Proposal for a new COST Action

Title:

Sustainable low-input cereal production: required varietal characteristics and crop diversity

Acronym: SUSVAR

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Part I - DRAFT TECHNICAL ANNEX

Sustainable low-input cereal production: required varietal characteristics and crop diversity

A. Background

There is an increasing demand throughout Europe for sustainable crop production characterised by reduced inputs of pesticides and synthetic fertilizers (low-input cropping systems) and increased agricultural biodiversity. This is reflected by the efforts to integrate environmental aspects of agriculture into the Common Agricultural Policy (CAP). The most rigorous low-input system is the organic farming system as defined by EU-directive 2092/91 where pesticides and synthetic fertilizers are generally not allowed and yield stability and quality have to be ensured by the cropping system itself. In the organic system, optimal crop rotation systems are critical to maintain balanced crop nutrition, avoid build-up of weed seed-banks and pathogen inoculum, and maintain soil fertility.

Often, in low-input systems yields are highly variable and of varying quality, partly because the varieties grown have not been developed for this system and are therefore not optimal. An important means of stabilising crop yields and quality is, therefore, selection and trialling of varieties and lines based on varietal characteristics of relevance for low-input production. In addition, there is increasing interest in using within-crop diversity in the form either of variety mixtures or of segregating populations as a means of increasing the adaptability of the crop to environmental variation. Other approaches include mixing cereal species or inter-cropping cereals with legume species.

Development of the better use of crop genetic diversity to increase the stability and efficiency of low-input systems is essential to the improvement of such systems and thus to increasing their attractiveness to farmers and consumers. Such a development is central to the necessary future reform of the CAP and to the direction of the reforms that have been proposed.

Varietal characteristics for low-input production (variety testing)

Modern cereal varieties have been developed with the aim of combining high productivity and uniform product quality under high-input conditions with pesticides, synthetic fertilizers and growth regulators, which also help to reduce environmental variation. Under low-input conditions, especially in organic farming, biotic and abiotic stresses and large environmental variation have to be overcome by growing appropriate varieties or populations, and by adapted crop and farm management practices. The following components are parts of the complex agroecosystem:

- Soil (microbiology, crop rotation, nutrient availability)
- Plant diversity (variety and species mixtures, weeds)
- Diseases and pests (on leaves, tillers, seeds and plant debris)
- Climate

It is questioned whether modern varieties possess the combinations of genetic characteristics necessary for appropriate levels of production in this context.

Important varietal characteristics to be considered in this Action are, therefore:

- nutrient acquisition ability (root morphology, nutrient uptake and use efficiencies, low-nutrient tolerance, symbioses).

- competitive ability (morphology, weed tolerance, growth rate, allelopathy),
- ecological combining ability (god performance in variety and species mixtures)
- disease resistance (morphology, specific and non-specific resistance properties, disease tolerance).

Other characteristics, including tolerance to attacks by pests and tolerance to climatic induced stress (water, temperature), will not be considered at this stage.

There is no doubt that varieties or lines with appropriate characteristics exist among current and older collections of varieties, in breeding programmes and in gene banks in different countries. There is a pronounced need to develop a research network to identify such lines either for direct use or as potential parental lines in breeding programmes.

However, because of variable environmental conditions, including differences among low-input cropping systems, it is not possible even within a locality to identify a single best variety for low-input farming. As examples, in crop rotations with weed problems, highly competitive varieties would be optimal whereas such varieties may be less suitable as components in variety or species mixtures, or with undersown crops. In situations with high soil fertility, e.g. after grass-clover leys, a high-yielding variety with a number of disease resistance genes would be optimal while in situations with low fertility a variety with high nutrient use efficiencies would be preferred: its susceptibility to diseases may be less important. The reduced N-inputs in organically grown wheat result in reduced or less stable baking quality in comparison with wheat grown under high input conditions. However, varieties exist that reliably produce high baking quality even under low-input conditions. Although increasing N-inputs results in higher protein content, this usually also increases susceptibility from diseases such as rusts, mildews, *Fusarium* and other soil-borne diseases. These diseases in turn reduce baking quality and, in addition, *Fusarium* species often produce mycotoxins, thus directly affecting consumer safety. This problem is under increasing attention in EU because of regulatory threshold values of the mycotoxins. There are variety differences in susceptibility and it is important for low-input and organic agriculture to have more access to such knowledge to guarantee safe and reliable production.

Extensive official variety VCU-testing (Value in Cultivation and Use) as well as variety trials by farmer's organisations and in research institutes take place in all European countries, though mainly in high-input environments, with the purpose of identifying desirable varieties. This information is disseminated nationally. Added-value of the national trials is expected if information about the results are spread more efficiently Europe-wide. This need is specifically obvious for organic farming, which in each country constitutes a small proportion of the cereal production area. Refined statistical methods investigating genotype-environment interactions are needed to analyse this type of data.

Intra-crop diversity (variety mixtures and populations)

Under low-input conditions, especially, it is impossible to predict which variety will perform the best in a given year and site. Growing different varieties in different fields of the same crop may reduce the risk of a crop failure. However, a better insurance against failure is to grow a mixture of varieties. Mixtures are known to increase yield and yield stability in high-input cropping systems by preventing or delaying disease progress and allowing yield loss compensation. Mixtures may be designed with varying numbers and proportions of components, enabling great flexibility both for achieving practical production requirements such as disease control, and for end-user requirements. Therefore, within-crop diversity, deployed strategically, might lead to greater profitability in lower input systems by practical benefits such as less disease, better resource utilization and generally more resilient crops. Some farmers are, therefore, already using mixtures in practice.

However, even mixtures are limited in their adaptability to adapt to changing circumstances from season to season and place to place. For this reason, there is now interest in considering the use of segregating populations (for short, populations) of cereals (especially wheat) which, theoretically,

should be more effective than mixtures in terms of stability, because of their built-in buffering capacity. This contrasts strongly with pure line varieties that can be selected for adaptation, but whose adaptability is limited to the plasticity of the individual genotype. Earlier work in California with segregating populations of barley showed that these populations were able to maintain, dynamically, their potential to buffer the population against previously unknown environmental variation, including pathogen variability.

Cereal variety mixtures have so far been studied mainly in relation to influence on control of single diseases and mostly under high-input farming conditions. Little work has been done to investigate the impact of soil physical and biological factors on the performance of populations and variety mixtures. Experimental as well as modelling studies are needed, therefore, to investigate whether these results can be transferred to low-input, especially organic farming, conditions, where there are complex interactions among crop, weeds and diseases partly due to varying nutrient availability. Refined statistical tools to judge and compare the efficiency of different mixtures are needed. Understanding mechanisms operating in genetically diverse crops is a prerequisite for developing methods for selecting varieties and lines with good mixing ability and for breeding directly populations with suitable within-crop diversity. Detailed information on varietal characteristics from a large range of environments is needed to design optimal mixtures.

In cereal production for animal feed there are few practical objections to growing mixtures of varieties or even species. In the high quality market such as for malting quality or bread making, there is resistance from the processors. Objections are based on perceptions of unevenness and may reflect some misunderstanding of relative genotypic and environmental contributions to variation. It has already been demonstrated, however, that excellent and stable malting quality of barley can be achieved with variety mixtures across variable environments. Similarly, some studies have shown that baking quality of wheat can be stabilized by growing appropriate mixtures.

Inter-crop diversity

A further form of insurance against unpredictable variation is to grow mixtures of species. This includes mixtures of cereals (wheat has been grown in reliable mixtures with barley and/or oats in Poland for many years) and of cereals with other species (wheat/bean mixtures have been shown to be productive and reliable in practice partly because of effective weed suppression). Practical experience has demonstrated that wheat varieties that show appropriate ecological combining ability are more likely to be successful in these roles. Part of such positive ecological combining ability may be expressed as reduced competitiveness against neighbouring plants. In other inter-cropping systems such as barley with undersown white clover for optimising the soil fertility of the following crop, it may be even more difficult to determine or achieve desired varietal characteristics as white clover is highly competitive.

Plant-plant interactions

It is important to realise that in current variety trials the varieties are screened for their performance in pure stands. This invites the major question, whether these trials provide us with enough information regarding the performance of specific varieties in variety or species mixtures. Intercropping research suggests that the performance of such mixtures is likely to benefit from differences in resource use and acquisition. We are currently lacking a sound and yet practical methodology for selecting suitable components of variety and species mixtures as long as it is not possible to predict the level of complementarity (differences in use of resources) between varieties or species, without actually having grown these together.

Other than interactions between the components of a mixture, the weed suppressive ability of the mixture may be important for the yield and yield stability of the crop. Here a range of hypotheses may be given on what constitutes the perfect mixture, e.g., that a combination of varieties that each on their own possesses good weed suppressive potential should result in a mixture with good

weed suppression. These hypotheses are waiting to be tested. On the other hand, the presence of weeds may have some positive advantages, depending on the weed species and the timing. These include ground cover, increased access to soil nutrients through, for example, mycorrhizal activity, induced resistance to diseases stimulated by pathogen spores from weeds, and promotion of beneficial arthropods.

Also the spatial arrangement of the crop plants contributes to the interplay of positive and competitive interactions with other plant genotypes or species in the stand. These interactions may all be dependent on densities of the plant stand which, therefore, is important to be taken into account in the process of developing appropriate trials and selection methods for desirable crop genotypes and mixtures.

In conclusion, a better understanding of the various plant-plant (crop-crop; crop-weed) interactions seems a very useful step in identifying the most appropriate strategy for composing suitable mixtures.

Plant-soil interactions

Low-input and organic agriculture are characterized by a reduced nutrient supply to the crop plants, compared to conventional production schemes. This production method requires cereal varieties that combine efficient nutrient uptake traits and the stability of yield under different environmental conditions. These requirements are not coved by modern cereal varieties since their productivity depends largely on high nutrient supply and frequent pesticide treatments.
Successful production in organic and low-input agriculture relies also on soil characteristics and the beneficial effect of resident microorganisms. The soil habitat is characterized by multiple interactions between the plant, the soil environment and resident microorganisms (bacteria, fungi, mycorrhiza etc). Physical and chemical soil factors influence aeration as well as water and nutrient availability. Many plant-associated microorganisms protect the plants, enhance the plants vigour and make nutrients available. In organic and low-input cereal production, well-adapted cultivars in combination with the beneficial effects of good soil structure, and microorganisms are instrumental to stabilise crop productivity and plant health.

Plant-disease complex interactions

Disease management in a low-input, especially organic system needs different priorities than in a conventional high-input system, due to interactions between a range of factors. The absence of pesticides leaves a higher diversity of pathogens to develop in the system. Further, an increased crop diversity and lower nutrient availability in the plant tissue may favour different development of pathogens. Pathogens occurring simultaneously on a plant compete with each other for resources, which also adds to altering the disease progress. Therefore, it is important to take into account the full range of pathogens (here designated “the disease complex”) when studying disease development in low-input farming systems. The varieties grown must be able to cope with the diversity of pathogens and the crop physiological stresses they inflict. This is reflected in their degree of resistance to the various pathogens as well as in their degree of tolerance, which determines how much they suffer from given infestation levels of particular diseases. Choosing genotypes for specific environments (defined among others by specific pathogens populations with specific virulence traits) requires experience and expertise in the above mentioned problem areas, intensive interaction with related scientific disciplines, a sound data basis and advanced statistical methods.

Genetic markers

The use of molecular genetic markers can be valuable in many aspects of the proposed Action. DNA markers are powerful tools in the breeding process especially in selection for qualitatively inherited traits that are difficult to assess. There is a need to identify genetic markers for traits of importance in low-input farming such that breeding for low-input farming can also take

advantage of modern biotechnology. This includes, for example, determining whether genotypes with desirable phenotypic characters are genetically similar (duplicates) or different. This provides a valuable focus for determining which genotypes may, or may not, be worth pursuing as potential varieties or parents.

The use of markers can be a particularly useful tool in determining the genetic composition of heterogeneous populations and variety mixtures under varying conditions. This will be helpful, for example, in determining the relative competitiveness (ecological combining ability) of different components in variety mixtures or populations. Markers can be used also to overcome some of the sometimes encountered, and more often envisioned, legal problems in dealing with genetic diversity in the seed market.

Why a COST Action?

The problems related to varietal characteristics and to crop diversity for low-input and especially organic cereal production, are certainly international, but currently, improved methods for assessment of important varietal characteristics, development of plant material and strategies for their use, are being developed largely at the national level. There is a clear need to bring these different solutions together for consideration, further development and dissemination at the European level. Another argument is that small breeding programmes/companies are under economic pressure and have the risk to disappear. The smaller breeding companies are looking for another niche market, like organic farming to be more competitive. This can only be successful for a limit area if the breeding program is internationally orientated.

Multidisciplinary national projects in European countries that are aimed at understanding and utilising the complex interactions between genotype, genetic diversity and environment to increase yield and quality in low-input cereal production, are listed under Part II-C. Networking among these projects is needed to maximise the efficiency and dissemination of these programmes, which is essential for competitiveness of European agriculture.

Other project listed under Part II-C describes work by different groups involved in marker gene association mapping. With a COST network, it is possible to bring together and merge a wide range of relevant information into a single database. This will have many possible uses in evaluating similarities and differences among genotypes and thus in rationalising their usefulness for different aspects of low input systems.

A small-scale four-country comparison trial has already taken place for a few wheat varieties within ECO-PB (a small Consortium contributing to organic breeding and seed production in Europe). ECO-PB does not have any funding source for networking, however, so this COST Action will provide a highly appropriate framework for continuing and extending this kind of nationally financed comparison.

In addition, this COST project provides a great opportunity to establish international tests for disease resistance and other characters, and to exchange materials and compare results. In this way, transfer to the international level would be highly beneficial for the internationalisation of appropriate breeding and variety testing within the EU. Included here is a unique opportunity to determine appropriate ways of handling crop populations in different environments and in the official EU system if they appear promising in practice.

Varieties of cereals are already exchanged among European countries. European policy with respect to testing of varieties combines national and international rules and procedures. Information about varieties is made available to end-users mostly by variety testing and official variety lists. It is important to develop official variety testing (VCU) to take into account new traits tested under environmental conditions with limited or no synthetic inputs. Some countries already test varieties under organic conditions; their methodologies can provide a platform for more general development. Better dissemination and collaboration would contribute to harmonising the procedures among EU member states. A meeting organised by the German Bundessortenamt in 2003 among German speaking countries (D, A, CH, including NL), showed a

great need to exchange criteria for testing organic varieties and how to adapt the testing protocol for organic agriculture. Developments in the directions proposed would contribute to release (registration) of varieties specifically for organic farming systems or low input systems (the present system has not yet proceeded to differential variety registration though some yield tests under low inputs have already been established and results are available).

Finally, the proposed developments at the levels of crop production and of breeding and varietal registration within existing EU countries will be of special benefit in bringing these initiatives and actions rapidly into sustainable low input crop production among the new partners in the expanding EU.

