease in leafy vegetables' (DISCOVAR) focused on two severe viral diseases affecting leafy vegetables worldwide: lettuce big-vein disease (LBV) and lettuce ring necrosis (LRN). In Europe alone, direct economic losses due to these rapidly spreading diseases exceed €50 million annually. The causative viruses are transmitted by a root-infecting fungus. When DISCOVAR was launched, neither of the agents had been adequately characterised and no reliable diagnostic tools were available.

Eradication of LBV and LRN seems practically impossible for several reasons: resting spores of the fungal vector can persist in soil for 15 years or more without losing the ability to transmit the virus, many vegetable crops and weeds can be symptomless carriers, and there is no known resistance in currently grown varieties. For control, growers rely on fungicides and soil sterilants, some of which are to be banned as chemical control has sometimes led to the presence of toxic residues in lettuce.

DISCOVAR objectives were to characterise the causative agents of LBV and LRN, to develop diagnostics for the viruses and their vector, to identify and exploit natural host resistance, and to develop a sustainable disease management system.

In the case of LBV, two viruses were purified from diseased plants: Mirafiori lettuce big vein virus (MiLBVV), causing typical LBV symptoms, and lettuce big vein associated virus (LBVaV), playing an unknown role. One virus (LRNV) was found in plants with LRN. Partners fully sequenced the genomes of MiLBVV and LRNV, proving in particular that they are different – albeit related – viruses, and assessing their variability across Europe.

Teams developed diagnostic tests offering quantification and sensitive, specific detection of the viruses and vector in breeding lines, weeds, soil, and irrigation water. Work also led to findings that will soon be exploited in breeding programmes: the identification and genetic characterisation of resistance in lettuce and endive. Lastly, partners devised a disease management system based on avoidance and improved hygiene measures (to be developed further). The consortium has been disseminating its results very actively, notably through the organisation of symposia for growers.

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# NONEMA
## Nematode-resistant GM plants

Parasitic nematodes (threadworms) affect many crops, causing severe losses. Current methods for controlling them are unsatisfactory: rotation of parasite-prone and parasite-resistant crops is not effective against broad-host-range nematodes, soil fumigation is environmentally unfriendly, available pesticides do not target nematodes specifically, and conventional resistance breeding is time-consuming, may alter quality traits, and tends to break down. To remedy this situation, the project 'Making plants resistant to plant-parasitic nematodes: no access - no feeding' (NONEMA) aims to engineer broad and durable nematode resistance into crop plants.

The idea is to erect barriers to nematode entry into, and feeding within, a host plant. A major task has been to identify plant and nematode proteins that contribute to these processes. This research has led to the identification of a dozen nematode pathogenicity factors. It has highlighted – for the first time in any animal – several cell-wall-degrading enzymes that nematodes secrete in order to penetrate plant roots. It has also revealed nematode proteins likely to participate in feeding site induction and plant proteins that parasites recruit for feeding site proliferation.

This knowledge has been exploited. RNA interference (blocking expression of target genes by means of double-stranded RNA) was used to block the synthesis of nematode-favouring proteins. Plants were transformed with constructs causing either a nematode gene or a plant gene to be silenced. In both cases, the modified plants looked normal but displayed resistance: parasite development was severely reduced and the few developing females contained no viable eggs. These results provide proof of concept for this novel approach.

The NONEMA partners are attuned to public concerns about genetically modified organisms. Their project highlights efforts within the scientific community to make GM solutions acceptable to EU citizens. In addition to the substantial advantages that plants engineered for durable resistance may offer, one important aspect of this project is the highly specific targeting of plant-parasitic nematodes via their interactions with plants. Furthermore, the NONEMA strategy involves restricting expression of the constructs introduced to key sites of parasite-host interaction and ensuring that they cannot spread into the environment or to other species.

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# NODO
## Exploiting plant defence mechanisms

Plants have evolved ways to defend themselves against microbes and pests. Plant oxylipins are among the compounds believed to participate in defence responses. Some oxylipins have antimicrobial properties and others may be regulators of defence gene expression. It is therefore imaginable to exploit them as 'green' agrochemicals or to boost their protective action through plant breeding or genetic engineering. The aim of the NODO project (Natural Oxylipins and Defence in Ornamentals) is to assess the potential of oxylipins as environmentally friendly plant protectors.

