Executive Summary:

Agriculture is one of the economic sectors that will be most affected by the unfavourable aspects of climate change. The success of crop production has a fundamental influence on food security, so the elimination or mitigation of losses due to these unfavourable effects is a strategic aim. For almost two decades basic and applied research has been underway in one of the biggest phytotrons in Europe, at the Agricultural Research Institute of the Hungarian Academy of Sciences (ARI HAS), to determine the likely effects of climate change. In acknowledgement of the value of this work, the institute has won a grant aimed at transforming the institute into a regional training and research centre for the whole of Central Europe. The strategic impact of the AGRISAFE project was to improve the research capacity by complex training to prepare researchers, breeders and crop producers to cope with the challenges raised by climate change. Work progress and achievements during the project:

WP1: 18 young scientists from the institute were involved in research on this topic. The project provided an excellent opportunity for them to develop their knowledge in foreign laboratories working on similar subjects. All of those who made study trips for training abroad carried out tasks related to their research in the institute on the effect of climate change. The partner institutions also had the opportunity to send 4 young and 2 experienced scientists to Martonvásár, not only to attend the training courses and symposiums, but also to exploit the special facilities available in the phytotron and to learn various experimental methods developed in the institute. WP2: The three recruited researchers started new research programmes. Balázs Tóth received research grants from the Hungarian Scientific Research Fund as well as the Norwegian Research Fund. The projects also involve positions for three new PhD students. Robert Doczi received an EU 7th Framework Marie Curie Reintegration Grant (ERG 256554; support: 45,000, duration: three years). He also applied successfully for an Infrastructure Development Grant at the National Office for Research and Technology for the establishment of new proteomics laboratory facilities with the participation of the members of the Department of Applied Genomics. Currently he has two grant applications pending. Gergely Gulyás analyzed the adaptive characteristics of flowering time in some varieties and in their offspring generations at the Department of Cereal Breeding in ARI HAS and found new regulating genes, identified new regulatory processes. The visit of Mariyana Georgieva was the first step to establish research collaboration between the Department of Molecular Genetics and Department of Cytogenetics of the Institute of Genetics, Bulgaria and the Department of Plant Genetic Resources and Organic Breeding in ARI HAS. WP3: Development of scientific and other equipment for training courses on environmental stress research connected with global climate change. The scientific and IT equipment required for the planned research on the effects of climate change were purchased. These developments led to a considerable improvement in the competitiveness of the institute both within and outside the EU. This improvement in competitiveness made a great contribution to achieving the main aim of the AGRISAFE project, namely to develop the Agricultural Research Institute of the Hungarian Academy of Sciences into a EU regional research and training centre for the study of climate change. WP4: A total of 140 young scientists (many of them PhD students) from 11 EU member states took part in the five courses. The speakers included experts from Spain, Italy, France, the UK, Germany, the Netherlands, Austria, Denmark, Israel, Switzerland and the United States. Organization of training

courses and symposiums related to climate change for researchers, breeders, crop producers and managers. The closing event in the series of courses was the final conference held on March 21-23, 2011. The conference ensured wider publicity, leading to a total of around 160 participants, who presented some 100 posters and several dozen oral presentations, summarising the results achieved so far in the search for responses to the challenge of climate change. WP5: Publication and popularisation of research and innovation results with funds from the project. The main aim was to provide information to present and future generations of agriculturalists, particularly crop producers. Efforts were made to make them aware of the effects of climate change and to recommend ways in which the unfavourable effects could be avoided or mitigated. The project website (www.agrisafe.eu) was set up to provide detailed information on the project. The scientific materials used in the theoretical training and the conference were uploaded to the website.

Project Context and Objectives:

Climate variability has a fundamental influence on agro-ecosystems. For a substantial part of Europe, climate change scenarios forecast significant decreases of up to 20% in plant productivity, coupled with a general decline in the stability of agricultural ecosystems. This is particularly true of the Carpathian Basin. Agriculture and food safety are extremely sensitive to climate changes, so adaptability to stress is likely to gain priority over the quantitative aspects of yield. This will demand new approaches both to plant breeding and crop production, and in research strategy. The Agricultural Research Institute of the Hungarian Academy of Sciences (ARI HAS) is one of the leading centres for crop research and breeding in Central and Eastern Europe, in the Central Transdanubian convergence region, with a profile involving complex, interdependent, basic, methodological and applied research projects culminating in practical applications. Based on its international recognition, accumulated knowledge and close contacts with farmers and processors, the institute aims to develop into a regional Research Training and Service Centre to train and develop researchers, breeders and producers capable of offering practical help to farmers in Central and Eastern Europe in countering the unfavourable effects of predicted climate change. An increase in research potential is envisaged through strategic partnerships based on existing international contacts, whereby young scientists could gain valuable know-how and experience abroad, while experienced colleagues would be invited to work at ARI HAS. The results will be published both in scientific papers, and in talks and pamphlets aimed at farmers and food consumers in general, to raise awareness of the likely effects of climate change and of how these can be mitigated in the interests of achieving secure food supplies.