Links with other EU research programmes

This Action focus on varieties and genetics of the crop and the influence of the genetic basis of the crop on yield, yield stability and quality considered in the complete cropping system of low-input including soil-interactions, weed and other plant interactions and disease interactions. These aspects combined are not covered by other COST Actions or EU-projects. As the Action necessarily has to includes many aspects of the low-input, especially organic cropping system, there will be links with other research programmes as indicated:

Links and complementarity with other COST Actions
Synergies are expected with the following related COST-Actions. This means that we will consider having common workshops and inviting participants from these Actions to participate in our activities when appropriate:

- COST631: Understanding and Modelling Plant-Soil Interactions in the Rhizosphere Environment.
- COST835: Agriculturally important toxigenic fungi
- COST838: Managing arbuscular mycorrhizal fungi for improving soil quality and health in agriculture
- COST849: Parasitic plant management in sustainable agriculture, which aims at increasing the understanding of the interaction between parasitic plants and their hosts.
- COST851: Gametic cells and molecular breeding for crop improvement
- Another proposal for a new COST Action: 'Improving quality of plant propagation material in support of organic farming' has been developed in collaboration with the present proposal and cover the seed production for organic farming for many crops.

Links with other EU research programmes
Results from the following EU projects will be interchanged due to common participants when possible:

- 'Strategies for Weed Control in Organic Farming' (WECOF). This project is led by Professor Ulrich Kopke at the Institute of Organic Agriculture, University of Bonn (IOL).
- 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). The project is led by Erik Steen Jensen, Risø National Laboratory Roskilde (Denmark)
- Mapping adaptation of barley to drought environments MABDE 2003-2005 Lead by: Ignacio Romagosa , Centre UdL-IRTA, 25198 LLEIDA (Spain)
- New strategies to improve grain legumes for food and feed (Grain Legumes), where workpackage 2.1 "Lower input farming" is led by Erik Steen Jensen, Department of Plant Research, Risø National Laboratory, Roskilde, Denmark.

Other interactions
The Action has members from the growing organisation ECO-PB (European Consortium of Organic Plant Breeding), e.g. many of the board members of ECO-PB are participants. The

Consortium aims at promoting organic plant breeding and seed production in Europe but has not funding for networking.

The action has members from the Working Group 'Crop-Weed Interactions' of the European Weed Research Society. This working group focuses on the interaction between crop and weed plants. Attention is given to a fundamental understanding of processes governing crop-weed interactions as well as the utilization of this knowledge for improved weed management.

A European Virtual Network of researchers working with variety mixtures was established during the COST817 (www.scri.sari.ac.uk/tipp/mix) and their activities will be strengthened by the Action as several of the participants have shown interest in the Action.

B. Objectives and benefits

The **main objective** is to establish methods for selecting varieties, lines and populations, and to develop ways to increase and make use of crop diversity and genotype-environment interactions to ensure stable and acceptable yields of good-quality crops for low-input, especially organic cereal production in Europe.

Secondary objectives

- to 1) develop hypotheses based on exchange of results from national research and development, 2) coordinate running national trials and 3) disseminate information and results within the following areas:
  - maintenance and enhancement of agro-biodiversity by use of genetic diversity
  - understanding the complex biological systems under low-input, especially organic farming conditions by collating new knowledge on plant complementarity (e.g. competitiveness and allelopathy), on epidemiology of disease complexes and on nutrient acquisition.
  - genetic resources for traits of importance under low-input, especially organic farming conditions
  - potential of genetically diverse cropping systems for reducing diseases and weeds and increasing nutrient uptake efficiency.
  - markers for traits relevant for low-input conditions and variety mixture efficiency
  - statistical analyses of genotype-environment interactions and mixture efficiencies
  - beneficial interactions of the resident soil microflora with cereal varieties under low input conditions
- To develop common acceptance for combinations of varietal characteristics required for cereal crops to be successful in different low-input, especially organic growing systems, and methodologies for measuring these characteristics.
- To implement strategic use of appropriate varieties, variety and species mixtures and populations to improve yield and yield stability in the different countries
- To evaluate the need for specific variety trials for organic farming on a European scale, and if necessary implement such trials by influencing policy making on regulation of organic variety testing and certification of population crops
- To develop research-based guidelines for variety testing authorities
- To evaluate farmer's practice and breeders methods and thereby establish an approach to breeding for crop material adapted to low-input/organic systems

The Action will provide a forum for exchange of knowledge and expertise between conventional production and the organic view of low-input production. In addition to the general benefits of establishing a network among breeders, farmers, extension services and researchers all considering cereal production and products in low-input and particularly organic farming systems, specific benefits for end-users are:

Breeders:

- Definition of combinations of traits for low-input/organic farming
- Definition of breeding methods (including the use of molecular markers) for obtaining these traits in varieties and in populations

VCU-testing authorities:

- Recommendations for new testing and listing procedures for organic/low-input variety testing and for population crops
- Procedures for combining information from national organic variety testing

Farmers and extension service:

- New stable, higher yielding crops
- Increased agro-biodiversity stabilizing the system as a whole
- New strategies for exploitation of genetic diversity.

Researchers:

- A European Network supporting researcher mobility to ensure interaction on planning of trials and on analyses of results as well as publication of common papers
- A European Network within which applications for European project funding can be generated.

Although designed principally for low-input and especially organic farming, the project overall should provide indicators for high input farming systems for ways in which efficiency could be improved and environmental impact reduced.

C. Scientific programme

To meet the goals of acceptable and stable yields in a complex self-sustained low-input cropping system, a high level of inter- and transdisciplinarity is aimed for in this Action. The nationally funded field trials (see present activities in Part II-C) at different sites in Europe are the central source for delivering scientific data for this Action. Here varieties, variety mixtures and crop populations will be tested and traits of importance for characterising the performance of the crop will be assessed using a common set of measures. Data will be analysed in collaboration among the experts from different disciplines within biology and agricultural sciences, e.g. plant biology and ecology, genetics, weed science, plant pathology, plant nutrition, agronomy, plant biochemistry, statistics, and mathematics (see List of scientists, Part II-B, and their recent, selected publications Part II-D). A major part of this activity will be dissemination of material and information across the network in connection with exchange of scientists, working group meetings, workshops and conferences.

The work in the Action will be organised in five different discipline based working groups as well as one practical oriented working group. Each WG will have to consider the implications of different levels of genetic variation of the crop (in the following for simplicity designated cultivars) the methodologies discussed as well as collating information from the different kind of national variety trials for evaluation of the proposed methodologies for identification of the characteristics of the crop.

The genetic material to be considered are the varieties, variety mixtures and populations included in the different kinds of national variety trials. In Part II-C, short descriptions of some of these variety trials are listed. During the Action some trials will stop and others will be initiated. The Action will be concerned with the organisation, coordination and evaluation of nationally funded field trials in contrasting environments to compare genotype-environment interactions and relative stability for yield and quality of lines, varieties, mixtures and populations considered

appropriate for use in low-input, especially organic farming. Data would be integrated across space and time.

All groups will have to consider crop quality in relation to the specific discipline, e.g. good malting quality, fodder quality or baking quality under low-input, especially organic conditions. This implies, when appropriate, developing and maintaining links with appropriate industries and assessing how novel quality requirements may be met.

All working groups will be concerned with bringing together information from different European countries on current practices. This will involve collection of farmer experience to determine why low-input and organic farmers use particular species, varieties and systems. It would also provide an opportunity to determine farmers' views of their future needs given the high variability in low-input/organic production systems.

A programme on evaluation of varieties has started recently in the Switzerland, UK and NL with the aim of increasing farmer participation in the process from initial variety selection through the whole food chain process. Again, it is important to provide a networking opportunity to extend this initiative to other countries.

WG1: Genetics and Plant breeding

Approaches to plant breeding to increase the genetic diversity of the crop will be studied, focusing on plant material adapted specifically to low-input/organic agriculture. This group will also coordinate national initiatives to search for genetic resources for low-input varieties. Further, it produces merged genetic association maps based on available data. Where national money is available, part of the material investigated in other groups may be described with respect to genetic markers.

Material and results from population breeding in wheat, currently limited to a few national programmes (UK, F) will be integrated into the overall European approaches to the uses of genetic diversity, initially with respect to wheat, but later with respect to other cereal species.

WG1 will ensure that principles and materials from WG3 to WG6 are integrated at appropriate levels of priority into the different approaches for the use of genetic diversity.

Milestones:

- Yearly compilation (in collaboration with WG2) and synthesis of results of population evolution from the different populations under study in participating countries and development of relevant breeding methodology to be applied for new populations
- Developing recommendations for the analysis of variety mixtures. (In collaboration with all other WGs)
- Make available results from national mixture trials and recommend specific mixtures for different environmental conditions meeting specific yield, disease resistance and quality targets (In collaboration with all other WGs)
- Making available national evaluations of genetic resources for their characteristics in low-input/organic growing conditions and joint analysis of these trial results (in collaboration with WG2)
- Trans-disciplinary meetings to ensure integration of important principles and material into the improved use of genetic diversity
- Exchange of genetic material that is especially adapted to organic/low input agriculture.
- Establishment of ring tests with a common set of varieties to compare selection methods used by different breeders of organic cereal varieties
- Determine for selected quality traits how quality from field grown mixtures compare to quality for the components and whether mixture components converge for quality attributes
- Developing recommendations for breeding procedures for low-input farming.

- Standardisation of marker sets and of the exploration of traits important for low-input farming enabling joint association analyses of marker and trait data.
- Consensus of methods for the testing of variety mixtures for the identity and quantity of the single varieties included.
- Plant breeding companies use the evaluated diverse genetic material in their breeding programs for crosses with locally adapted germplasm. They develop special varieties for organic and low input farming which are then tested in organic registration trials in countries where these exist (e.g. Austria, Switzerland, Germany)

Deliverables:

- Dissemination of results and material from population breeding trials in the UK and F
- Extending the principles of population breeding to other species and countries in the EU
- Report on the value of populations for sustainable low input cereal production and on the ways in which they might be registered officially.
- Identification of lines suitable for low-input/organic farming among large collection of genetic resources
- Breeding scheme for varieties appropriate for low-input farming including the possible use of those varieties in mixtures.
- Documentation on genetic improvement for low input/ organic farming systems from field trials in different locations
- Farmer guidelines for participatory breeding
- Implementation of standards for molecular marker sets and trait explorations in joint projects.

WG2: Biostatistics

This group will discuss design of experiments for variety trials - especially those that involve more factors and/or many varieties. Statistical analyses of appropriate measurements for disease resistance and weed competitiveness both for single trials and a series of trials will be discussed and recommendations will be given. The statistical analysis of non-normal distributed data will be discussed. Methods for describing genotype × environment interactions and prediction of variety performance under specific environmental conditions will be discussed. The group will also discuss the statistical analyses of variety mixture efficacies, which may include some methods for intra-plot competition. There is also a need to link with methods for extensive trials using few varieties grown on farmer's fields and involving participation from farmers and others in varietal evaluation. The group will act to ensure that appropriate designs and statistical methods are used within the network.

Milestones

- Exchange of statistical experience with variety trials.
- Pointing out efficient types of experimental designs for variety trials under low input.
- Discussion on how to analyse non-normal distributed data - both for the individual trials and for series of trials
- Discussion on how to analyse intra-plot and inter-plot competition
- Participation in the joined analysis of the trial results (WG6)
- Participation in the statistical analysis of the data from potential ring test (WG1, WG3, WG4, WG5)

Deliverables

- Information on methods to analyse non-normal distributed data to all participants.
- Statistical methods for modelling the varieties performance under low input.

- Statistical methods for describing the variety performance in series of trials with large GE-interactions
- Statistical methods for modelling the effect of mixtures (in cooperation with other WGs).
- Workshop on genotype-environment interaction and variety testing in collaboration with WG6

WG3: Plant –soil interaction

The group will study differences in nutrient acquisition between grain cultivars under various growth conditions. The group will put its emphasis on root and crop traits that improve nitrogen (N), potassium (K) and phosphorus (P) acquisition and use efficiencies in low input/organic farming. The group will also discuss and exchange research protocols about the isolation and the use of root associated microbes and their impact on yield stability in low-input agricultural systems. Particular emphasis will be put on the interaction of microbes and cereal varieties but also on the ability of microbial inoculants to reduce the impact of leaf and ear diseases, to control soil and seed-borne pathogens and to stimulate plant growth. This will lead to a better understanding of the interactions within the triangle cultivar, soil and root associated microbes. In addition, the effect of different cultivars on indigenous plant-beneficial microorganisms will also be considered. The benefit of crop diversity for increasing nutrient uptake and use efficiency attained by intercropping of cultivars/crops will be evaluated.

WG3 will coordinate the organization of specific small-scale field trials and greenhouse experiments at their respective institutions, where national funding is available. Finally, the group will contribute to the European analyses of large-scale experiments.

Milestones:

- Establishment of a common experimental set up scheme.
- Annual examination of varieties and variety mixture including multisite monitoring of root development, nutrient uptake, yield and quality traits.
- Evaluation of the impact of soil and environmental factors on crop and variety performance.
- Information about the plant and specific cultivar associated microorganisms.
- Assessment of the effects of the beneficial effect of microorganisms on cultivars adapted for production under low input agricultural conditions.

Deliverables:

- Recommendations (for breeders, variety testing authorities, farmers and scientists) on important nutrient uptake traits in cereal cultivars for use in low input and organic farming.
- Insight into the role of plant associated microorganisms in organic and low input agricultural systems.
- Review of the interaction between soil conditions, predisposition of cultivars and the associated microorganisms that influence nutrient uptake, plant vigour and plant health.

WG4: Plant-plant interactions

In composing a variety mixture, one might expect that combining the varieties that perform best in pure stand will probably give the best result. Such varieties may only differ to a minor extent, and that therefore there will be little or no added value to the use of a mixture. Another strategy is to select for complementarity (niche differentiation) among the constituents of the mixture. It might well be argued that, in terms of productivity and stability, variety mixtures are likely to benefit from differences in resource use and acquisition among the components of the mixture. Complementarity, or niche differentiation, should result in a reduced level of interspecific competition, increasing the opportunities for individuals to perform well. The mixed population as a whole will perform better than the respective pure stands and occupy a larger niche, both of

which will contribute to the suppression of weeds. Several questions concerning the potential contribution of variety mixtures in suppressing weeds come up. It is not clear if the inclusion of varieties with a strong weed suppressive ability, due to a high competitive ability or allelopathic potential will be advantageous or disadvantageous. In a pure stand high competitive ability of the crop will be advantageous, but in mixtures this ability may negatively affect the performance of the other components of the mixture.

For this reason, the group on plant-plant interactions will initially focus on a very basic question: 'what strategy should be followed to obtain the best combination of individual varieties (or species)?' Should superior performance in pure stand be the guiding principle, or should it be the complementarity amongst the components of the mixture? The current variety trials will be insufficient to reveal the suitability of varieties for inclusion in a mixture. A more practical next step will then be the development of sound and yet practical screening procedures for identification of the suitability of individual varieties to be included in variety mixtures. A further perspective would be to extend this knowledge to intercrop diversity.

The group will contribute with the relevant information on Plant-plant interactions for other Working Groups through cross-linkages.