Specific NODO objectives are: (1) to evaluate the chemoprotective potential of oxylipins as sprays replacing agrochemical treatments that are soon to be banned; (2) to alter oxylipin synthesis in the model plant *Arabidopsis thaliana* by genetic modification, with a view to enhancing plant resistance; and (3) to apply the knowledge gained to ornamentals.

The work has progressed well. Partners have tested the toxicity of different oxylipins towards six bacterial pathogens, six fungal pathogens, and four insects. They have also studied effects of oxylipins on the expression of relevant *Arabidopsis* genes. From this work a number of promising oxylipins have emerged.

A prerequisite to oxylipin testing is the production of oxylipins in sufficient quantities. Partners have successfully synthesised over 73 different molecules, particularly ones that are expensive or not commercially available. An interesting approach was to express enzymes of oxylipin biosynthesis *in vitro* for use in semi-enzymatic oxylipin synthesis procedures.

Genetic modification of Arabidopsis has yielded transgenic lines where selected genes involved in oxylipin synthesis are either knocked out or over-expressed. To study these plants, teams have developed a powerful oxylipin profiling technique for the simultaneous analysis of more than 120 metabolites. The method is also being applied to ornamentals of the genus *Pelargonium* (e.g. geraniums) challenged with bacterial or fungal pathogens, in order to better understand the protective role of oxylipins in these plants.

The next step is to develop GM ornamentals with enhanced oxylipin synthesis conferring resistance to pests and pathogens.

This project should pave the way towards reducing the use of environmentally unfriendly pesticides and insecticides in horticulture while providing breeders with material for developing new, resistant pelargonium varieties.

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# More successful outcomes

**Here is a brief presentation of the other KA5.1 plant health projects ranked among the top 15 by the independent panel of experts.**

## APOPHYS
## Mapping the potato genome

Potato is the fourth most important field crop worldwide. Half of the world's potato-growing area lies in Europe. On the basis of a high-density genetic map, the APOPHYS project has yielded an important tool for marker-assisted breeding of new, improved potato varieties: a partial physical and functional map of the potato genome, emphasising strategically important genes and functions. APOPHYS findings will contribute towards the 'Potato Genome Initiative', an international endeavour aiming to sequence the entire potato genome by the end of 2008.

QLK5-CT-2002-01849, Developing a physical and functional map of potato: creating new sources for molecular markers to breed cultivars with multiple resistances and quality traits http://www/dpw.wau.nl/pv/projects/apohys/

## BARRACUDA
## Tackling barley leaf spot

Barley leaf spot is a new disease that has recently appeared in Europe among cereal crops. The fungus *Ramularia collo-cygni* has been pinpointed as a pathogenic factor, although environmental factors are also blamed. The BARRACUDA project aimed to improve understanding of the disease and its causes, to identify resistance sources in barley, and to generate knowledge and tools for resistance breeding. Noteworthy achievements include techniques for identifying, isolating, storing, and propagating the fungus, molecular markers for its detection in the host, and resistant breeding lines with which SME partners have begun a resistance-breeding programme.

QLK5-CT-2002-70866, Resistance breeding against the barley leaf spot complex, a new barley disease in Europe http://homepage.boku.ac.at/bistrich/barracudahome.htm

## ERWINA
## Environment-friendly plant protection

Focusing primarily on fire blight (a bacterial disease) and scab (a fungal disease) in apple and pear, the ERWINIA project partners have paved the way for commercial exploitation of a new, environment-friendly plant protector: the growth regulator prohexadione-Ca. They have demonstrated that although the compound exerts no direct antimicrobial action, it acts by stimulating a metabolic defence response in treated plants. They have cloned relevant plant genes and have fully elucidated the protective mechanism, identifying the active principle. The project's industrial partner has started commercialising prohexadione-Ca for fire blight control, and there is a possibility of developing at least one additional new product on the basis of project findings.