Project objectives for the 1st period

WPO: Project management

- Task 0.1. Supporting project governance
- Task 0.2. Project administration and logistics
- Task 0.3. Financial and contractual management

WP1 Exchange of know-how and experience by developing strategic partnerships (including twinning) with well-established research teams in the European Union

Within the framework of this work package the expansion and development of cooperation with the following institutions was planned for the first period.

Delegation of three young students to spend 3-6 months in foreign laboratories:

- Task 1.1. Biochemistry and Physiology Department, Rothamsted Research, Harpenden, UK
- Task 1.3. Institut für Pflanzengenetik und Kulturpflanzenforschung, IPK-Gatersleben, Germany.

Delegation of three PhD students from the region:

- Task. 1.4. University of South Bohemia, Czech Republik
- Task. 1.5. Sapientia University, Romania
- Task. 1.6. Institute of Genetics and Biotechnology, Slovak Academy of Sciences Nitra, Slovakia.

WP2 Recruitment of experienced researchers working in the field of environmental stresses

Within the framework of this programme it was planned to employ experienced scientists in ARI HAS. At present three scientists are involved in the programme:

- Task 2.1. Recruitment of Gergely Gulyás PhD in place of Dávid K?szegi
- Task 2.2. Recruitment of BalázsTóth PhD
- Task 2.4. Arrival of Mariyana Georgieva in place of Svetlana Landjeva PhD

WP3 Development of scientific and other equipment for training courses on environmental stress research connected with global climate change

- Task 3.1. Establishment of a meteorological station

This has been installed and is being used for the collection and analysis of local data on meteorological changes.

- Task 3.2. Construction and installation of an audiovisual lecture room

This has been completed and is being used for the training sessions which make up part of the project.

- Task 3.3. Purchase of equipment for the determination of stress tolerance in cereals

This equipment has been purchased and is in use for laboratory and field experiments on stress tolerance and for the collection and analysis of the data.

- Task 3.4. Purchase of equipment to analyse the effect of high temperature and drought on sexual processes in plants

The laboratory equipment purchased includes microscopes, microtomes and the software required for data processing.

- Task 3.5. Molecular genetic analysis of plant stress responses

The existing instruments have been supplemented to allow plant stress responses to be analysed at the molecular level.

- Task 3.6. Analysis of the effect of drought on maize production in field experiments

Additional instruments and software have been purchased for analysing the effect of drought on the leaf area and the intensity of photosynthesis and for processing the data of field experiments.

- Task 3.7. Improvement in the bioinformatics basis for the tasks undertaken in the project

Multiprocessor work stations, linked in a cluster, have been constructed.

WP4 Organization of training courses and a conference related to climate change for researchers, breeders, crop producers and managers

The aim of this work package was to organise theoretical and practical training sessions to prepare researchers and plant breeders for the challenges represented by climate change.

- Task 4.1. Climate change: facts and fictions

The aim of this training session was to review the technical arsenal now available to agrometeorology.

- Task 4.3. Biotic and abiotic stresses

The aim of this training session was to demonstrate how conventional breeding methods can be applied to develop resistance to the biotic and abiotic stress factors induced by climate change.

WP5 Dissemination and promotional activities related to climate change in agriculture

- Task 5.1. Scientific papers, magazine articles, books, publications

Publication of scientific papers in Hungarian and international journals, with special emphasis on the international journal edited in the institute (Acta Agronomica Hungarica). Publication of scientific reports

in the institute magazine (Martonvásár). Informative and marketing publications aimed at agricultural specialists working in small and medium-sized farms.

- Task 5.2. Training sessions for specialists

Scientific and non-scientific lectures. Participation in higher education in agriculture. Organisation of field days in the Central and Eastern European region. The aim is to provide training for the next generation of scientists (PhD students).