Milestones

- Strategic meeting for formulation of hypothesis on how mixtures should be constituted in order to maximise the productivity, stability and weed suppression function of (variety or species) mixtures.
- Development of experimental set-up for testing of the various hypotheses.
- Acquisition of national/international project funds for conducting the proposed experiments at selected sites.
- In parallel, combining data from ongoing national studies on different aspects of weed suppression ability (e.g. early vigour, allelopathy, phenology and morphology)
- Development of a procedure for screening individual varieties for their suitability in variety mixtures.

Deliverables

- Recommendations on a strategy for obtaining the most suitable variety mixtures in terms of productivity, stability and weed suppression
- Recommendations on how to evaluate individual varieties for their suitability to be included in variety mixtures.
- Guidelines with methods for assessing weed suppression ability

WG5: Plant-Disease complexes

This working group will focus on disease control in low-input and organic farming. In this system pathogen diversity is generally higher on both species and genotype levels, which may result in multiple interactions and pathogen-pathogen competition on the individual host plant, which makes it more relevant to focus on disease complexes rather than diseases individually. Further, the changed nutrient availability in such systems may favour other pathogens, as well as non-pathogen microorganisms, compared to the situation in high-input systems. This may give rise to the need for different priorities for disease control in the two systems. To this adds the effect of an often higher genetic diversity in the crop, e.g. via variety mixtures and populations. Overall, this means that knowledge from disease epidemiology in a conventional high-input agricultural system is not necessarily transferable to a low-input system. However, the present days basic knowledge on epidemiology of common pathogens is generated in high-input agriculture, and it is therefore of importance that complementary knowledge is generated within the organic system.

The diversity of pathogens is something the varieties grown should be able to accommodate, in this context is it important to establish the ideal resistance characteristics of a

variety/mixture/population, e.g. overall non-specific resistance or specific resistance against the relevant pathogens. The complexity of the organic system means that different varieties may be optimal here, compared to those in a high-input system under the same set of environmental conditions.

The analysis of this complex biological situation requires development of appropriate statistical and mathematical models, to gain full information from extensive data sets and compilation of these from across national trials.

The diseases investigated are those of particular relevance in low-input/organic farming, including diseases on leaves as well as on seeds, but only those included in projects with national funding can be considered. Earlier, in COST817 1993-1998, varieties and lines of barley and wheat were tested in common European disease nurseries for rust and mildew diseases. This has continued on a small scale for yellow rust of wheat and leaf rust of barley and wheat. Barley breeders and researchers have joined forces in an International Ring Test for Leaf Scald Resistance in Spring Barley (http://www.crpmb.org/scald/). Such activities will be implemented for combinations of diseases and plant material of importance in low-input/organic crops in Europe.

In practice, breeders and epidemiologists will often have a different approach for studying disease development in the field, with the latter being interested in greater detail of the disease progress in time and space. This means that breeders often produce large amounts of data, which are not fully utilised from a scientific point of view. It is therefore worthwhile, to reconsider the way disease data are obtained (well knowing that time resources may be a limiting factor), to gain the optimal amount of information for all parties from the resources invested.

Milestones

- Establishment of international ring tests for evaluating stability of disease resistance under low-input cropping systems in variable environments
- Exchange of experience between breeders and scientists to develop improved methods for scoring/assessing disease resistance, giving attention to disease complexes, under field conditions, as these trials are carried out nationally each year.
- Development of common improved methods for analysis of disease resistance and evaluation of modelling methods for synthesis of knowledge.
- Establish the influence of cropping systems on disease levels and plant health
- Monitoring the contamination of wheat and barley grain by Fusarium mycotoxins and improvement of resistance level in breeding programs

Deliverables

- Annual publication of results from disease resistance trials for barley and wheat varieties of common interest
- Establishment of common guidelines and recommendations for assessment of disease resistance to fungal pathogens, and complexes of these, on wheat and barley in variable environments
- Review paper on the state of knowledge, appropriate methods for analysis and potential for models of disease complexes.
- Guidelines to farmers on cropping practice to reduce disease levels in low-input/organic cropping systems.
- Report on monitoring the contamination of wheat and barley grain by Fusarium mycotoxins and improvement of resistance level in breeding programs

WG6: Variety testing and certification

The group will exchange and discuss the research protocols which are used for (official) organic variety testing, establish which plant characteristics are relevant to test and suggest best

methodologies to assess these characteristics. It will also bring together comparative studies between organic and conventional variety testing in order to learn if organic variety testing leads to other variety choices. It can also learn which characteristics really need to be tested under organic conditions to produce good phenotypic variation for evaluation, and for which characteristics one can also extrapolate the results of tests under conventional conditions. It can lead to design of a testing system with as little extra costs as possible by integrating conventional and organic tests.

Some countries (e.g. AT, CH, DK, UK, NL and to some extent DE) already test varieties for organic production. It is important to disseminate relevant outcomes and expertise from these countries as similar considerations would be needed in each country and national solutions would be reached more efficiently by collaboration. This would contribute to harmonising the procedures in different EU countries including potential new countries.

The group will extract the relevant information from the other working groups to build in guidelines.

Milestones:

- Inventory of characteristics evaluated in organic variety trials in the participating countries including the handling of variety mixtures and populations completed
- Inventory of protocols and methodologies to evaluate characteristics including the handling of variety mixtures and populations in organic variety trials completed
- Joint analysis of results of comparative variety trials of different countries in Europe completed in collaboration with WG2
- Synthesis of results of comparative research between organic and conventional variety trials discussed
- Design of an efficient testing system for organic varieties with low costs by defining those characteristics that can be added to conventional tests and those that need to be tested under organic conditions.

Deliverables:

- Knowledge on the possible benefits of conducting variety trials under organic conditions (presented in the form of a scientific article)
- Knowledge on the possibility to set up a combined system of organic and conventional VCU
- Guidelines for conducting organic variety trials, including variety characteristics which are specifically desired by the organic sector and best methodology to evaluate the characteristics
- Recommendations to authorities for certification of variety mixtures and populations

D. Organisation

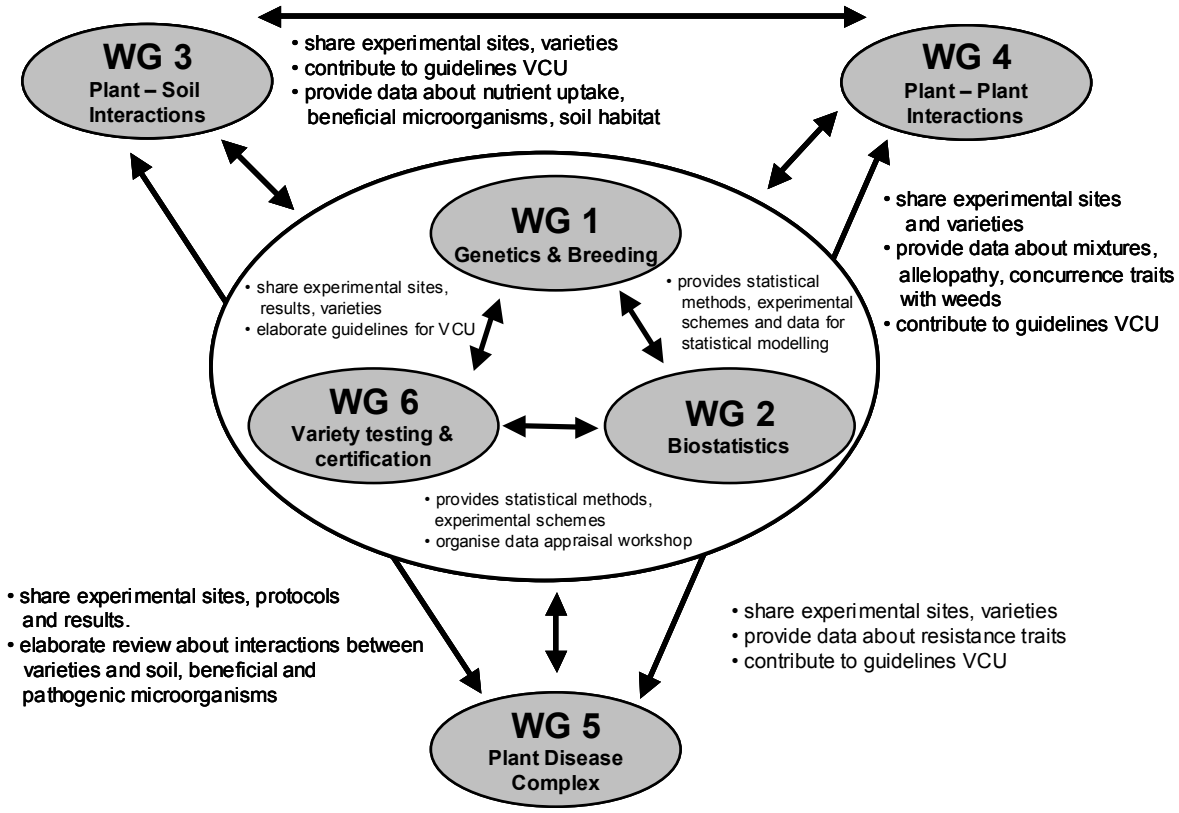
The Action aims to integrate the expertise from different areas of study to improve selection for crops with stable and acceptable yields and good quality in complex self-sustaining low-input cropping systems. It will be essential, therefore, to establish a dynamic organisation with much interaction among the different WGs in an inter- and transdisciplinary way. All groups will come together once a year (see Timetable, Part I-E).

The collaboration is organised into a number of strongly interacting Working Groups as described in Part I-C. Each WG has a Working Group Coordinator responsible for the day-to-day coordination of the Working Group. Many participants in the Network will participate in more than one Working Group since reaching the objectives of the Action needs different combination of experts in different areas at different times. Among the scientists listed (Part II-B), about 50% have shown interest in more than one WG (10% in more than two WGs). Further, about 50%

have shown interest in WG1. The interaction between the Working Groups is shown on the figure below and the main goals of the Working Groups are shown in the Table below.

	WG short title	**Main goals**
WG1	Genetics and Breeding	Genetic resources for low-input/organic traits, breeding for mixing ability, population breeding, genetic association maps (for nutrient efficiency, field resistance to pathogens and weed competitiveness)
WG2	Biostatistics	Design of field experiments/variety testing in complex systems, analysis of series of trials when large GE-interactions, statistics for variety mixture efficacies and populations,
WG3	Plant- soil interactions	Measurements of nutrient uptake and use efficiency, root traits in varieties, variety mixtures and populations, plant-soil micro-organisms interactions
WG4	Plant-plant interactions	Develop a guiding principle for composing mixtures with optimal productivity, stability and weed suppression function; determination of niche differentiation; selection principles; methods for measurement of competitive ability
WG5	Disease complexes	Analyses of interactions among pathogens on the same host plant, methods for disease assessment and field resistance in complex systems, disease assessment in variety mixtures and populations
WG6	Variety testing and certification	VCU (Value of Cultivation and Use)-testing in organic and low-input systems including the handling of variety mixtures and populations

Organisation of activities and reciprocal benefits between WGs



A central activity of the Action is to coordinate the nationally funded field trials at different sites in Europe. Participants in the Action will be involved in national field trials aimed at testing varieties for low-input/organic production or be interested in contributing to the analysis of material or data from such trials. In Part II-C, some of these variety trials are listed as well as other projects, which will be included in the Action. During the Action some trials will stop and others will be included in the Action if the aims are in accordance with the objectives of the Action. The priorities

A Management Committee (MC) will be formed which is responsible for the effective interaction and coordination among all Working Groups. The MC will make the priorities within the frame of the WG-descriptions for which specific cropping systems, pathogen systems etc. should have high priority in the Action. The MC will meet twice a year for optimal management of the large and complex Action, preferably in relation to other activities of the Action.

The proposer is responsible for setting up and maintaining a website for the Action.

The Action will extensively use the possibility for granting mobility of scientists to exchange methods between laboratories, prepare common trials, discuss results and exchange material.

E. Timetable

The estimated duration of the action is 4 years. Within this time period the deliverables will be achieved. However, as breeding is a long-term process the consequences of the work in the Action are expected to have a much wider perspective.

As most of the activities in the Action will be in relation to field experiments, the time schedule will be very much dependent on the starting date of the Action with respect to the growing season.

Working Group meetings will when possible be held as satellite meetings to other Conferences/Workshops such that the work of the COST Action can be communicated to the relevant scientific communities as well as practice.

	MC	WG						Conference/Workshop	Other activities
		1	2	3	4	5	6		
Year 1	– 1st MC – joint meeting MC+WGs	♦	♦	♦	♦	♦	♦		– Field trial inspections for participants – Exchange of scientists
Year 2	– MC – Conference+MC+WGs	♦ ♦	♦ ♦	♦ ♦	♦ ♦	♦ ♦	♦ ♦	Genotype-environment interactions and variety testing	– Field trial inspections for farmers, advisors, breeders, authorities etc. – Exchange of scientists
Year 3	– MC – Conference+MC+WGs	♦ ♦	♦ ♦	♦ ♦	♦ ♦	♦ ♦	♦ ♦	Variety mixtures and populations	– Field trial inspections for farmers, advisors, breeders, authorities etc. – Exchange of scientists
Year 4	– MC – Conference+MC+WGs	♦ ♦	♦ ♦	♦ ♦	♦ ♦	♦ ♦	♦ ♦	Closing conference with proceedings in reviewed journal	– European VCU and certification of heterogeneous crops – Exchange of scientists

F. Economic Dimension

The following 18 COST countries have actively participated in the preparation of the Action.

Austria	Hungary	Portugal
Czech Republic	Italy	Slovak Republic
Denmark	Latvia	Spain
Finland	The Netherlands	Sweden
France	Norway	Switzerland
Germany	Poland	United Kingdom

About 130 scientists from nearly 60 institutions are listed in Part II-A. On the basis of national estimates provided by the representatives of these countries, the economic dimension of the activities to be carried out under the Action has been estimated, in 2003 prices, at minimum EUR 11.7 million per year summing up to minimum EUR 46.8 million for the 4-year period considered. The estimates is based on the following figures (assuming that colleagues of those on the list takes part in projects related to the Action):

- 100 scientists of 60 000 EUR/man-year
- 80 technicians of 40 000 EUR/man-year
- 100 PhD students and secretaries of 25 000 EUR/man-year

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

G. Dissemination plan

As indicated under Part I-B, the target audiences for this action include

- Farmers using high input or low-input systems, especially, however, organic farmers
- Breeders using high input or low-input systems, especially, however, organic breeders
- Industry represented by the end-users of cereal products
- Variety testing and listing authorities including Government and European level policy makers
- Other researchers

Information and results will be disseminated by

- Posting general information (e.g. all reports from activities of the Action) on a public Website developed by the Action at its very beginning
- Establishment of e-mail network
- Making project results available on the Internet as a supplement to scientific publications.
- Publications such as description of field trials, proceedings of workshops and conferences
- Non-technical publications in local languages
- On-farm events using extensive networks of demonstration farms
- Participatory research networks organised for participatory research projects
- Research-based guidelines for farmers, breeder and authorities
- Additional routes for the dissemination of research findings should be by direct contact with the VCU authorities and relevant government departments in each country
- National and international conferences with emphasis on low-input, especially organic farming
- Articles in scientific journals

Dissemination tools and facilities of ECO-PB, e.g., their monthly Newsletter, will be used when relevant.