QLK5-CT-1999-01583, Induction of pathogen resistance in fruit trees by transiently altering the flavonoid metabolism with specific enzyme inhibitors http://www.weihenstephan.de/ob/-fireblight/fireblight_project_summary2002.htm

## EURICE
## Fungus-resistant GM rice

The aim of the EURICE project is to create fungus-resistant rice varieties by genetic modification. Interesting strategies include targeting payload genes to the chloroplasts to prevent gene flow by cross-pollination to non-GM cultivated and weedy rice, making their expression fungus-inducible to minimise their effects on the rice plant, and combining two defence genes to avoid resistance

breakdown. The project has yielded various transgene-expressing rice plants, some of which show enhanced resistance. Importantly, EURICE partners have studied spontaneous gene flow from transgenic to weedy rice and have established a reliable protocol for testing transgenic rice plants in the field without gene flow occurring. This has made it possible to begin evaluating GM lines in the field.

QLK5-CT-1999-01484, European rice: transgenes for crop protection against fungal diseases

## DEMETRA
## Predicting ecotoxicity

The aim of the DEMETRA[5] project is to produce software for predicting the ecotoxicity of pesticides and related compounds on the basis of their structure. The idea is to build and validate a hybrid system combining various algorithms based on quantitative structure-activity relationships established for five different end points (an end point refers to a specific organism with a specific administration route and a specific exposure time). This approach could guide the development of new pesticides, facilitate preparation of registration dossiers, and provide a tool for regulatory bodies.

[5]QLK5-CT-2002-00691, Development of Environmental Modules for Evaluation of Toxicity of pesticide Residues in Agriculture http://www.ecee.ugal.ro/looknou/PROJECTS/UNDERWAY/projects%20EUFP6.htm

## KARNAL BUNT RISKS
## Sound risk assessment

Karnal bunt is a fungal disease of wheat in other parts of the world but not in Europe; but the causative agent has been intercepted in imported grain. The appearance of karnal bunt in European crops would threaten EU wheat quality, yield, and exports. The KARNAL BUNT RISKS project aims to provide sound risk assessment tools and a science-based risk management strategy for the disease. The approach combines experimentation, modelling, and the use of geographical information systems. Achievements include predictive models, a socio-economic impact study, data on the survival of spores in soil under European conditions, identification of a fungicide that is effective against the disease, and screening methods for identifying alternative fungicides in case the pathogen should become resistant.

QLK5-CT-1999-01554, Risks associated with *Tilletia indica*, the newly-listed EU quarantine pathogen, the cause of karnal bunt in wheat

# Lessons and recommendations

**The independent reviewers indicated not only gaps and stumbling blocks in individual projects, but also some general conclusions:**

- **Fragmentation of research:** evaluators pinpointed fragmentation of effort as an obstacle to efficiency and to maximising the benefits of research for society. In specific cases they recommended either cross-connections between related projects or placing the research focus in a broader perspective.

- **Transferring/exploiting results:** several project consortia seemed to have experienced difficulties. Obstacles included, in one project, the lack of an industrial partner, in another, the absence of an exploitation plan, and in a third, unfamiliarity with intellectual property law regarding a patent application. Perhaps guidance is needed in this area. In the longer term, the career advancement of applied scientists might be geared more closely to the exploitation of results. In one instance, training of users had successfully achieved such transfer. This initiative seemed worth copying.

- **Improving contacts with society:** in a number of instances evaluators called for an increased effort as regards dissemination of results not only to specific end-users but also to European citizens in general. The benefits were seen as transparency and a constructive public debate.

- **Training of researchers:** this was mentioned in roughly half of the projects, suggesting it is a feature which could be strengthened.

## Growing awareness of things to come

At the end of the evaluation, the panel of independent experts discussed future research needs in the light of changes likely to affect crops over the next ten years:

- **Support for EU Regulations:** A review is under way of all active ingredients that are used in plant protection products within the European Union. The review was launched in 1992 and is due to be completed by 2008. Some of the research projects reviewed here will help to quantify the risks posed by particular active ingredients. There is now a need to extend this work. Legislators need to know if mixtures of ingredients pose extra risks. And if tests should indicate synergistic (non-additive) side effects, then it will be scientifically important to understand the underlying mechanisms.