- Task 5.3. Electronic articles, media channels

Posting of information on climate change on the institute's website (www.mgki.hu). Expansion of the number of links. Expansion of the information available on climate change on these links. Interviews on regional and national radio stations.

Project objectives for the 2nd period

WPO: Project management

Task 0.1. Supporting project governance

Task 0.2. Project administration and logistics

Task 0.3. Financial and contractual management

WP1 Exchange of know-how and experience by developing strategic partnerships (including twinning) with well-established research teams in the European Union

Within the framework of this work package the expansion and development of cooperation with the following institutions was planned for the second period.

Delegation of young scientists to spend 3 or 6 months in foreign laboratories:

- Task. 1.4. Faculty of Agriculture, Babes Bolyai University, Romania
- Task. 1.6. University of Agricultural Sciences, Nitra, Slovakia
- Task. 1.7. Department of Biochemistry and Molecular and Cellular Biology of Plants, Zaidin Experimental Station, SCIC-Granada, Spain

Cooperation between the Cell Biology Department and the Department of Biochemistry and Molecular and Cellular Biology of Plants, Zaidin Experimental Station, SCIC-Granada, Spain.

- Task. 1.8. Department of Biomolecular Sciences and Biotechnology, University of Milan, Italy

Cooperation between the Maize Breeding Department and the Department of Biomolecular Sciences and Biotechnology, University of Milan, Italy.

- Task. 1.9. Agriculture and the Environment Division, Rothamsted Research, Harpenden, UK

Cooperation between the Maize Breeding Department and the Environment Division, Rothamsted Research, Harpenden, UK.

Delegation of young scientists from the region to ARI HAS:

- Task 1.3. Institut für Pflanzengenetik und Kulturpflanzenforschung, IPK-Gatersleben, Germany

Cooperation between the Department of Genetics and Plant Physiology and the Gene Bank Department of the Institut für Pflanzengenetik und Kulturpflanzenforschung, IPK-Gatersleben, Germany

- Task. 1.7. Department of Biochemistry and Molecular and Cellular Biology of Plants, Zaidin Experimental Station, SCIC-Granada, Spain

Cooperation between the Cell Biology Department and the Department of Biochemistry and the Department of Biochemistry and Molecular and Cellular Biology of Plants, Zaidin Experimental Station, SCIC-Granada, Spain.

WP2 Recruitment of experienced researchers working in the field of environmental stresses

Within the framework of this programme it was planned to employ experienced scientists in ARI HAS. At present three scientists are involved in the programme.

- Task 2.1. Recruitment of Gergely Gulyás PhD in place of Dávid Kszegi
- Task 2.2. Recruitment of BalázsTóth PhD
- Task 2.3. Recruitment of Robert Dóczi PhD in place of Péter Szcs
- Task 2.4. Arrival of Mariyana Georgieva PhD student in place of Svetlana Landjeva PhD (she started her work at first period and finished at second period).

WP3 Development of scientific and other equipment for training courses on environmental stress research connected with global climate change

Within this work package tasks were planned for the first period and the purchases had been completed.

After the first round of purchases had been completed, it became clear how much of the funds available had been utilised. Thanks to the public procurement procedure the sum actually spent was less than the funds made available on the basis of the original budget. This allowed equipment costing a total of around 8.4 million forints to be purchased during the second period, based on the experience gained during the operation of the new equipment purchased during the first year.

WP4 Organization of training courses and a conference related to climate change for researchers, breeders, crop producers and managers

The aim of this work package was to organise theoretical and practical training sessions to prepare researchers and plant breeders for the challenges represented by climate change.

- Task 4.2. Climate change: a challenge for crop production:

The aim of this training session is to learn how to draw conclusions from long-term experiments and how these can be utilised in the production of crops exposed to extreme weather conditions. An introduction to various production methods. Sustainable agricultural systems. Practical training in the planning of field experiments and the use of various up-to-date methods of statistical evaluation.

- Task 4.5. Drought and yield, the role of high temperature on plant gametes

The aim of this training session is to acquaint the participants with fundamental aspects of the interaction between plants and their environment, starting from the responses of the whole organism, down to the cell and molecular level. The effect of heat and drought stress on the plant development and yield of cereal species will be subjected to cell biological and genomic analysis.

Laboratory sessions to learn the most up-to-date molecular and gene technological methods.