PART II – ADDITIONAL INFORMATION

A. Historical background

As the research and development for sustainable low-input cereal production is building on the vast amount of work going on in breeding and variety testing in the conventional mainly high-input production in all European countries, the list of experts involved in writing the application is large. Further, as the background for sustainable production is characterization of the full agro-ecosystem, scientist from many scientific disciplines need to be involved. Finally, the users of the research based guidelines (farmers, breeders, authorities) also have taken part in defining the objectives and means of reaching them. Therefore, the list of participants includes about 130 scientists (Part II-B). However, management of the interaction among these many people at the European level is a great need. This is demonstrated by the list of national projects (Part II-C), which have many aims in common. A combination of the data produced in these about 70 projects from 18 countries will give rise to very much added value for the competitiveness of European research and development. As some of these many national/international projects will end and others will start during the progress of the Action, the priorities for selecting specific crops, cropping systems, weeds and pathogens is expected to change, which should be possible within the dynamic management of a COST Action.

The historical reasons for this group of people joining a COST Action are

- successful networking activities taking place during the COST817 Action (chaired by Hanne Østergård, Risø National Laboratory, DK) concerning genetic resources of resistance genes of wheat and barley and pathogen diversity for the important leaf diseases of these crops have created a Network which now is a integrated part of this Action with the focus on applications of their work for sustainable low-input production
- Consortium for Organic Plant Breeding (ECO-PB) is a new Network, whose members have supported the idea of a larger COST Action where more aspects than the breeding can be taken into consideration.
- National projects in DK, UK and NL building on the same kind of organization of scientific disciplines to support the organic breeding and variety testing in these countries

B. List of scientists

The list includes scientists and other experts from Universities, National and Private Research Institutes and Organisations, and Breeding Companies who have expressed interest in the Action. They are related to the Action through national/international projects listed in Appendix A or through expected future projects not listed.

Expert (group)	Institution/Company	E-mail	Expertise	WGs
Austria				
Johann Birschitzky	Saatzucht Donau	johann.birschitzky @saatzucht-donau.at	Plant breeding	6
Franziska Löschenberger	Saatzucht Donau	franziska.loeschenberger @saatzucht-donau.at	Plant breeding	3,6
Julia Lafferty	Saatzucht Donau	lafferty@edv1.boku.ac.at	Plant breeding	1,5
Michael Oberforster	Agricultural Inspection Service and Research Centre Vienna	michael.oberforster @lwvie.ages.at	Cereal variety testing and registration	3,6
Wilfried Hartl	Ludwig-Boltzmann.-Institute for Biological Agriculture and Applied Ecology	wilfried.hartl @univie.ac.at	Nutrient availability, weed-crop interaction in organic cropping systems	4
Czech Republic				
Antonin Dreiseitl	Agricultural Research Institute Kromeriz Ltd.	dreiseitl@vukrom.cz	Genetic resources, resistance to diseases	1,4
Vaclav Sip Jana Chrpove	Research Institute of Crop Production, Prague–Ruzyne	sip@vurv.cz	Resistance to diseases, plant breeding	1,6
Denmark				
Hanne Østergård	Risø National Laboratory	hanne.oestergaard @risoe.dk	Biometry, population biology, variety mixtures	1,2,4, 5
Michael Lyngkjær	Risø National Laboratory	michael.f.lyngkjaer @risoe.dk	Plant pathology	3,5
Erik Steen Jensen	Risø National Laboratory	erik.s.Jensen @risoe.dk	Crop ecology, sustainable cropping systems, nutrient cycling, symbiotic N2-fixation	3,4
Henrik Hauggaard-Nielsen	Risø National Laboratory	henrik.hauggaard-nielsen@risoe.dk	Plant competitive interactions, organic cropping systems, nutrient cycling and symbiotic N2-fixation	3,4
Gunter Backes	Risø National Laboratory	gunter.backes @risoe.dk	Marker technologies, linkage map, quantitative traits	1,2
Ahmed Jahoor	Risø National Laboratory	ahmed.jahoor @risoe.dk	Genetic resources, plant breeding	1
Mogens Hovmøller	Danish Institute of Agricultural Sciences (DIAS), Flakkebjerg	mogens.hovmoller @agrsci.dk	Plant pathology, pathogen population biology,expression of host resistance	1,5
Hans Pinnschmidt	DIAS, Flakkebjerg	hans.pinnschmidt @agrsci.dk	Plant disease epidemiology, GxE interactions, expression of host resistance	2,5
Preben Klarskov Hansen	DIAS, Flakkebjerg	prebenk.Hansen @agrsci.dk	Crop-weed Interaction, weed science, competition	4

Expert (group)	Institution/Company	E-mail	Expertise	WGs
Ilse A. Rasmusssen	DIAS, Flakkebjerg	ilsea.Rasmussen @agrsci.dk	Weed science, organic farming	4
Gerhard Deneken Jakob Willas	DIAS, Tystofte	gerhard.deneken @agrsci.dk/ jakob.willas@agrsci.dk	Variety testing, agronomy, statistics	6
Kristian Kristensen	DIAS, Foulum	kristian.kristensen @agrsci.dk	Biometrics, genotype-environment interactions, experimental design	2
Ingrid Kaag Thomsen	DIAS, Foulum	ingrid.thomsen @agrsci.dk	C and N turnover in soil, long-term effects of cropping systems	3
Niels Erik Nielsen	The Royal Veterinary and Agricultural University	nen@kvl.dk	Soil fertility, nutrient acquisition by plants and plant nutrition	3
Tara Singh Gahoonia	The Royal Veterinary and Agricultural University	tsg@kvl.dk	Root methods, genetic diversity in root traits and nutrient uptake efficiency	3
Jacob Weiner	The Royal Veterinary and Agricultural University	jw@kvl.dk	Plant competition, allocation and modeling of plant growth	4
Sven Hermansen	Association of organic farmers	sh@okologiens-hus.dk	Advisor, organic farming, project planning and managing	1,3,4, 5
Ole Andersen	Sejet Plant Breeding	oan@sejet.com	Plant breeding	1,3,4, 5
Finland				
Marja Jalli	Boreal Plant Breeding Ltd	marja.jalli @borealpb.com	Resistance breeding, plant pathology, fungal population biology	1,5
Sirkka Jaakkola	MTT Agrifood Research Finland	sirkka.jaakkola @mtt.fi	Weed biology, allelopathy	4
France				
Marie-Helene Bernicot	Technical Institute for Cereals and Forage	Mhbernicot @itcf.fr	Weed biology, allelopathy	4
Bernard Rolland	National Institute for Agricultural Research (INRA), Rennes	brolland @lerheu.rennes.inra.fr	Genetics, plant breeding, agronomy, variety testing	1,6
Jean-Marie Nolot	INRA Toulouse	jmnolot @toulouse.inra.fr	Agronomy, environmental diagnosis	3
Philippe Burger	INRA, Toulouse	pburger @toulouse.inra.fr	Wheat development for genotype combinations, near remote sensing technology.	6
Bruno Colomb	INRA, Toulouse	Colomb @toulouse.inra.fr	Plant nutrition, characterization of N and P deficiency, soil N and P fertility	3
Dominique Desclaux	INRA Montpellier	dominique.desclaux @ensam.inra.fr	Plant breeding, GxE interaction, participatory breeding method	1
Jean-Claude Mouret	INRA Montpellier	Jeanclaude.mouret@ensam.inra.fr	Agronomy, environmental diagnosis	3
Ivan Sache	INRA Grignon	sache @platon.grignon.inra.fr	Plant disease epidemiology	5
Claude Pope Christian Lanou	INRA Grignon	pope @grignon.inra.fr	Plant disease epidemiology, variety mixtures	5
Olivier Gardet	INRA Le Moulon	gardet@moulon.inra.f	Plant breeding, variety testing	1,6

Expert (group)	Institution/Company	E-mail	Expertise	WGs
Isabelle Goldringer	INRA Le Moulon	isa@moulon.inra.fr	Population genetics, quantitative genetics	1,4
Philippe Le Coent Martine Franck	Group of study and Inspection of Varieties and Seed	philippe.lecoent @geves.fr martine.franck @geves.fr	VCU variety testing and certification	6
Laurence Fontaine	ITAB	laurence.Fontaine @itab.asso.fr	Plant breeding, variety testing	6
Yvan Moënne-Loccoz	University Claude-Bernard, Lyon	moenne @biomserv.univ-lyon1.fr	Microbial ecology, Microbial inoculants, Biocontrol	3
Germany				
Guido Hass	University of Bonn	g.haas @uni-bonn.de	Agronomy, cropping systems, variety testing, ideotype definition, environmental impact assessment	1,3,6
Karl-Josef Müller	Cereal Breeding Reseach Darzau	k-j.Mueller @darzau.de	Plant breeding, plant pathology	1,5
Maria Finckh	Kassel University	mfinckh @wiz.uni-kassel.de	Variety mixtures, plant pathology	1,5
Hans-Peter Piepho	University of Hohenheim	piepho @uni-hohenheim.de	Biometrics, genotype-environment interactions, yield stability analysis	2,6
Werner Vogt-Kaute	Organic farmers' association	w.vogt-kaute @naturland.de	Variety testing, seed propagation, seed treatment	1,6
Gabriele Berg	University of Rostock	gabriele.berg @biologie.uni-rostock.de	Plant pathology, biocontrol of plant diseases	3
Klaus-Peter Wilbois	Forschungsinstitut für Biologischen Landbau, Berlin	klaus.wilbois @fibl.de	Plant protection, plant breeding	1,5
Hungary				
Géza Kovács	Agricultural Research Institute of the Hungarian Academy of Sciences	kovacsg @mail.mgki.hu	Genetics, plant breeding, population and biometrical genetics, genetic conservation	1,3
Italy				
Domenico Rau	University of Sassari	d_rau73 @yahoo.it	Plant breeding, population genetics of plant and pathogenic fungi.	1
Giovanna Attene	University of Sassari	attene@uniss.it	Plant breeding, population genetics of plant and phytopathogenicfungi.	1,5
Nicola Pecchioni	Università degli Studi di Modena e Reggio Emilia	Npecchioni @mail.unimore.it	Molecular markers, QTL analysis, association mapping	1
Enrico Francia	Università degli Studi di Milano	enryfrancia @libero.it	Molecular markers, QTL analysis	1
Roberto Paulini	Dipartimento di Produzione Vegetale, Università della Tuscia	rpaolini @unitus.it	Weed science	4
Antonio Blanco	Università degli Studi di Bari	Blanco @agr.uniba.it	Plant breeding, plant molecular genetics.	1,3

Expert (group)	Institution/Company	E-mail	Expertise	WGs
Natale Di Fonzo	Experimental Institute for Cereal Research, Section of Foggia.	Difonzo @iscfoggia.it	Plant breeding and genetics	1,3,6
Michale Stanca	Experimental Institute for Cereal Research, Section of Fiorenzuola d'Arda	Michele @stanca.it	Plant breeding and genetics	1
Giampiero Valè	Experimental Institute for Cereal Research, Section of Fiorenzuola d'Arda	gp.vale @iol.it	Plant breeding, plant pathology, marker technologies	1
Gianni Tacconi	Experimental Institute for Cereal Research, Section of Fiorenzuola d'Arda	tacconig @libero.it	Plant breeding, plant pathology, marker technologies	1
Latvia				
Isaak Rashal	Institute of Biology, University of Latvia	Izaks @email.genet.edu.lv	Resistance, use of molecular markers, plant genetic resources	1,5
The Netherlands				
Edith Lammerts van Bueren,	Louis Bolk Institute	e.lammerts @louisbolk.nl	Participatory plant breeding, variety testing, concepts and strategies.	1
Aart Osman	Louis Bolk Institute	a.osman @louisbolk.nl	Plant breeding, variety testing, variety mixtures, participatory research.	6
Henk Bonthuis	Wageningen University and Research Centre	henk.bonthuis @wur.nl	Variety testing, plant breeding, agronomy and plant pathology	6
Fred van Eeuwijk	Wageningen University and Research Centre	fred.vaneeuwijk @wur.nl	Biometrical models for GxE, adaptability and stability, QTLxE	2
Hermann J. van Eck	Wageningen University & Research Centre	herman.vaneck @wur.nl	Marker technologies, QTL analysis	1,2
Lammert Bastiaan	Wageningen University and Research Centre	Lammert.bastiaans @wur.nl	Integrated weed management	4
Norway				
Mauritz Åssveen	The Norwegian Crop Research Institute	mauritz.aassveen @planteforsk.no	Variety testing	6
Birgitte Henriksen	The Norwegian Crop Research Institute	birgitte.henriksen @planteforsk.no	Plant pathology, seed borne diseases in cereals	5
Helge Skinnes	Agricultural university of Norway/ GRAMINOR breeding Ltd.	helge.skinnes @ipf.nlh.no	Breeding for disease resistance, use of molecular markers/ biological control of Fusarium and mycotoxins	1,5
Lars Reitan	GRAMINOR Breeding Ltd.	lars.reitan @graminor.no	Plant pathology, breeding, Agronomy, variety testing	1,5,6
Anne Kristin Løes	Norwegian Centre of Organic Farming, Tingvoll Gard	anne.k.loes @norsok.no	P and K in organic farming systems, plant adaptations to low P- and K-availability	3
Poland				
Paweł Krajewski	Institute of Plant Genetics, Polish Academy of Sciences	pkra@igr.poznan.pl	Biometry, quantitative genetics, software production	2
Jerzy H. Czembor	Plant Breeding and Acclimatization Institute (IHAR) – Radzikow	j.h.czembor @ihar.edu.pl	Plant pathology, plant breeding, variety mixtures and intercropping, variety testing	1,5,6