- **Climate change:** models predict the increasing influence of global warming with warmer temperatures and more winter precipitation in Northern Europe, and increased severity of drought in Central and Southern Europe. This is likely to alter both crop distribution and the distribution and severity of diseases, pest infestations, but also beneficial organisms. To prepare EU agriculture and horticulture for these changes, experts called for reliable models of pest and disease reactions to climate change.

- **Exotic pathogens and pests:** individual countries may cite the danger of importing exotic pathogens and pests to justify stopping imports of crop products. Within the World Trade Organisation, a Sanitary and Phytosanitary Agreement has been adopted which requires countries to base such decisions on a pest risk analysis that clearly demonstrates both the absence of the pest or disease in the importing country and the reality of the risk. Hence research is needed, to deliver sound basic data and understanding for each of the (very large number of) potential risk organisms.

- **Evolving farming systems:** in the light of evolving farming systems and practices, the experts called for studies aiming to probe and compare the environmental effects of conventional, organic, and integrated farming systems, including systems using genetically modified organisms, and to build a knowledge base for landscape management in the future.

- **GM crops:** the experts thought it important to collect baseline environmental data before GM crops now in the pipeline are grown on a large scale. More knowledge and tools are required to monitor and manage GM crops, to assess their benefits and risks, and to predict their impacts on non-GM crops and on the environment. This research should involve the close collaboration of experts in multiple disciplines, policy-makers, and diverse stakeholders. The aim should be that acceptance / rejection of specific GM crops within integrated crop and pest management systems should be based on sound data and understanding.

- **Sustainable rural development:** the experts focused on obstacles to innovation in rural areas. They called for a major research effort to support sustainable rural development based on diversification of economic activities in these areas.

- **Other important topics:** diagnostic tools for pests and diseases, particularly for new quarantine organisms that tend to spread and for organisms that have become hard to control in the wake of pesticide withdrawals or resistance appearing in pests; low-energy-input crops; and environmentally friendly alternatives to agrochemicals (NB: the experts called for harmonised and simplified regulation and registration of such alternatives).

## Echoes from Glasgow

**After the formal presentations in the EU seminar held at Crop Science and Technology 2004, some 70 participants discussed plant health and crop protection research – present and future – in the European Union. The three points attracting the most discussion were:**

- EU-funded research has generated cutting-edge knowledge, both basic and applied, which will contribute substantially to improving crop health and to reducing pesticide use throughout Europe. It was hoped that future Framework Programmes would continue the work. Some pests and diseases pose a future threat to farm crops, others to forest trees and others again to the rural landscape. Experiences with new laboratory methodologies, and with new pests in the field, emphasise the importance to Europe of remaining at the cutting edge.

- The success stories demonstrate the utility of biotechnology and molecular genetics in solving difficult crop protection problems, with no possible threat to the environment. The science enables faster and more accurate diagnosis of pests and diseases. But an infrastructure of reference methods, standards and databases will be needed if the new diagnostic technologies are to be widely adopted.

- Experience of the Western Corn Rootworm, its establishment and spread in Europe, and the unexpected discovery that it can feed and survive on wheat roots and weeds, underlines the importance of reinforcing diagnostics and science-based risk assessment for quarantine pests and pathogens. It may also be timely to look afresh at research aspects of EU quarantine policy, for example to revise lists of quarantine organisms, to develop methodologies for protecting risk and impact of new pests, to strengthen the scientific basis of intervention strategies, to widen the basis of reference collections, working wherever possible in collaboration with partners in countries outside Europe where the pests are already established.

# The Sixth Framework Programme and beyond

As the remaining ongoing FP5 projects reap their harvest of achievements, the Sixth Framework Programme is in full swing. FP6 aims to integrate European research, to structure the ERA, and strengthen its foundations. Research is being carried out in seven Priority Thematic Areas (Life Sciences, Genomics and Biotechnology for Health; Information Technologies; Nanotechnologies; Aeronautics/ Space; Food Quality and Safety; Sustainable Development, Global Change and Ecosystems; Citizens and Governance) plus a broader area which notably includes anticipating science and technology needs and scientific support to policy. The main domain for plant health research is Thematic Priority 5 (TP5), 'Food Quality and Safety' (€680 million).