WP5 Dissemination and promotional activities related to climate change in agriculture

- Task 5.1. Scientific papers, magazine articles, books, publications

Publication of scientific papers in Hungarian and international journals, with special emphasis on the international journal edited in the institute (Acta Agronomica Hungarica). Publication of scientific reports in the institute magazine (Martonvásár).

Informative and marketing publications aimed at agricultural specialists working in small and medium-sized farms.

- Task 5.2. Training sessions for specialists

Scientific and non-scientific lectures. Participation in higher education in agriculture. Organisation of field days in the Central and Eastern European region. The aim is to provide training for the next generation of scientists (PhD students).

- Task 5.3. Electronic articles, media channels

Posting of information on climate change on the institute's website (www.mgki.hu). Expansion of the number of links. Expansion of the information available on climate change on these links. Interviews on regional and national radio stations.

Project objectives for the 3rd period

WPO: Project management

- Task 0.1. Supporting project governance
- Task 0.2. Project administration and logistics
- Task 0.3. Financial and contractual management.
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WP1 Exchange of know-how and experience by developing strategic partnerships (including twinning) with well-established research teams in the European Union

Within the framework of this work package the expansion and development of cooperation with the following institutions was planned for the second period.

Delegation of young scientists to spend 3 or 6 months in foreign laboratories:

- Task 1.2. Department for Agrobiotechnology, IFA-Tulln, Institute for Biotechnology in Plant Production, University of Natural Resources and Applied Life Sciences, Vienna, Austria

Cooperation between the Cereal Resistance Breeding Department of ARI HAS and the Department for Agrobiotechnology, IFA-Tulln, Institute for Biotechnology in Plant Production, University of Natural Resources and Applied Life Sciences, Vienna, Austria.

- Task. 1.9. Agriculture and the Environment Division, Rothamsted Research, Harpenden, UK

Cooperation between the Maize Breeding Department and the Environment Division, Rothamsted Research, Harpenden, UK.

Delegation of young scientists from the region to ARI HAS:

- Task. 1.7. Department of Biochemistry and Molecular and Cellular Biology of Plants, Zaidin Experimental Station, SCIC-Granada, Spain

Cooperation between the Cell Biology Department and the Department of Biochemistry and the Department of Biochemistry and Molecular and Cellular Biology of Plants, Zaidin Experimental Station, SCIC-Granada, Spain.

- New Task

Cooperation between the Plant Physiology Department of ARI HAS and the Department of INRA/Univ. Paris-Sud, Orsay.

WP2 Recruitment of experienced researchers working in the field of environmental stresses

Within the framework of this programme it was planned to employ experienced scientists in ARI HAS. At present three scientists are involved in the programme.

- Task 2.1. Recruitment of Gergely Gulyás PhD in place of Dávid K?szegi
- Task 2.2. Recruitment of BalázsTóth PhD
- Task 2.3. Recruitment of Robert Dóczi PhD in place of Péter Sz?cs.
-

WP3 Development of scientific and other equipment for training courses on environmental stress research connected with global climate change

Within this work package tasks were planned for the first period and the purchases had been completed.

After the first round of purchases had been completed, it became clear how much of the funds available had been utilised. Thanks to the public procurement procedure the sum actually spent was less than the funds made available on the basis of the original budget. This allowed equipment costing a total of around 76 782 euros to be purchased during the second period, based on the experience gained during the operation of the new equipment purchased during the first year.

WP4 Organization of training courses and a conference related to climate change for researchers, breeders, crop producers and managers

The aim of this work package was to organise theoretical and practical training sessions to prepare researchers and plant breeders for the challenges represented by climate change.

- Task 4.3. The high added value of conventional breeding

The aim of this training session is to demonstrate how conventional breeding methods can be applied to develop resistance to the biotic and abiotic stress factors induced by climate change. Importance of the gene bank in preserving agronomic traits and in exploiting the biodiversity of various crops. Fundamental breeding techniques and the importance of modern gene pyramiding. Special selection techniques. Theory and practice of abiotic stress resistance. Theory and practice of biotic stress resistance. Modern practice of maintenance breeding.

- Task 4.6. Final Conference on Climate change: a challenge for plant breeding, the way forward

Due to the interactive nature of the training sessions, the results and experience gained during the series of courses will be summarised at a scientific conference, where the keynote speakers will be the leading experts involved in the training sessions.