Expert (group)	Institution/Company	E-mail	Expertise	WGs
Henryk J. Czembor	IHAR – Radzikow	h.czembor @ihar.edu.pl	Plant breeding, variety mixtures and intercropping, variety testing	1,5,6
Portugal				
Maria Carlota Vaz Patto	Instituto de Tecnologia Química e Biológica - BCV	Cpatto @itqb.unl.pt	Marker technology, quantitative genetics, disease resistance	1, 5
Slovak Republic				
Ján Kraic	Research Institute of Plant Production (RIPP)-Piešťany	kraic@vurv.sk	Molecular breeding, biochemistry	1
Edita Gregová	RIPP Piešťany	gregova@vurv.sk	Wheat quality, variety testing	1
Mária Žaková	RIPP Piešťany	zakova@vurv.sk	Biostatistics	2
Valéria Šudyová	RIPP Piešťany	sudyova@vurv.sk	Plant breeding	1, 5
Martin Pastirčák Jozef Gubiš	RIPP Piešťany	pastircak@vurv.sk gubis@vurv.sk	Plant pathology	5
Spain				
D. Rubiales	Institute for Sustainable Agriculture (CSIC)	ge2ruozd@uco.es	Resistance, breeding	1, 5
Francisco Barro Losada	CSIC	ge1balof@uco.es	Genetic transformation and functional genomics	1
Antonio Martín Muñoz	CSIC	ge1mamua@uco.es	Interspecific hybridization	1
Sergio Atienza Peñas	CSIC	es2atpes@uco.es	Breeding, molecular markers, end-use quality	1
Juan Ballesteros Ruiz	CSIC	cs9baruj@uco.e	Haploidy	1
Pilar Hernández Molina	CSIC	ge1hemop@uco.es	Molecular markers	1
J.C. Sillero	CIFA Alameda del Obispo	ge2sapus@uco.es	Resistance, breeding	1, 5
I. Solis	Agrovegetal SA	isolis@us.es	Breeding, agronomy	1, 6
J.M. Urbano	University of Seville	urbano@us.es	Breeding , agronomy	1, 5, 6
Juan Bautista Alvarez Luis Miguel Martín	University of Córdoba	ge2alcaj@uco.es ge1mamlm@uco.es	Bread-making quality	1
Conxita Royo	Centre UdL-IRTA, Lleida	concepcio.royo@irta.es	Plant breeding and physiology	1,3
José Luis Molina	Centre UdL-IRTA, Lleida	joseluis.molina@irta.es	Plant breeding and genetics	1
Ignacio Romagosa	Centre UdL-IRTA, Lleida	iromagosa@pvcf.udl.es	Biometrical models and plant breeding	2
Gustavo Slafer / Roxana Savin	Centre UdL-IRTA, Lleida	slafer@pvcf.udl.es/ savin@pvcf.udl.es	Crop Physiology	3
Sweden				
Nils-Ove Bertholdsson	Svalöf-Weibull AB	nils-ove.bertholdsson @swseed.com	Plant breeding, plant nutrition, weed competitiveness, allelopathy	1,3,4
Stine Tuvesson	Svalöf-Weibull AB	stine.tuvesson @swseed.com	Marker selection	1

Expert (group)	Institution/Company	E-mail	Expertise	WGs
Morten Rasmussen	Svalöf-Weibull AB	Morten.rasmussen @swseed.com	Plant breeder, disease resistance	1,5
Sandra Wright	Göteborg University	sandra.wright @molbio.gu.se	Plant pathology, biocontrol, microbial ecology	3
Ulla Didon	Swedish University of Agricultural Sciences	ulla.didon@evp.slu.se	crop-weed interaction, weed competition, organic farming	4
Switzerland				
Mathias Menzi	Swiss Fed. Res. Station Agronomy, Zurich-Reckenholz	mathias.menzi @fal.admin.ch	Breeding, agronomy, variety testing	6
Hans-Rudolf Forrer	Swiss Fed. Res. Station Agronomy, Zurich-Reckenholz	hans-rudolf.forrer @fal.admin.ch	Plant pathology, breeding, agronomy, variety testing	1,5
Padruot M. Fried	Swiss Fed. Res. Station Agronomy, Zurich-Reckenholz	padruot.fried @fal.admin.ch	Breeding, agronomy, variety testing	5,6
Arnold Schori	Swiss Fed. Res. Station of Plant Production, Changins	arnold.schori @rac.admin.ch	Triticale breeding, variety testing	1
Dario Fossati	Swiss Fed. Res. Station of Plant Production, Changins	dario.fossati @rac.admin.ch/	Wheat breeder, variety testing	1,6
Geert Kleijer	Swiss Fed. Res. Station of Plant Production, Changins	geert.kleijer@rac.admin.ch	Wheat quality, genetic resources	1,6
Cécile Brabant-Hirondelle	Swiss Fed. Res. Station of Plant Production, Changins	Cecile.brabant@rac.admin.ch	Spring wheat breeder, variety testing	1
Fabio Mascher	Swiss Fed. Res. Station of Plant Production, Changins	fabio.mascher@rac.admin.ch	Plant pathology, resistance trials, microbial inoculants	3,5
Christine Arncken	Research Institute of Organic Agriculture - Frick	christine.arncken @fibl.ch	Breeding, variety testing, holistic varietal quality research	1,6
Genevieve Defago	Federal Institute of Technology	genevieve.defago @ipw.agrl.ethz.ch	Plant pathology, microbial ecology, biodiversity, biosafety	3
United Kingdom				
Martin Wolfe	Elm Farm Research Centre	Martin @wakelyns.demon.co.uk	Variety mixtures, intercropping, population breeding, participatory research	1,3,4, 5,6
Scott Philips	Elm Farm Research Centre	scott.p@virgin.net	Variety mixtures, intercropping, population breeding, participatory research, weed population biology	1,4,5, 6
Fergus Lyon	Middlesex University	f.lyon@mdx.ac.uk	Farmer participatory research	6
Frances Harris	Kingston University	f.harris @kingston.ac.uk	Farmer participatory research, nutrient cycling in farming systems	6
Elizabeth Stockdale	Rothamsted Research	Liz.stockdale @bbsrc.ac.uk	Soil science, nutrient cycling in organic farming systems, farming system planning	2,3

Expert (group)	Institution/Company	E-mail	Expertise	WGs
Stuart Swanston	Scottish Crop Research Institute (SCRI)	s.swanston @scri.sari.ac.uk	Malting quality, biofuels, variety mixtures	1
Graham Begg	SCRI	g.begg @scri.sari.ac.uk	Statistical analysis and modelling of vegetative interactions	2,4
Jim McNicol	SCRI	jwmcni @scri.sari.ac.uk	Statistical analysis	2
Adrian Newton	SCRI	Anewto @scri.sari.ac.uk	Variety mixtures, biofuel, plant pathology	1,5
Simon Oxley	Scottish Agricultural College (SAC)	s.oxley @ed.sac.ac.uk	Plant pathology	5
Steve Hoad	SAC	s.hoad @ed.sac.ac.uk	Agronomy, variety mixtures	1
Neil McRoberts	SAC	n.mcroberts @au.sac.ac.uk	Epidemiology, modelling, statistical analysis, systems analysis	5
Bill Spoor	SAC	w.spoor @ed.sac.ac.uk	Plant breeding, genetic base broadening and variety mixtures	1
D.H.Ken Davies	SAC	k.davies @ed.sac.ac.uk	Weed specialist	4
Simon Kerr	National Institute of Agricultural Botany (NIAB)	simon.kerr @niab.com	Variety testing, agronomy	
Rosemary Bayles/ Jane Thomas	NIAB	rosemary.bayles @niab.com	Plant pathology, variety testing	5,6
John Law/ Robert Cooke	NIAB	john.law @niab.com	GxE analysis, variety testing	2,6
Paolo Donini	NIAB	paolo.donini @niab.com	Molecular markers	1
Michael Shaw	The University of Reading	m.w.shaw @reading.ac.uk	Variety mixtures, population biology of host-pathogen adaptation	5
Bob Froud-Williams	The University of Reading	r.j.froud-williams @reading.ac.uk	Weed science, weed suppression, varietal selection, competition	4
Peter Young	University of York	jpy1@york.ac.uk	Mycorrhizal fungi and other plant-associated microbes	3

C. Examples of on-going field trials and other experimental activities to be included in the Action

Austria

A: Seeds for organic farming – Austrian organic plant breeding
Contact: J. Birschitzky, Saatzucht Donau. Funded by the Austrian ministry of agriculture (2002-2004).
Aim: To ensure the supply of suitable varieties which have been organically propagated for organic farming
Experiments: 50 winter wheat and 90 spring barley were tested at 2 locations on organic farms. Several traits (e.g. weed competitiveness, N-uptake) in addition to those used in conventional breeding were evaluated. The material included varieties and breeding lines from the conventional program as well as some specifically chosen for organic breeding
Analytical aspects: Evaluation of the need of a specific breeding program for organic/low-input farming
B: Selection Criteria in Organic Cereal Breeding with Respect to Genetic Influence on Seed Quality
Contact: Wilfried Hartl, Ludwig-Boltzmann-Institute for Biological Agriculture
Aim: Establishing methodology of selection criteria for low input farming
Experiments: Winter wheat and spring barley grown under organic conditions were extensively evaluated. Influence of seed provenience, N-uptake and transport under water stress, weed competitiveness, light interception.
Analytical aspects: Statistics over varieties, locations, years and interactions between evaluated parameters

Czech Republic

A: Localization of resistance genes to *Blumeria graminis* f. Sp. *Hordei* in new sources of *Hordeum vulgare* ssp. *Spontaneum* using molecular markers.
Grant Agency of the Czech Republic (2003-05)
B: Selection and joint use of barley genetic resources for cheap and health-safe reduction of yield loss caused by *Blumeria graminis* f. sp. *Hordei.*
Joint project of the Czech Republic and China (Czech part funded by the Czech Ministry of Education) (2003-05)
C: Identification of resistance genes in barley varieties.
Central Institute for Supervising and Testing in Agriculture (Czech Republic).
Contact: Antonin Dreiseitl, Agricultural Research Institute Kromeriz Ltd.
D: Detection and development of new sources of resistance to fungal and viral diseases in wheat
Contact: Vaclav Sip, Research Institute of Crop Production, Prague-Ruzyne
Aim: 1/to detect sources of combined (specific) resistance to important diseases and exploit them in breeding wheat varieties for low input systems; 2/ to analyze genetic background of resistance and use available molecular markers to speed up the breeding process; 3/to evaluate the selection procedures and specify properties of developed materials for their exploitation in breeding and growing.
Experiments: National tests of resistance to *Fusarium head blight,* brown leaf spot diseases (*Septoria tritici, Stagonospora nodorum, Pyrenophora tritici-repentis),* yellow rust, stem rust, brown rust and powdery mildew each year on 4 locations with cca 50 winter and spring wheat materials (potential sources of resistance from international cooperation, advanced breeding lines); tests of resistance to BYDV at Prague-Ruzyne. Yield trials with newly developed varieties

under low input conditions (reduced application of chemicals and reduced N doses) and with conservation tillage practices at three locations.
Analytical aspects: Analysis of data obtained in tests with artificial infection - visual scoring of symptoms and evaluation of effects on important yield and grain quality characters; application of available molecular markers to detect resistance genes; the use of common statistical methods for data evaluation in variety trials.

E: Breeding wheat and barley for resistance to *Fusarium* head blight (FHB) infection and mycotoxin accumulation in grain
Contact: Vaclav Sip and Jana Chrpova, Research Institute of Crop Production, Prague-Ruzyne
Aim: 1/ Analysis of *Fusarium* pathogen spectra and factors that influenced accumulation of *Fusarium* mycotoxins in the territory of Czech Republic; 2/ pathogenicity studies and implications for resistance tests; 3/ exploitation of detected (developed) resistance sources in wheat and barley breeding; 4/variety characteristics from these aspects and choice of suitable varieties.
Experiments: Mycological survey and mycotoxin content determination in 250 samples of wheat (barley) collected from different regions of Czech Republic. Pathogenicity studies with selected 20 isolates of different *Fusarium* species that were common in the examined territory and their molecular characterization - application of obtained results in resistance tests. Examination of appr. 50 materials (potential sources of resistance obtained from different European countries and advanced lines) at 4 locations in Czech Republic and in established international trials (reduced number of items) - determination of important characters related to disease severity and accumulation of DON. Evaluation of response to FHB infection in appr. 70 winter wheat and spring barley varieties from the official trials. Determination of effects of conventional and conservation tillage practices and other factors on FHB infection, DON content and grain quality in examined 15 wheat varieties from experiments at 3 locations.
Analytical aspects: Evaluation of different characters obtained in tests with artificial infection; exploitation of PCR techniques and ELISA and GAS chromatography (mycotoxin spectrum) for detection of mycotoxin contamination; routine statistical analyses of data on different examined characters.

Denmark

A: Characteristics of spring barley varieties for organic farming
Contact: Hanne Østergård, Risø National Laboratory. Fiancing body and period: DARCOF and gov. institutes, 2002-2005 (and G.Deneken, I.Rasmussen, P.Hansen, M.Hovmøller, H.Pinnschmidt, N.E. Nielsen, I.K.Thomsen, G.Backes, K.Kristensen,)
Aim: Better understand biotic interactions in the organic growing system, investigate the importance of genotype-environment interactions, select genotypes suitable for organic farming conditions, implement variety mixtures for increasing stability, implement organic variety testing if needed.
Experiments: 1) about 110 varieties and six 3-ways mixtures assessed over four years under organic and non-organic conditions for disease resistance to natural occurring diseases and weed competitiveness; 2) multifactorial field experiments looking at weed competitiveness, influence of scald and net blotch interactions on healthy leaf area and yield, and nutrient uptake in few varieties and their combination in mixtures.
Analytical aspects: 1) Analysis of genotype-environment interactions; 2) association mapping; 3) identification of characters that confer improved productivity in each of the production environments, 4) design of experiments, 5) plant epidemiological models, 6) VCU.

B: International ring testing for resistance to leaf scald in spring barley; Resistance biology of *Ramularia* leaf spot in spring barley.
Contact: Hans Pinnschmidt/Mogens Hovmøller, Danish Inst. For Agric. Sci. Fiancing body and period: Jyllerup foundation, 2003.
Aim: 1) characterise scald resistance performance of varieties in relation to environmental effects; 2) establish methods for resistance testing.

Experiments: 1) international scald nursery trials on ca. 12 locations using ca. 45 cultivars; 2) screening ca. 30 spring barley varieties for *Ramularia* resistance under different inoculum levels.
Analytical aspects: 1) statistical techniques to analyse multi-environment variety trials.

C: Barley – Efficient resistance breeding by means of marker technology

Contact: Ahmed Jahoor, Risø National Laboratory. Financing body and period: Ministery of Food, Agriculture and Fisheries, 2001–2005,
Overall aim: New sources of resistance against powder mildew, leaf rust and scald in barley: introgression into cultivated barley and marker for the resistances.

D: Breeding - barley and wheat

Contact: Ole Andersen, Sejet Plant Breeding, Horsens
Aim: Breeding for barley and wheat for Danish low-input conditions with emphasis on disease resistance, weed competitiveness and nutrient uptake.
Analytical aspects: Plant breeding, plant pathology, weed competitiveness, experimental design, prebreeding seed material

E: New production methods for grain legumes and cereals for animal feed

Financing body and period: DARCOF and gov. institutes, 2000-2003.
Contact: Henrik Haugaard-Nielsen /Michael Lyngkjær, Department of Plant Research, Risø National Laboratory, Roskilde, Denmark

F: Intercropping of cereals and grain legumes for increased production, weed control, improved product quality and prevention of N-losses in European organic farming systems.

Contact: Erik Steen Jensen, Department of Plant Research, Risø National Laboratory, Roskilde, Denmark. Financing body EU FP5, 2003-2005.
Aim: Increase the knowledge on the multifunctional role of intercropping: production level and stability, resource use, environmental impacts, and product quality of intercrops. It is included in the EU project to develop a simulation model for modelling grain legume-cereal intercrops, which can be used in the design of intercrops and strategic planning of cropping systems with intercrops and also to carry out on-farm demonstration activities.
Experiments: Research on experimental and on-farm fields are conducted under varying climatic and edaphic conditions to determine the yield advantage and stability of cereal-grain legume intercrops compared to their respective sole crops on both the national and regional level.
Analytical aspects: Stable isotopes, symbiotic N2-fixation in legumes, competitive ability against weeds, plant health, food and feed quality.