## ERA-building

In addition to traditional instruments, such as the Specific Targeted Research Projects, Coordination Action and Specific Support Actions, FP6 features two new ones: Networks of Excellence (NoE) and Integrated Projects (IP). NoE aim to integrate the critical mass of resources and expertise needed to give Europe the leading edge in any one specific topic. In IPs, teams working on different aspects of a problem or at different stages in the innovation chain coordinate their efforts. Training, dissemination, and interfacing with society are important in both cases.

Other prominent features of FP6 are ERA-NETs – i.e. networks of national and regional research programmes – and Technology Platforms (stakeholder forums), important because they are helping to shape the EU research agenda. The Technology Platform 'Plants for the Future' (http://www.epsoweb.org) is particularly relevant to plant and crop health.

## Food quality and safety

The 'fork-to-farm' approach of TP5 involves researching food chains and the farming environment with a view to health- and safety-boosting improvements. In the field of crop health there is a continued focus on new and problematic pests and diseases, non-chemical crop protection strategies, crop improvement, diagnostics, and risk assessment, with increased emphasis on the coexistence of GM and non-GM crops, on organic and low-input farming and their impacts on food and feed quality and safety.

The three FP6 crop health projects that were showcased at Crop Science and Technology 2004 are described below. At the time of writing there is a call for proposals for a Network of Excellence for the development and implementation of durable pest control strategies. For scientists, legislators, and farmers, such a network could become the first point of reference in Europe in its field.

## QualityLowInputFood
## Improving low-input food chains

'Improving quality and safety and reduction of cost in the European organic and "low input" food chains' (QualityLowInputFood) is an Integrated Project with four main objectives: (1) to enable producers to match expectations of consumers regarding the quality and nutritional value of foods produced in organic and other low-input farming systems; (2) to increase cost-efficiency along the food chains while improving or maintaining quality; (3) to contribute to minimising food safety risks, from production to the distribution stage and during food handling by consumers; and (4) to contribute to reducing fossil energy use and the environmental impact of organic and low-input farming.

The project combines consumer and nutrition studies with research focusing on crop and livestock production, food processing, quality assurance, and supply chains. Approximately 8% of the effort is devoted to 'horizontal activities' such as identifying socio-economic, environmental and sustainability impacts of project innovations, dissemination, and training (of junior scientists as well as users/stakeholders).

The project's main plant health components are: interactions between soil/fertility management and crop resistance, control of seed-borne diseases, control of mycotoxin-producing fungi, and the integrated use of non-chemical crop protection strategies.

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## HAIR
## Pesticide risk indicators

The project *Harmonised environmental indicators for pesticide risk* (HAIR) aims to provide a set of harmonised indicators for assessing the environmental and human health risks of pesticides, implemented in an easy-to-use software package. This tool will include methods for predicting exposure and the environmental fate of pesticides (including the risk of groundwater contamination), as well as health risks for pesticide handlers, the general public, and aquatic and terrestrial organisms.

The indicators being developed will support the task of monitoring and managing the overall risks of pesticides. They will contribute directly to EU environmental and sustainable agriculture policies.

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## MOSAICS
## Managing microbiological resources

Microbes can threaten plant as human and animal health, food contamination and spoilage. Access to microbiological resources and related information thus has strategic importance. It is the role of biological resource centres to provide this access. Their work is complicated by the complexity of the legal framework in which they operate: a tangle of international, supra-national, and national provisions ranging from those of the Convention on Biological Diversity on Access and Benefit-Sharing (ABS) to intellectual property rights and the regulations governing the flow of biological resources.

The project 'Development of a system for appropriate management of access to and transfer of microbiological resources' (MOSAICS) aims to create an integrated system for managing the ABS issues related to microbiological resources. Its operational objectives are to find ways to put a reliable 'value' on these resources, to develop standard documents and procedures for their registration and tracking and, finally, to integrate these aspects into a system for resource trading, with balanced benefit sharing for all parties entitled to be rewarded for their contribution.