Together with the lectures and practical manuals written for the training sessions, the complete proceedings of the final conference will be made available not only on the project website, but also on disc and in printed form. The most important data will also be distributed as fact sheets.

WP5 Dissemination and promotional activities related to climate change in agriculture

- Task 5.1. Scientific papers, magazine articles, books, publications

Publication of scientific papers in Hungarian and international journals, with special emphasis on the international journal edited in the institute (Acta Agronomica Hungarica). Publication of scientific reports in the institute magazine (Martonvásár).

Informative and marketing publications aimed at agricultural specialists working in small and medium-sized farms.

- Task 5.2. Training sessions for specialists

Scientific and non-scientific lectures. Participation in higher education in agriculture. Organisation of field days in the Central and Eastern European region. The aim is to provide training for the next generation of scientists (PhD students).

- Task 5.3. Electronic articles, media channels

Posting of information on climate change on the institute's website (www.mgki.hu). Expansion of the number of links. Expansion of the information available on climate change on these links. Interviews on regional and national radio stations.

Project Results:

WP1 Exchange of know-how and experience by developing strategic partnerships (including twinning) with well-established research teams in the European Union. Coordinator: Dr. Beáta Barnabás

The clarification of the biological background to the interactions between the plant and its environment is important for the following reasons:

The negative effects of climate change on the life processes of crop plants has a great influence on yield potential, thus exerting an effect on the ability of the world to achieve sustainable food and fodder production.

The study of the genes responsible for the morphological traits and metabolic processes that determine plant responses and of how they are expressed helps scientists to breed plant varieties resistant to environmental stress factors.

The achievement of optimum production conditions greatly promotes the exploitation of the genetic potential latent in various crops.

Special attention is paid in the Martonvásár institute to the complex investigation of the environmental stress tolerance of cereals, from the molecular level to the whole plant level.

The system of chambers available in the institute for artificial plant growth (phytotron) provides excellent facilities for this research, as it allows drought and temperature stress to be simulated in an exact manner.

A considerable number of young scientists from the institute are involved in research on this topic. The AGRISAFE project provided an excellent opportunity for them to develop their knowledge in foreign laboratories working on similar subjects.

All of those who made study trips for training abroad carried out tasks related to their research in the institute on the effect of climate change. The partner institutions also had the opportunity to send experienced or young scientists to Martonvásár, not only to attend the training courses and symposiums, but also to exploit the special facilities available in the phytotron and to learn various experimental methods developed in the institute.

Scientists received training in the following fields:

1. Study of stress tolerance using molecular genetic tools and cell biology

Tibor Kiss PhD student spent 7 months (16.11.2009 -17.12.2009 and 11.01.2010- 30.06.2010) at the Dipartimento di Scienze Biomolecolari e Biotecnologie (DSBB), Milano, Italy, where his project leader was Prof. Mirella Sari Gorla.

He is a young scientist working at the Cereal Breeding Department of ARI HAS, who needed to learn new experimental techniques in the field of molecular breeding. He joined a running project in DSBB: the isolation of pollen-specific genes and the examination of phylogenetic relationships between the Ga1 gene in maize inbred lines and other Zea species.

Katalin Jäger PhD spent almost 6 months (01.10.2009 - 11.03.2010.) in Spain at the Department of Plant Biochemistry, Cell and Molecular Biology, Estación Experimental del Zaidín of the Consejo Superior de Investigaciones Científicas (CSIC), Profesor Albareda 1, Granada, where her project leader was Dr. Adela Olmedilla .

The Department of Plant Cell Biology at the Agricultural Research Institute of HAS and the Department of Plant Biochemistry, Cell and Molecular Biology at EEZ CSIC Granada have cooperated in research on the effect of environmental stress on in vitro microspore development and plant reproduction for the past ten years. Both partners are involved in work on the in situ hybridisation technique, and are interested in learning and adapting immunogold labelling methods for cereal species. The continuing exchange of experienced scientists is necessary to ensure methodological progress.

The aim of her stay at EEZ CSIC was to study:

- in situ hybridisation on acrylic resin-embedded semithin sections and
- immunogold labelling for electron microscopy.

Ambrus Bakó PhD student visited the Institute of Plant Genetics and Biotechnology (IPGB SAS), Nitra for two months (01.02.2010 - 11.04.2010). His project leaders were Dr. Anna Pretova and Dr. Bohus Obert

His work as a research associate in the Applied Genomics Department of ARI HAS includes the quantitative analysis of gene expression in the transgenic maize lines used in the institute's breeding programmes. In the temperate zone, low temperatures (near or below 0°C) in spring can be a significant threat to crop production. At IPGB SAS there is an ongoing maize biotechnology project which can provide embryogenic calli of maize for molecular studies.