G: Nutrient acquisition and crop performance

Contact: Niels Erik Nielsen, Department of Agricultural Sciences, Royal Veterinary and Agricultural University, Copenhagen. Duration 2002-2005.
Aim: Study of variety/mixture performance including rooting depth in interaction with varying soil fertility and mineralization levels.
Experiments: spring barley varieties grown alone and in mixtures are studied in a field experiment with four levels of manure application and in fields with high and low soil fertility due to cropping one and four years after grass and clover ley.
Analytical aspects: Reflectance measurements, root development, biomass and grain yields, and efficiencies of N, P and K acquisition and use.

H: Resistance to *Puccinia striiformis* in wheat

Contact: Mogens Hovmøller, Danish Inst. For Agric. Sciences. Fiancing body and period: Farmers Union/Ministry of Food, Agriculture and Fisheries, 2004.
Aim: 1) characterise resistance to yellow rust in wheat in relation to environmental effects including pathogen genotype;
Experiments: Disease development in approx. 50 wheat cultivars to newly emerged pathotypes including a pathotype possessing virulence for *Yr15* which was discovered for the first time in 2002.
Other activities: Participation in European ring test for analysing stability of different sources of yellow rust resistance in different agro-ecological zones in Europe.

I: New Strategies to Improve Grain Legumes for Food and Feed. WP 2.1 Lower Input Farming.
Contact: Erik Steen Jensen/Michael Lyngkjær, Risø National Laboratory. Fiancing body and period: EU FP6 and gov. institutes, 2003-2007
Aim: Test of innovative management strategies for improved crop and rotational health and grain quality in cropping systems with grain legumes (including intercropping with cereals).
Experiments: experiments in field and under controlled conditions with intercrops of pea and cereals to study optimisation of intercrop design for disease and parasitic weed management in pea and determination of grain quality.

Finland

A:Virulence survey studies on barley leaf spot diseases (net blotch and scald)
B: Resistance breeding on barley (net blotch, scald, mildew)
Contact: Marja Jalli, Boreal Plant Breeding Ltd

France

A: Breeding and management of cereals cultivars innovations (durum wheat and rice) for territorialized organic agriculture.
Contact: Dominique Desclaux, INRA Montpellier- France: Action 'IMPACT' INRA, 2002-2005 (and B.Colomb, INRA-Toulouse)
Aim: Studying interest of durum wheat populations, finding alternative breeding methods to increase and manage genetic variability, understanding Soil organic nitrogen dynamics, importance of genotype-environment interactions, assessing social and economic factors of organic conversion by producers, build a collective learning network at territorial level, develop a co-breeding program involving producers (participatory breeding method).
Experiments: Different varietal types will be compared: Populations, mixtures, pure lines including wild species. Screening of lines (rice or durum wheat) in organic conditions in 7 locations.
Analytical aspects: Plant breeding, Participatory breeding program, Statistics, GxE interactions,, Agronomical diagnosis from plant revealers of limiting factors, socio-economical models
B: Variety research in winter wheat and triticale for organic farming systems.
Contact: Olivier Gardet INRA Le Moulon, Bernard Rolland INRA Rennes, and Laurence Fontaine, ITAB
Financing body and period: Action CPER Bretagne (2002-2006), ONIC (2003- 2004).
Aim: to determine if cereals cultivars created for integrated farming are suitable for organic farming.
Experiments: about 40 wheat varieties and 10 triticale varieties are screened for suitability for organic farming on three locations. The research protocol includes characteristics such as disease resistance, weed competitiveness and baking quality and yield. The system is compared with results of testing the same varieties in integrated farming trials.
Analytical aspects: Statistics, genetics, assessing baking quality, development of screening methods, Agronomical diagnosis from plant revealers of limiting factors.
C: Analyses of results from a wheat cultivar mixture network conducted with farmers and a miller.
Contact: Claude Pope
Aim: The analysis concerns disease resistance (mainly septoria leaf blotch), yield, and baking quality. The fields are characterised by factors limiting yield components (soil, water stresse etc) and analyses of genotype x environment interaction are undertaken to assess the yield stability.
D: Studying evolution and adaptation of bread wheat populations and Early-stage breeding for mixing ability
Contact : Isabelle Goldringer. Financing body and period: BRG 2002-2003, 2003-2004.
Aim: 1) study and compare the evolution of diversity for molecular markers, candidate genes and adaptive traits in experimental wheat populations conducted under dynamic management for 10

to 20 generations and in old varieties populations cultivated by farmers. 2) test whether selection in the early stage can allow to identify genotypes with a good mixing ability among a large number of varieties representing a wide genetic variability in bread wheat.
Experiments: 1) Evaluation of different wheat populations (from experimental dynamic management and cultivated by farmers) in different growing conditions: low input and organic, in different locations (research staions, farms). Measure of agronomic and adaptive traits, and genetic diversity.
2) 20 lines derived from of a wheat dynamic management programme, 20 lines from a multilocal and multitrait recurrent selection programme and 10 official varieties are evaluated in a Single-Row Plot (SRP) design. Earliness traits, morphological characteristics, yield components are measured on each plot. As a reference for pure stand, the 50 lines will be grown simultaneously in larger plots. Evaluation of binary and 4-way mixtures of genotypes based on the statistical results.
Analytical aspects: statistical modelling (producer-competitor model, Azaïs 1987) of the interactions between genotypes may provide relevant genetic parameters indicating whether a genotype is characterisc or stimulating for its neighbours and whether it is resistant or to competition with other genotypes.

E: Selection of plant varieties for better compatibility with plant-beneficial root-colonizing microbes and effect of microbial inoculants.

Contact: Yvan Moënne-Loccoz, UMR CNRS 5557 Ecologie microbienne, Université Claude Bernard (Lyon 1), 43 Bd du 11 Novembre, 69622 Villeurbanne (cedex), France; Financing body and period: projects Pnetox, BRG; 2003-2005.
Experiments: Analysis of the effect of phytohormone-producing, nitrogen-fixing *Azospirillum* phytostimulators on the crop and on mycotoxin-producing *Fusarium*. Analysis of the adaptation of biocontrol pseudomonads and other bacteria to the rhizosphere.

Germany

A: Evaluation of spring and winter barley disease resistance in the field, especially loose smut covered smut and leaf stripe

Contact: Karl-Josef Müller, Cereal Breeding Research Darzau.
Aim: Getting knowledge about differences of susceptibility between common varieties related to loose and covered smut, finding resistant varieties as a source for further breeding, distinguishing different sources of loose smut on a set of test-varieties.
Experiments: 50 spring and 90 winter barley varieties are tested under artificial inoculation and natural infection conditions in an organic farming system.

B: Interactions between growing conditions, fungal diseases, baking quality and mycotoxin load in organic wheat production

Contact: Maria Finckh, Ecol. Plant Protection, University of Kassel, 37213 Witzenhausen, Germany.
Aim: 1) determine the effect of variety mixtures on disease development baking quality and seed health. Based on the data, it will be attempted to make predictions on the crucial factors influencing baking quality and mycotoxin load. Seed samples from three years will be analysed in the course of the project. 2) develop improved serological methods for detection of seed borne fusarioses and mycotoxins. These methods will be of use in quality assurance for human and feed consumption and for seed certification for organic farming where seed treatments against fusarioses are not available.
Experiments: Pure stands and a mixture of two popular varieties are are grown on eight farms and data will be collected on nutrient availability, soil conditions, rotation and disease pressure. An additional replicated experiment is being conducted in two crop rotation schemes

C: Field trials under organic conditions

Contact: Werner Vogt-Kaute, Naturland e.V. Steingrund 27, 97797 Wartmannsroth
Aims: Finding new varieties for organic farmers. Financed by plant breeding companies and Naturland, an organic farmers' association

Experiments: Standards, not yet released varieties, varieties from abroad and variety mixtures. 10 – 30 varieties for each crop. On 1 location: spring wheat, winter rye, winter triticale, spring triticale, winter barley, spring barley, spring oats. On 3 locations: winter wheat.
Analytical aspects: Statistics on yield and competitive factors. Analyses of baking quality (wheat)

Hungary

A: Use of traditional and molecular methods in research on cereals suitable for organic farming. Subtask: organic breeding of hulled wheat species.
Contact: Géza Kovács, Agricultural Research Institute of the Hungarian Academy of Sciences. Fiancing body and period: Ministry of Education and gov. institutes, 2002-2005
Overall Aim: Better understanding of biotic and abiotic stress reactions under organic growth conditions, investigate the importance of genotype-environment interactions, select genotypes suitable for organic farming conditions, develop organic plant breeding methods.
Experiments: 1) about 300 genebank accessions and genotypes of hulled wheat species assessed over three years under organic conditions for abiotic stress tolerance (drought and frost), disease resistance to natural occurring diseases and weed competitiveness; 2) classical genetic analysis of agronomic traits important in organic farming; 3) Comparison the effectiveness of different breeding methods suitable for organic breeding; 4) evaluation of the developed lines and genetic materials in multifactorial field experiments under organic farm conditions at different locations.
Analytical aspects: 1) Analysis of genotype-environment interactions; 2) genetic study of weed competitiveness; 3) identification of characters that confer improved productivity and quality in each of the production environments, 4) design of experiments, 5) evaluation of different breeding methods.
B: Extrusion and transmission of einkorn (*Triticum monococcum* L. ssp. *monococcum)* genetic variability using classical genetic and biotechnological techniques.
Contact: Géza Kovács, Agricultural Research Institute of the Hungarian Academy of Sciences. Fiancing body and period: Hungarian Scientific Research Fund, 2001-2004
Overall Aim: Evaluation of natural diversity of einkorn. Assessement of biotic and abiotic einkorn genetic resources and transmission of their resistance to agronomically usefull genotypes via classical and biotechnological methods.
Experiments: 1) 128 different einkorn landrace and genebank accessions assessed over three years under field conditions for measuring their genetic variability, agronomic performance and robustness of the agronomic traits. 2) Transmission of biotic and abiotic stress tolerance (drought and frost) to other agronomically important cereal species via interspecific and intergeneric crosses. 3) extrusion of genetic variability using diferent biotechnological methods (genetic transformation not included).
Analytical aspects: 1) Genetic diversity studies; 2) genetic study of biotic and abiotic stress tolerance, 3) Study the embryogenic capacity of the intergeneric hybrids.

Italy

A: Barley breeding for *Pyrenophora graminea* resistance: from conventional to molecular assisted selection (MAS) for the development of a healty crop
Contact: Antonio Michele Stanca, Experimental Institute for Cereal Research (ISC), Section of Fiorenzuola d'Arda, Financing body and period: Italian Ministry of Agriculture and Forestry-MiPAF

Aim: a) Evaluation of advanced breeding lines and accessions from the Italian barley collection and International barley core collection (BCC) in field and laboratory (sandwich test) for *Pyrenophora graminea* resistance/tolerance; b) Applications of STS molecular marker (MWG2018) linked to the Rdg2 qualitative resistance to assess the introgression of the gene into barley elite lines; furthermore, markers flanking the Proctor QTL are used to follow this resistance in barley breeding programs; c) Identification of new sources of resistance or tolerance to be passed to the farmers for immediate utilization and to breeders for varietal improvement. A

more stable resistance to this disease in barley cultivars would result in a reduction of fungicide applications and environmental pollution.

Experiments: several advanced barley breeding lines developed at the ISC and genetic materials from the BCC will be evaluated for their degree of resistance to the the natural infection by the Italian field population of *P. graminea* spread by a susceptible genotype; the same materials will be also evaluated for their level of resistance under artificial inoculation. Resistant advanced breeding lines in which Rdg2 or the quantitative Proctor-resistance function as source of resistance will be selected with PCR based markers.

B: **Genetic structure of *Pyrenophora teres* Drechs. populations collected from populations landraces of barley (*Hordeum vulgare* L.)**

Contact: Giovanna Attene, Dipartimento di Scienze Agronomiche e Genetica Vegetale Agraria; University of Sassari, Italy. Financing body and period: Italian Government – MURST and CNR.

Aim: 1) To estimate the amount of genetic variability between and within *Pyrenophora teres* (the pathogen) populations sampled from sympatric populations of barley (the host) landraces. 2) To detect the level of gene flow between the population of host and pathogen; 3) To determine the relative contribution of sexual vs asexual reproduction within *P. teres* populations; 4) To compare both host and pathogen population genetic structure to answer the question: is there a parallelism in the population structure of the two protagonist?. This we would allow: 1) to contribute to a better knowledge of the co-evolutionary dynamics in *P. teres*-barley landraces plant-pathosystem; 2) to use the information obtained from populations genetic study to predict the "risk" of pathogen populations evolution; this could be useful to guide resistance-breeding strategies for durable resistance for this pathogen (McDonald and Linde, 2002).

Analytical aspects: 1) Using appropriate parameters to describe the level and the structure of both plant and pathogen populations. 2) Integrating plant and pathogen datasets of molecular (AFLP, SSR, ISSR, SSAP) and phenotypic (mainly quantitative traits) variation, and from cross inoculation experiments.

C: Durum wheat under reduced nitrogen input and marker-assisted selection for yield and quality components

Contact: Antonio Blanco Department of Agroforestry and Environmental Biology and Chemistry, section Genetics and Plant Breeding, Bari. Financing body and period: Italian Government – MURST.

Aim: 1) Phenotypic characterization of cultivated and wild wheat germplasm, and segregant populations for several agronomic important traits in replicated trials under low nitrogen fertilization; 2) identify polymorphic molecular markers correlated to the phenotypic expression of grain yield and quality component traits. The approach of genome analysis of segregant populations by molecular markers are used to localize the target genes along the chromosomes and to provide markers for breeding programs.

Analytical aspects: Suitable genetic materials will be used, specifically: i) one collection of 50 accessions of breeding interest, including landraces, old and modern cultivars, breeding lines and wild accessions of the var. dicoccoides and dicoccum; ii) 65 recombinant inbred lines (RIL) obtained from crossing the Italian durum wheat cv. Messapia and one accessione of the wild tetraploid wheat MG4343 of the var. dicoccoides. The detection of QTLs for the phenotypic expression of grain yield and quality will be based on the linkage map described in Blanco et al. (1998). Molecular markers linked to the trait of interest will be tested within the experimental collection of 50 accessions. In this way it will be possible to monitor the presence of QTLs detected in the segregant populations.

D: Integration of low-input agricoltural systems for durum wheat safety and quality.

Contact: Natale Di Fonzo,Experimental Institute for Cereal Research (ISC), Section of Foggia. Financing body and period: Italian Ministry of Agriculture and Forestry- MiPAF

Aim: 1) identification of germoplasm adapted to low-input production as well as suitable low-input cropping system minimizing the use of pesticides; 2) promising accessions will be passed on to European breeders for immediate utilization and as parents for new breeding programs.