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# On the horizon

On 6 April 2005, the European Commission launched its proposal for the Seventh Framework Programme (2007-2013). The proposed programme includes four components: **Capacities** (infrastructures and research for SMEs), **People** (human potential and science careers), **Ideas** (investigator-driven 'frontier' research under a newly created European Research Council), and **Co-operation** (receiving the bulk of EU research funding).

The overarching aim of the **Co-operation** component is sustainable development. This sub-programme should, in the main, span the same themes as FP6, plus an additional one: 'Security and Space'. As far as plant research is concerned, the most interesting opportunities are under the themes 'Biotechnology, Food and Agriculture' and 'Energy' (renewable fuel production), as well as the **Ideas** sub-programme.

The Commission proposal takes into account the views expressed during a very broad consultation with other EU institutions, the Member States, the scientific community, industry, and all stakeholders in European research. In particular, evaluations and workshop discussions similar to those highlighted in this brochure have contributed – and will continue to contribute – to shaping the future direction of EU-funded research.

# 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)
  ISBN: 92-894-9032-2
- Rural Development: The impact of EU research (1998-2004)
  ISBN: 92-894-8247-8
- Organic Food and Farming Research in Europe
  ISBN: 92-894-9600-2
- Towards a European knowledge-based bioeconomy, York University 2004
  ISBN: 92-894-8778-X
- Renewable biological materials for non-food use: The impact of EU research (1998-2004)
  ISBN: 92-894-8977-4
- Support to Common Agriculture Policy: The impact of EU research (1998-2004)
  ISBN: 92-894-9060.
- Key Action 5 External Advisory Group
  Report and opinion of research carried out under the European Commission's Fifth Framework Programme [1998-2002]
  ISBN: 92-894-5790-2
- Science for society. Science with society. How can research on food and agriculture in Europe better respond to citizen's expectations and demands? Summary of EURAGRI conference, Brussels, 14-15 October 2002
  ISBN: 92-894-5320-6
- New vision on European food and agricultural research. Summary of EURAGRI conference Athens, 8-9 May 2003
  ISBN: 92-894-6260-4
- Science for society. Science with society. Summary of the EURAGRI conference Brussels, 3-4 February 2005. How to adapt and use the knowledge base for an optimal functioning of the food-health-agriculture system in the European Union
  ISBN 92-894-9787-4
- Key Action 5. Sustainable agriculture, fisherties and forestry. Research projects. Volume 1 (1999-2001).
  ISBN: 92-894-0932-0
- Impact of EU Research, 16 agricultural success stories under the FAIR programme
  ISBN: 92-894-9685-1
- Food Quality and Safety in Europe - Project synopses
  ISBN: 92-894-6811-4

**For further information, please visit the Agri-Net website:**

http://europa.eu.int/comm/research/agriculture/index_en.html

**Or contact us:** rtd-food@cec.eu.int

European Commission

**EUR 21467 - Plant Health - The impact of EU Research (1998-2004)**

Luxembourg: Office for Official Publications of the European Communities

2005 – 32 pp. – 21.0 x 29.7 cm

ISBN 92-894-9026-8

This brochure presents the results of an evaluation of 47 research projects on plant and crop health that were funded under the EU's Fifth Framework Programme for Research and Technological Development. The evaluators' chosen top 15 projects are described in more detail in "Success stories" (pp 13-22). The results of nine of these projects were also presented at a seminar entitled 'EU-funded Pesticide Related Research – Agriculture, Human Health and Environment' (http://www.bcpc.org/Seminars2004/BCPC_Seminars_2004/Eu-Funded_Research/index.asp). The lessons and the recommendations resulting from the Evaluation and the seminar discussion are summarised on pages 23-25. Finally, pages 26-29 offer a glimpse of the research projects on plant and crop health in the current Sixth Framework Programme and the future possibilities.

KI-NA-21467-EN-C

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ISBN 92-894-9026-8
9 789289 490269