His task at IPB SAS focused on the study of gene expression changes caused by cold treatment in embryogenic calli of maize, including:

- Semi-quantitative RT-PCR for determining fold changes in the mRNA levels of selected genes
- 2D-PAGE analysis of changes in the proteome of the samples.

Annamaria Mészáros PhD spent a month in the Department of Experimental Biology, Babes-Bolyai University, Cluj-Napoca, Romania (18.03.2010-03.04.2010. and 16.04.2010-30.04.2010).

The Plant Biotechnology group directed by Prof. E. Rakosy deals with the development of tissue culture methods to establish propagation protocols, the investigation of abiotic stress effects on cultures of potato and tobacco, the creation of resistant plants via genetic engineering, the investigation of stress-induced genes by molecular methods and the somatic hybridization of potato to transfer quantitative resistance traits to biotic and abiotic stresses from wild relatives.

The work was focused on studying the drought stress response of the model plant Arabidopsis thaliana cv. Columbia.

On two other occasions (02.12.2009-22.12.2009 and 12.01.2010-21.01.2010) Annamaria Mészáros visited the Department of Technical and Natural Sciences, Sapientia University, Mircurea-Ciuc, Romania. The laboratories, covering a total area of 220 m2, specialize in Microbiology, Biochemistry and Molecular Biology, Enzymology and Bioinformatics, and also include two preparative laboratories. Although plant sciences did not previously form part of the curriculum, due to the growing interest in this subject it has been decided to establish a new field of specialization, General Biotechnology.

Andrea Szenzenstein PhD student paid a 1-month visit (01.03. 2010 - 31.03.2010) to the Laboratory of Growth Regulators, Palacký University & Institute of Experimental Botany AS CR, ?lechtitel? 11, 783 71 Olomouc, The Czech Republic.

One of the main topics in the Plant Cell Biology group, where she works in Martonvásár, is the improvement of the in vitro androgenic ability of elite lines of maize and the inheritance of this ability. The physiology of the donor plant greatly influences the androgenic response, but the mechanism is not precisely known. It is thought that hormonal levels may have an important role. In this connection, the aim of her stay was to learn techniques for the detection of plant hormones. In the partner laboratory a UPLC-MS method for plant hormone detection was developed and is used as a routine procedure. Very few data can be found in the literature about the hormonal levels of maize tassels. Her purpose was to determine the cytokinin and auxin levels in different parts of the central spike of the tassel and to analyse the differences between them.

Attila Fábián PhD student spent 12 days in the Institute of Experimental Botany, Academy of Sciences of the Czech Republic, Czech Republic (08.11.2010-20.11.2010)

During his visit he worked on the adaptation of fluorescent cytoskeleton visualizing techniques to the plant materials used in experiments in Martonvásár, such as maize microspores and maize suspension cultures. The aim of the research training was to study the indirect immunofluorescencent labelling of microtubules and the fluorescent labelling of F-actin by fluorescent phalloidin.

Visiting scientist working in this field:

Adela Olmedilla PhD from the Spanish Council for Scientific Research (CSIC), spent a month at the Agricultural Research Institute HAS, in the Department of Plant Cell Biology (15.10.2010-15.11.2010)

The main purpose of her stay was to share her experience in light and electron microscopy techniques with the members of Dr. Barnabas' group.

This stay also provided an opportunity to prepare an I-LINK-project proposal with CSIC that, if successful, will facilitate new collaboration including not only the Spanish (CSIC) and Hungarian (HAS) labs, but also a Slovak lab belonging to the Institute of Plant Genetics and Biotechnology of the Slovak Academy of Sciences (SAS), in order to introduce proteomics in the study of plant embryogenesis (identification of major proteins in early embryo development, in zygotic, somatic and gametic embryogenesis).

2. Identification of candidate genes for stress tolerance by means of functional genomics

András Bálint, PhD, spent the period from 1 Nov. 2008-31 Jan. 2009 as a post-doctorate fellow in Gatersleben, with the aim of learning the TILLING method (Targeting Induced Local Lesions IN Genomes). This is a new reverse genetic method with which lines with mutations for a given gene can be identified rapidly and cheaply. It can also be used to identify allelic variants of a given gene, e.g. in variety collections (this method is known as Eco-TILLING). The original method uses artificially induced mutants, while Eco-TILLING examines naturally occurring mutations. It is planned to apply this method for a variety of purposes in the Department of Genetics and Plant Physiology of ARI HAS.