Experiments and Analytical aspects: The project will focus on evaluation and utilization of durum wheat varieties (mainly modern) developed in different countries for high quality, safety

and healty grain. Experiments to properly define low input systems will include minimum tillage, the rate of nitrogen pre-sowing and top-dressing to get the best yield performance and healty and high grain quality characteristics. Development of the main fungal diseases (seed-born, foliar, spike and grain diseases) will be monitored; for some diseases (brown rust, mildew and *Fusarium*) evaluation will be carried out also in glasshouse with defined isolates or races of the pathogen.

E: Mapping Adaptation of Barley to Drought Environments (MABDE).

Contact: Nicola Pecchioni, Università degli Studi di Modena e Reggio Emilia. Financing body and period: European project: MABDE 2003-2005

Aim: Identification and confirmation of candidate genomic regions associated with yield under drought conditions using . Assessment of the role of candidate genes for adaptation. Germplasm improvement for water use efficiency under rainfed Mediterranean environments.

Experiments A selected set of 250 barley genotypes, including both landraces and improved cultivars, are tested for agronomical, physiological and genetic characterization. Localization of genomic regions involved in drought resistance by means of association mapping studies. Beside this, drought tolerance QTLs and the candidate genes underlining them are precisely tagged in the barley genome using a molecular linkage map.

Analytical aspects: Statistics. Employment of the landraces as a useful source of new genetic variation.

Latvia

A: Detection of the adaptive gene complex in the Latvian barley and their mapping by means of molecular markers

B: Investigation of the new effective sources against to barley powdery mildew and they introduction into Latvian barley varieties

Contact: Isaak Rashal, University of Latvia. Financing body and period: Latvian Council of Sciences, 2001-2004

The Netherlands

A: Suitable Varieties: Variety Research for Organic Farming Systems

Contact: Edith Lammerts van Bueren, Louis Bolk Instituut

Financing body and period: Ministry of Agriculture and Fisheries, Regional Research Organisations, Arable Product Board, 2001-2004

Aim: designing a scientifically and economically sound system of Value for Cultivation and Use research for Spring Wheat and Onion

Experiments: about 30 varieties are screened for suitability for organic farming on three locations. The research protocol was developed in close collaboration with the sector and includes characteristics such as weed competitiveness and baking quality and yield. The system is compared with results of testing the same varieties in a conventional trial

Analytical aspects: Statistics. Develoment of screening methods for characteristics such as weed competiveness and appropriate tests for baking quality.

B: Spring and Winter Wheat Variety Mixtures for Organic Farming Systems

Contact: Edith Lammerts van Bueren, Louis Bolk Instituut

Financing body and period: Triodos Foundation Fund, Louis Bolk Instituut, an Organic Trader and two organic farmers 2000 – 2003 (may continue)

Aim: combining different wheat genotypes to enhance yield stability and baking quality

Field experiments: about 5 mixtures and pure stands of the component varieties for both spring and winter wheat are tested in two organic farms.

Analytical aspects: Statistics. Assessing baking quality.

C: Mapping Adaptation of Barley to Drought Environments (MABDE)

Contact: Fred van Eeuwijk, participating in EU-project MABDE 2003-2005

Aim: Barley is the predominant crop in the driest land areas throughout the Mediterranean, Being annually grown on 15 million ha. Grain Yields are particularly affected by drought. The main objective of the larger EU-project is to understand the genetic and physiological dynamics and

processes underlying adaptation to drought. Novel materials will be developed and studied across a wide range of Mediterranean drought-prone environments throughout Europe, North Africa and West Asia. Contemporary genetics and plant physioloty tools will be used in order to formulate a germplasm improvement strategy for water use efficiency under rainfed Mediterranean environments.

D: Enhanced biodiversity and weed-suppression in agro-ecosystems

Contact: Lammert Bastiaans; Group Crop and Weed Ecology, Department of Plant Science, Wageningen University and Research Centre

Aim: Investigate how an increased vegetational diversity by mixed cropping and/or by diverse field margins can lead to the suppression of populations of weedy plants.

Norway

A: Studies of the availability of soil phosphorus (P) and potassium (K) in organic farming systems, and of plant adaptations to low P- and K-availability

B: Organic cropping systems for higher and more stable cereal yields, focussing on nutrient cycling in farming systems nourished mainly by green manure crops

Contact: Anne-Kristin Løes; Norwegian Center of Organic Farming, Tingvoll Gard

Poland

A: Creation of prebreeding material of spring barley (malting quality and fungal disease resistance) and winter wheat (fungal disease resistance and quality)

Contact: Henryk J. Czembor, Jerzy H. Czembor, IHAR – Radzikow

Polish Government (Polish Ministry of Agriculture and Rural Development), 2001-2005

B: Creation of prebreeding materials of winter wheat with high tolerance to acid soil conditions / Identification of triticale genotypes with high quality.

Contact: Henryk J. Czembor, IHAR, Polish Government (Polish Ministry of Agriculture and Rural Development), 2001-2005

C: Tolerance of wheat and triticale for the presence of aluminium ions (acid soils) in soil and genetic studies of this tolerance.

D: Identification of new sources of resistance to barley leaf rust (Puccinia hordei Otth.)

Contact: Henryk J. Czembor, IHAR, State Committee for Scientific Research (KBN), Poland, 2002 – 2005.

Aim: Exchange of statistical experience with variety trials. Pointing out efficient types of experimental designs for variety trials under low input. Information on methods to analyse non-normal distributed data to all participants.

E: Evaluation of pathogenicity of major pathogens of barley and protection of barley using genetic resistance.

Contact: Jerzy H. Czembor, IHAR, 2001 – 2010,

F: Construction of software tools for the analysis of MET data obtained in breeding experiments (part of larger project) COBORU. 2002-2003

G: Statistical models for the analysis of multi-environment plant trial data; IPG PAS 2001-2003

Aim: the application of incomplete-block designs in the multi-environment experiments and utilization of the mixed linear model for the data analysis

Contact. Paweł Krajewski, IPG PAS

Slovakia

A: Utilization of agriculturally important resistance genes in breeding by classical and molecular breeding approaches

Contact: Valéria Šudyová, Svetlana Šliková, Research Institute of Plant Production, Piešťany

Aim: to transfer effective resistance genes (against fungal pathogens and viruses) into localy adapted germplasm of wheat and barley to be more valuable for low-input and organic farming systems

Experiments: Long-term molecular breeding programme (MAS) for transfer of *Lr*, *ym*, and *Yd* genes into wheats and barleys, respectively.
Analytical aspects: Creation, characterization, and transfer of new-developed advanced wheat and barley lines into breeding programmes, studies of MAS effectivity in practical breeding.

B: Genetic diversity enhancement by identification and transfer of new, low frequented, and „forgotten" alleles into breeding

Contact: Edita Gregová, Zuzana Lajchová, Research Institute of Plant Production, Piešťany
Aim: to identify new gene(s) improving technological quality of wheat, to incorporate these genes, or re-integrate others low frequented and interesting alleles from their donors into modern cultivars
Experiments: Wide screening of European obsolete cultivars and landraces for presence of low frequented and new HMW-GS alleles, identification of lines possessing these alleles, their multiplication, creation of hybrid lines by classical crossing and selection by molecular markers.
Analytical aspects: Extension of genetic diversity, identification and characterization of selected alleles on technological quality, transfer of characterized created advanced lines into breeding programmes directed also into non-traditional farming systems.

C: Virulence analysis, resistance testing, identification and characterization of new and effective sources of resistance

Contact: Jozef Gubiš, Katarína Bojnanská, Viera Gottwaldová, Research Institute of Plant Production, Piešťany
Aim: 1) to perform virulence analyses of important pathogens (*Blumeria graminis, Puccinia triticina, Pyrenophora teres, Rhynchosporium secalis*) in the Slovakia
2) to identify sources of effective reistance genes and to use them
Experiments: Monitoring in territory of Slovakia, field and laboratory testing of resistance, detection of specific genes of resistance.
Analytical aspects: Results from virulence analyses, characterization of level of resistance in broad set of genotypes.

D: Evaluation of morphological, agronomical, biochemical, and molecular diversity in maintained original barley and wheat germplasm

Contact: Ján Kraic, Michaela Benková, Pavol Hauptvogel, Research Institute of Plant Production, Piešťany
Aim: 1) to evaluate morphological traits, agronomical characteristics, interactions with the most important phytopathogens, biochemical characteristics (enzymes, starch, fibre) and molecular diversity in original germplasm developed and growed in our territory, maintained in collection of genetic resources or also cultivated at this time 2) to identify new and better genetic resources of dietary fibre, starches with beneficial effects for consumers, essential or profitable lipids (fatty acids) in the frame of traditional crops growed here years before.
Experiments: Over 50-year old tradition in wheat, barley, and other cereals genetic diversity maintenance and evaluation. Field plots in several locations during 2-4 years according to optimal growing systems. Evaluation of biological and genetical diversity in territory over cca 100 years, field experiment (cca 110 barley genotype and more than 100 wheat genotypes) directed to morphological, agronomical, and phytopathological evaluation, laboratory testing of resistance genes presence, activities of selected enzymes, starch and fibre content, and DNA-based diversity.
Analytical aspects: Study of genetic diversity from the point of view of morphology, agronomy, quality. Cooperation with plant breeders. Overwiev of germplasm development over cca 100 years, prediction of trends in future germplasm development and change. Identification of interesting sources, their incorporation into different, mainly low-input farming systems.

E: Pathogenic fungi and mycotoxins in grain – diagnostics, monitoring, and breeding

Contact: Martin Pastirčák, Martina Hudcovicová, Valéria Šudyová, Svetlana Šliková, Research Institute of Plant Production, Piešťany
Aim: qualitative and quantitative diagnostics of seed-borne wheat pathogens (mainly *Fusarium* ssp., also *Septoria tritici*), evaluation of pathogen spectra accumulated toxins, application of these methods in breeding for *Fusarium* resistance, comparison of conventional, low-input, and organic

farming systems from „*Fusarium*“ point of view, development of wheat lines resistant/ partially resistant against them.
Experiments: Field tests in conventional, low-input, and organic farming systems, monitoring of pathogens and toxins distribution.
Analytical aspects: Results of wheat genotypes resistance against selected seed-borne pathogens, mycotoxin accumulation in different cultivars growed.

F: Statistical evaluation of variety trials in field plots
Contact: Mária Žáková, Alžbeta Žofajová, Research Institute of Plant Production, Piešťany
Aim: The use of multivariate statistical methods (such as the cluster analysis, factor analysis, analysis of main components, etc.) in study of genetic variation usable in plant breeding. The aim was to choose useful methods for this study and getting knowledge about variability of genetic resources.
Experiments: On-going field experiments in barley and wheat in the frame of field evaluation and selection of donors usable in breeding programmes.
Analytical aspects: Using the suitable algorithms to discover the most interesting (similar, disimilar, identical, etc.) genotypes.

Spain

A: Resistance against leaf rust and septoria leaf blotch in durum wheat
Contact: JC Sillero, CIFA, Alameda del Obispo, Apdo 3092, 14080 Córdoba,
Financing body: PIA, Junta de Andalucía, Period 2003-2005

B: Breeding for disease resistance in durum wheat
Contact: D. Rubiales, Institute for Sustainable Agriculture, CSIC, Apdo. 4084,14080 Córdoba
Financing body: PETRI-CICYT, Period 2002-2005

C: New strategies for disease and weed control in wheat under conservation agriculture
Contact: M.M. Catedra and JJ Perez, CIFA, Rancho de la Merced, Apdo 589, 14080 Jerez-Cádiz
Financing body: PIA, Junta de Andalucía, Period 2003-2005

D:Seed storage proteins as quality components and genetic markers of cereals
Contact: J.B. Alvarez and L.M. Martin, Department of Genetics, University of Cordoba, Spain
Aim: Identification of new allelic variants of storage protein genes, evaluation of their contribution to quality of cereal produtcs, regeneration and characterization of germplasm from the bank reserves.
Experiments: germination, multiplication and evaluation of old accesions.
Analytical aspects: differents types of elctrophoresis, statistics ans employment of the landraces as a useful source of genetic variation.

E: Developing wheat with enhanced nitrogen use efficiency towards a sustainable system of production.
Contact: Conxita Royo, Àrea de Conreus Extensius. Centre UdL-IRTA, Lleida. Financing body and period: DG Research, UE. EC RTD Programme: Quality of Life and Management of Living Resources. Key Action # 5.1.1. Sustainable agriculture-new and improved production and farming systems. 2002-2004.
Aim:a) Develop molecular genetics to screen for N use in future breeding programmes, and b) Develop new wheat genotypes with enhanced N-use by cereal transformation on elite and double haploid mapped lines to over-express glutamine synthetase in the shoot.
Experiments: Transformed wheat is being tested for N-fertiliser use, nitrate leaching, productivity and quality in the field. Sets of transformed wheat are being characterized for growth, development and morphphysiological traits associated with yield and quality.

F: Mapping Adaptation of Barley to Drought Environments (MABDE)
Contact: Ignacio Romagosa and José Luis Molina-Cano. Àrea de Conreus Extensius. Centre UdL-IRTA, Lleida Centre UdL-IRTA. Financing body and period: European project. Framework V INCO-MED (MABDE: ICA3-2002-10073) 2003-2005.
Aim: Identification and confirmation of candidate genomic regions associated with yield under drought conditions; Assessment of the role of candidate genes for adaptation; Germplasm

improvement for water use efficiency under rainfed Mediterranean environments; development of integrated models of Genotype x Environment Interaction
Experiments: A selected set of 250 barley genotypes, including both landraces and improved cultivars, are tested for agronomical, physiological and genetic characterization in more than 30 environments * year across the Mediterranean Basin.. Localization of genomic regions involved in drought resistance by means of association mapping studies. Beside this, two barley mapping populations are also studied for drought tolerance QTLs and the candidate genes underlining them are precisely tagged in the barley genome using a molecular linkage map.
Analytical aspects: Association mapping; Genotype x Environment Interactions; Employment of the landraces as a useful source of new genetic variation.

G: Physiological Basis of Wheat Responses to Nitrogen Fertilisation in the Ebro Valley
Contact: Gustavo Slafer, Centre UdL-IRTA/ICREA, Roxana Savin, Centre UdL-IRTA/ICREA
Financing body and period: Ministry of Science and Technology. Spain (Project AGL2003-06978) 2003-2005
Aim: to identify and quantify the main wheat ecophysiological attributes that determine the responses to nitrogen fertilisation under different Mediterranean conditions. This project will analyse the genetic and environmental interaction determining the responses of bread wheat to different strategies of nitrogen fertilisation, through both conventional and computer-assisted experimentation identifying mechanisms involved in the responses at a crop level of organisation, attempting to identify avenues to optimise productivity while preventing environmental damage.
Experiments: This project will analyse the genetic and environmental interaction determining the responses of bread wheat to different strategies of nitrogen fertilisation, through both conventional and computer-assisted experimentation identifying mechanisms involved in the responses at a crop level of organisation, attempting to identify avenues to optimise productivity while preventing environmental damage.
Analytical aspects: Yield Physiology; Nutrient absorption and partitioning; Genotype x Environment Interactions.