Fruzsina Szira, PhD student, spent the period from 1 Nov. 2008-31 Jan. 2009 in Gatersleben, participating in the work of two research teams: the Genome Diversity Team headed by Dr Nils Stein, in which she examined gene expression changes during the cold hardening of cereals, and the Resources Genetics and Reproduction Team headed by Dr Andreas Börner, where she tested methods for measuring the osmotic stress tolerance of barley and the mapping of loci influencing this trait.

Ildikó Karsai DSc spent 4 months in the School of Agriculture, Policy and Development, University of Reading, Whiteknights, PO Box 237, Reading, Berkshire, RG6 6AR, Great Britain (15.09.2010-15.01.2011)

She worked on two research topics during this time:

- Elaboration of a non-destructive methodology for establishing plant developmental patterns in cereals
- Studying the effect of heat stress on the early plant development in wheat.

The type and intensity of negative changes caused by heat stress during flowering and seed development showed strong dependence on the developmental stages of the developing seed. To study this phenomenon, the progenies of plants stressed with heat at different times after anthesis were included in an experiment in which the initial plant development was studied under control and heat stress conditions. The aim was to evaluate how applying heat stress to developing seeds affects the early vigour and heat stress tolerance of the next generation of seedlings developing from the stressed seeds.

Imre Majláth PhD student spent 3 months in the School of Biological Sciences, University of Bristol, United Kingdom (10.01.2011-20.04.2011).

He worked with the Arabidopsis Research Team, who had already demonstrated the different growth habits and distinct morphology of Landsberg erecta (Ler) and Cape Verde Islands (Cvi) natural accessions and of Ler-Cvi Near Isogenic Lines (NIL) both at low and high temperatures under different levels of red:far-red (R:FR) illumination. A QTL was found on chromosome 2 and Erecta, which encodes a putative receptor protein kinase with a pivotal role in cell-cell communication and plant morphogenesis, was identified as the candidate gene.

The aim of his work was to explore the QTL region on chromosome 2 and confirm the gene(s) responsible for the Light Forage Strategy.

Ildikó Vashegyi PhD student spent 3.5 months in the Dept of Cell and Developmental Biology, John Innes Centre, Norwich Research Park, United Kingdom (03.01.2011-30.04.2011)

The knowledge gained from experiments on genetic model organisms, combined with the use of the well-constructed experimental systems designed for cereals at the Institute could lead to a better understanding of the functioning of complex signal transduction mechanisms and genetic regulation processes in monocots in relation to their abiotic stress responses. Therefore, the aim of her visit to the Department of Cell and Developmental Biology, John Innes Centre, Norwich was to become involved in the research there, to become acquainted with new approaches and scientific views, to learn new experimental methods and techniques, and to work with model plant species (Arabidopsis thaliana and Brachypodium distachyon).

Visiting scientists working in this field:

Kerstin Neumann, a PhD student from the Leibniz Institut für Pflanzengenetik und Kulturpflanzenforschung (IPK), Gatersleben, Germany spent 6 months (01.09.2009-28.02.2010) at the Department of Genetics and Plant Physiology ARI HAS, Martonvásár.

The subject of her work as a PhD student at IPK is the mapping of drought tolerance loci in barley. In addition to a DH population for classical QTL mapping, a diverse barley collection for association mapping was also phenotyped in IPK and in ARI HAS. All statistical procedures for dealing with the population structure were examined in IPK with a set of Diversity Array Technology markers (DArT).The main aim of the visit was:

- to teach the Hungarian research partners to use the statistical procedures and software necessary for association mapping.
- to evaluate the data from a rain shelter experiment using the association mapping population for barley
- to conduct a small germination experiment with this population to evaluate differences in root length between the genotypes.

Jean-Marc Ducruet PhD from INRA/Univ. Paris-Sud, Orsay, spent a month at ARI HAS in the Department of Plant Physiology (13.02.2011-19.03.2011).

The aim of his visit to ARI-HAS was:

- to improve the thermoluminescence set-up used in ARI-HAS
- to train scientists in the use of the thermoluminescence technique.