Sweden

A: Characterisation of root and seed associated microorganisms and their contribution to disease control and plant vigour
Contact: Sandra Wright, Dept. of cellular and molecular biology, Göteborg,University, Göteborg.
Financing body and period: SLF, 1999-2004: Genetic analysis of mode of action of a biocontrol pseudomonad. SLF, 2003-2006: Microbial inoculants to induce resistance in cereals to diseases and insect
pests.
Aim: to understand how associated microbes interact with barley and its pathogens, and to uncover the microbial environment for plants of various cultivars that results in the most resistant and healthy crops.
Plants exist in nature in close association with their microflora, and they are dependent on it for nutrient uptake, health and vigour. Initial results from our laboratory demonstrate that cultivars and near-isogenic lines of barley produce a differential disease resistance induction in response to seed treatment with the same isolate of a plant-associated microorganism. Thus, for every cultivar there exists an optimal microflora that protects the plants from diseases and renders them more vigorous. In low-production systems, the use of fungicides is restricted, and therefore it is of great benefit to protect plants from foliar diseases and pests by deploying the naturally existing microflora.
Experiments: Isolation of cereal-associated bacteria from low-input production sites, determination of the optimal cultivar – isolate combinations for maximal control of powdery mildew and rust and to studying the genetic basis for this interaction

B: Introduction of N-use efficiency, weed competition and allelopathy in breeding of barley and wheat for organic farming.
Contact: Nils-Ove Bertholdsson, Svaloef Weibull AB, Sweden. Financing body and period: FORMAS and Svaloef Weibull AB, 2002-2004.

Aim: To develop and evaluate new breeding selection methods to improve n-use efficiency, weed competition and allelopathy in barley and wheat
Experiments: Screening of breeding lines for N-use efficiency using hydroponics. Screening of barley and wheat germplasm for cultivars with high allelopathic activity. Testing of selected lines on organic yield trials. Improve N-use efficiency and allelopathy in current breeding material. Characterisation of marker populations.
Analytical aspects: 1) Determine the contribution of allelopathy in the complex of weed and crop interference. 2) Determine the roll of the root system in N-use efficient and weed competitive crops

C: Efficient use of DNA markers for improved development of healthy plants.
Contact: Stine Tuvesson/Morten Rasmussen, Svaloef Weibull AB. Financing body and period: FORMAS, Oresund Food Network, 2002-2005.. Evaluation of molecular markers. Financing body and period: SLF, 2002-2004. (72kEUR)
Aim: To improve the selection efficiency for disease resistance and allelopathy in wheat and barley.
Experiments: Develop marker population. Automation and identifying microsatellite (SSR) markers

D: International ring testing for resistance to leaf scald in spring barley;
Contact: Morten Rasmussen, Swalöf-Weibull AB, Sweden
Aim: 1) characterise scald resistance performance of varieties in relation to environmental effects; 2) germplasm for disease resistance in barley
Experiments: International scald nursery trials on ca. 12 locations using ca. 45 cultivars;

Switzerland

A: Variety testing for official registration of winter wheat varieties in a network of organic farms.
Contact: Mathias Menzi or Padruot M. Fried, Swiss Federal Research Station for Agroecology and Agriculture, Zurich-Reckenholz
Financing body and period: Funds of Research Station (Federal Government); 2001-2004.
Field experiments: 25 winter wheat (8 locations) and 25 varieties of winter barley (5 locations) are screened for suitability for organic farming. The protocol includes results on agronomic traits including several diseases as well as results on quality which includes baking experiments with the obtained flour. The system is being compared with the varieties which are tested on a parallel network on integrated farms.
Analytical aspects: Statistics over varieties x locations x years.

B: Development of alternative seed treatment methods to control seed born diseases on wheat in organic farming.
Financing body: funds of the Research Station.
Contact: Hans-Rudolf Forrer or Padruot M. Fried, Swiss Federal Research Station for Agroecology and Agriculture, Zurich-Reckenholz .
Experiments: Laboratory experiments: warm water treatments and treatments with different plant or other organic extracts. Field experiments: multilocation trials on efficacy.

C: Development of wheat and triticale varieties, that meet low-input production requirements
Contact: Dario Fossati, Cécile Brabant, Fabio Mascher , Geert Kleijer, and Arnold Schori, Swiss Federal Research Station for Plant Production of Changins, Nyon.
Financing body and period: funds of the Research Station (federal government), 2004 – 2007
Overall aim: Obtaining wheat and triticale varieties that combine good resistance, high yield and excellent baking or forage quality. Swiss varieties prove to be adapted for low-input and organic farming under most different environmental conditions.
Experiments: 1)Testing of advanced breeding lines and varieties under low-input conditions and different environmental conditions; 2) study the development of variety mixture and bulk populations under low-input conditions

D: Baking quality of wheat
Contact: Gert Kleijer, Swiss Federal Research Station for Plant Production of Changins, Nyon.
Financing body and period: funds of the Research Station (federal government), 2004 – 2007
Overall aim: Obtaining wheat varieties with high baking quality; analyses of the influence of low-input on baking quality; analyses of the influence of rare glutenins alleles on baking quality (COST 851).
*Analytical aspect*s: baking quality analyses (see activity CH-A M. Menzi, FAL).
E: Exploiting and enhancing resistance in wheat and triticale to stabilize yield under low-input and organic farming conditions
Contact: Fabio Mascher-Frutschi, Swiss Federal Research Station for Plant Production of Changins, Nyon. Funds of the Research Station (federal government), 2004 – 2007
Aim: to provide information about resistance patterns in actual and old varieties, landraces and other genotypes for the main wheat and triticale leaf, ear and seed transmitted diseases. Identify durably resistant varieties and breeding lines, contribute to the obtention of new resistant varieties.
Experiments: 1)greenhouse and field trials to test resistance of genotypes, including powdery mildew, leaf and stripe rust, septoria diseases, fusarium ear blight. 2) greenhouse screening of stinking smut. 3) greenhouse trials to test interaction of azospirillum inoculants with wheat genotypes to enhance resistance against Fusarium Head Blight and foliar diseases.
F: Plant fitness through colonization by natural occurring beneficial rhizobacteria.
Contact: Geneviève Défago, Federal Institute of Technology (and Yvan Moënne-Loccoz, France).
Aim: to analyze the ability of the cereal cultivars to be colonized by naturally and inoculant bacteria which enhance the plants' fitness under low input and alpine conditions.
Experiments: The experiments within this project include the study of the diversity of biocontrol bacteria (mainly pseudomonads) in the rhizosphere of cereal cultivars. Bacterial isolates showing beneficial characteristics will be analyzed for their mechanism of action, their survival strategies and the influence on non-target microorganisms.

United Kingdom

A: Cereal varieties for organic production: Developing a participatory approach to seed production and varietal selection.
Contact: Scott Phillips, Elm Farm Research Centre. DEFRA funded (OF0330), duration 4 years, started August 2002.
Aim: To develop a robust system for identifying, testing, multiplying and marketing cereal varieties, lines, mixtures and populations best suited to organic production in different parts of the country.
Experiments: 1) testing for seed borne diseases in organic cereal seed lots to identify scale and extent of problem; 2) determining the presence of genetic resistance to seed borne disease for a range of cereal species and varieties; 3) identifying methods for control of seed borne disease considering both cultural approaches and seed treatments; 4) extensive cereal variety trialling.
Analytical aspects: 1) establish methodology for implementation and assessment of participatory research and development approaches; 2) establish methodology for conducting and analysing extensive cereal variety trials.
B: Generating and Evaluating a Novel genetic Resource in Wheat in Diverse Environments.
Contact: Martin Wolfe, Elm Farm Research Centre. DEFRA funded (AR0914), 2001-2007.
Aim: To increase the sustainability and competitiveness of both non-organic and organic farming systems by developing genetically diverse wheat populations that will respond rapidly to on-farm selection for improved productivity and yield.
Experiments: 1) Produce composite cross populations of wheat comprising parent material with either high yield potential, high quality potential or both high yield and high quality; 2) grow the populations in a diverse range of production environments over a period of three seasons. 3) Track the genetic changes that occur as the populations evolve using molecular markers.

Analytical aspects: 1) Analysis of gene x environment interactions; 2) identification of molecular markers to discriminate the relative contribution of the parent lines; 3) identification of characters that confer improved productivity in each of the production environments.

C: Organic cereal variety and mixtures trials.

Contact: Scott Phillips, Elm Farm Research Centre. Funded by Sheepdrove Trust, 2002-2007.

Overall Aim: To determine the relative performance of leading cereal varieties grown as pure stands and as variety mixtures under organic conditions.

Experiments: 1) Trials established on up to 6 sites that compare the performance of a broad range of varieties from all of the main cereal species.

Analytical aspects: 1) gene x environment interactions; 2) comparisons of mixtures and pure stands.

D:Defining stability of host-pathogen dynamics in heterogeneous canopy structures.

Contact: Adrian Newton, Scottish Crop Research Institute, SEERAD 2002-2006.

Aims: To characterize the host-pathogen interactions in barley which lead to stability in crop and semi-natural vegetation, i.e. avoiding directional selection for virulent, aggressive pathogen populations.

Experiments: Spatial and temporal deployment of barley genotypes; monitoring disease, yield, quality and pathogen population structure

Analytical aspects: Determine contribution of genotypes to different components of the crop.

E: Fundamentals of sustainable agroecosystems.

Contact: Paul Hallett, Scottish Crop Research Institute. SEERAD 2002-2005.

Aim: To gain a fundamental understanding of ecosystem and biophysical interactions that promote sustainable agroecosystems.

Experiments: Establish a field experiment with manipulation of soil physical disturbance to influence microbes, root environment, pathogens and weed proliferation.

Analytical aspects: Determine the capacity of soils to withstand environmental stresses, cycle nutrients, and support plants

F: Demonstrating the potential of wheat varietal mixtures for grain distilling

Contact: Stuart Swanston, Scottish Crop Research Institute. SSCR

Aim: Determine which combinations of wheat varieties give improved agronomy and alcohol yield

Experiments: Combinations of current varieties on plot and field scale at three sites.

Analytical aspects: Alcohol yield determinations.

G: Ecological management and biotechnology.

Contact: Geoff Squire, Scottish Crop Research Institute. SEERAD

Aim: Identify the nature of the association between functional diversity in seedbank-based plant communities and coexistence of functional types at higher trophic levels through analysis of resource utilisation patterns at the individual level.

Experiments: Following ex-situ characterisation of individual *Capsella bursa-pastoris* and other common arable weeds, communities of known ecotypes will be reconstructed under field conditions for assessment of resource distribution, canopy architecture and functional diversity of insect herbivores and their natural enemies.

Analytical aspects*: Characterisation of individuals in terms of energy budgets, life history strategies and structure or architecture will provide quantitative data for parameterisation of individual-based spatially explicit models of trophic interactions and coexistence. Model output will allow generation of hypotheses for field experimentation. Both field data and model output will be used to develop statistical techniques for a trait space approach to the analysis of functional diversity.*

H: Exploiting genetic diversity in cereal production.

Contact: Bill Spoor, Scottish Agricultural College, SEERAD

Aim: To investigate the characteristics determining the benefits of variety/genotype mixtures of barley in terms of morphological, physiological and agronomic properties of the components of the mixture.

Experiments: Experiments carried over 4 seasons and involve 4 sites; genotypes examined in pairwise and multiple combinations; monitoring of disease, yield and quality.

Analytical aspects: Morphological and physiological characterization of single genotypes and genotype combinations; visual assessment, leaf canopy analysis, chlorophyll assessement,and leaf gas exchange
to characterize structure and physiology of barley canopies at different growth stages, stem extension/canopy expansion, canopy senescence and grain filling.

I: Cereal pathogen virulence surveys, identification of resistance genes; exploitation of resistance in low input systems; resistance to foliar and seedborne diseases in cereal varieties. European ring tests for resistance to wheat yellow rust.
Contact: Rosemary Bayles, National Institute of Agricultural Botany.

J: Assessment of varietal characters required for sustainable agriculture
Contact Simon Kerr, National Institute of Agricultural Botany. DEFRA funding for a review

K: Epidemiology of barley disease complexes.
Contact: Neil McRoberts, Scottish Agricultural College. SEERAD
Aim: To improve the management of multiple diseases of barley in low-input or reduced cost production systems, through exploitation of ecological processes occurring within the crop.
Analytical aspects: The work combines field experimentation, mathematical modelling and statistical fanalysis to examine the ability for growers to select low-impact disease complexes through the use of genetic diversity in the host crop and manipulation of growing conditions.

L: Weed control in organic farming (WECOF)
Contact: Ken Davies, SAC. EU
Aims: To identify the relative importance of canopy traits in wheat, and ideotypes, in the reduction of weed competition through shading. A model is being developed to assist in breeder-level selection of such traits, and to help advisers and farmers identify useful varieties from variety trials. A decision supprt system for organic farmers to help manage weeds is also being developed.
Experiments: Started in 2000, over 4 seasons on 2 main sites in UK plus at pilot sites on farms (EU partners have further sites in Germany, Spain and Poland). Monitoring the canopy morphology development, relating to light interception and weed growth, for a very wide range of wheat cultivars at our centre. At all centres, for certain variety canopy types, also examine the impact of row width and sowing direction.
Analytical aspects: Using modelling to determine the key canopy facters in determining light interception at ley growth stages, and their relative importance for different situations.

D. Recent publications of listed scientists organised according to Working Group:

WG1

Araus, J.L.; Bort, J.; Steduto, P.; Villegas, D.; Royo, C. (2003). Breeding cereals for Mediterranean conditions: Ecophysiological clues for biotechnology application. **Annals of Applied Biology** 142: 129-141.

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Atienza, S.G., Ramírez, C.M., Hernández, P., Martín, A. (2003) Chromosomal location of genes for carotenoid content in *Hordeum chilense*. **Plant Breeding** (In press).

Backes, G., Hatz, B. & Jahoor, A., Fischbeck. (2003). RFLP diversity within and between major groups of barley in Europe. **Plant Breeding** 122: 291-299.

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Barro, F.**,** P. Barceló, P.A. Lazzeri, PR. Shewry, A. Martín, J. Ballesteros. (2002). Field evaluation and agronomic performance of transgenic wheat. **Theoretical and Applied Genetics** 105: 980-984.

Barro, F., Rooke, L., Bekes, F., Gras, P., Tatham, A.S., Fido, R., Lazzeri P.A. Shewry, P.R., and Barcelo, P. (1997). Transformation of wheat with HMW glutenin subunit genes results in improved functional properties. **Nature Biotechnology** 15:1295-1299.

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Blanco A., Bellomo M.P., Cenci A., De Giovanni C., D'ovidio R., Iacono E., Laddomada B., Pagnotta M.A., Porceddu E., Sciancalepore A., Simeone R., Tanzarella O.A. (1998). A genetic map of durum wheat. **Theoretical and Applied Genetics** 97: 712-728.

Blanco A., Pasqualone, A., Troccoli, A., Di Fonzo, N., Simeone, R., (2002). Detection of grain protein content QTLs across environments in tetraploid wheats. **Plant Molecular Biology** 48: 615-623.

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