Due to the extreme continental climate, there are few years when Hungary does not face severe economic losses related to environmental factors. These include long periods of drought, excessive quantities of rainfall in the wrong place at the wrong time, extremely cold winters or hot summers, or the sudden appearance of pests or pathogens in epidemic proportions, all of which are capable of destroying the efforts of a whole year, or even a whole decade. Both plant breeders and crop producers have an interest in finding crops capable of tolerating environmental changes with as little damage as possible. In order to develop such crops, knowledge of plant defence mechanisms and regulatory processes is essential.

As the scientist from the Faculty of Agriculture of Babes Bolyai University was unable to participate, Franti?ek Bezunk PhD student, working on the molecular background of drought stress, was delegated by the University of South Bohemia in ?eské Bud?jovice, Czech Republic to ARI HAS. He spent two months (19 Jan.-19 Mar. 2009) in ARI HAS in order to learn new molecular methods. He participated in work on the selection and characterisation of smoke-induced genes and in cloning and vector construction. He became acquainted with the microarray and quantitative PCR methods. Possibilities have been outlined for long-term cooperation between the two institutes, in which the experience gained by both partners could be used to mutual advantage. The first project is likely to be the development of transgenic flax lines with drought tolerance and insect resistance, involving joint construct preparation and transformation experiments. In some regions of the Czech Republic flax production is of great significance. The use of drought-tolerant transgenic lines could be one way of improving yield stability and obtaining a higher quantity of good quality oil.

Éva Tamás, PhD student from Sapientia University, Romania spent two months (1 Nov.-20 Dec. 2008 and 5-16 Jan. 2009) in ARI HAS. Her PhD work involves enhancing the synthesis of terpenoids in tissue cultures of Ligularia, partly by selection at cell level and partly by genetic transformation. She already had satisfactory knowledge on molecular methods, so the aim of her visit was to learn plant regeneration and transformation methods. Although the duration of her visit was not sufficient to carry out a complete transformation cycle, she was able to follow the different parts of the process on various plants (tobacco, marrow, maize). She was able to learn the advantages of both the Agrobacterium-mediated and biolistic methods of transformation, including the various factors that influence their efficiency. Staff from the Cell Biology Department were also involved in teaching these methods. The knowledge acquired during her visit will allow her to carry out transformation experiments independently and carry out checks on the transformed plants. The Sapientia University has indicated an interest in further cooperation. The department in question deals principally with nature protection and ecology, and aims to elaborate new technologies and products for horticulture, which has a long tradition in the region. The joint development of plants resistant to drought or other stress factors could thus be of outstanding importance.

Lenka Fraterova, PhD student from the Institute of Genetics and Biotechnology, Slovak Academy of Sciences, Nitra, Slovakia spent two months (23 Feb.-30 Apr. 2009) at ARI HAS, during which period she also took part in the course on "Climate change: Challenge for the training of applied plant scientists. Biotic and abiotic stresses" organised in the framework of WP4.The subject of her PhD work is the induction of somatic embryogenesis in pine species and the measurement of extracellular protein activity (chitinases, glucanases) in the embryos. As the necessary analytical background is available in her home laboratory, the aim of her visit was to learn various molecular techniques. She became acquainted with the bacterial cloning technique, and with methods for the isolation and identification of plant nucleic acids. She was also able to follow the process of Agrobacterium-mediated transformation. Many of the Martonvásár staff have good personal and professional contacts with staff from the Nitra institute, and there is frequent cooperation between the two institutes. ARI HAS would be interested in the method used for the induction of somatic embryogenesis. As this is a pathway in which new plants are guaranteed to originate from a single cell, it would allow transgenic plants to be selected with better efficiency after genetic transformation, eliminating somatic mosaicity in the plants. The Applied Genomics Department possesses transformation constructs with which alien catalase (CAT) or superoxide dismutase (SOD) genes can be incorporated into transformed plants. These two oxidative enzymes are involved in the general defence mechanism of plants, and their over-expression in pine species is expected to result in increased heat or drought tolerance. The Nitra research team is currently working on the development of plant material that could be used for re-afforestation in the wake of the destruction of forests in Slovakia. This system provides the possibility of selecting and multiplying lines with better resistance to climate change.

3. Agro-ecological research

Balázs Varga PhD spent 3 months in the Institute of Biodiversity, VTI-Braunschweig, Johann Heinrich von Thünen-Institut, Germany (06.09.2010-03.12.2010).

Free air carbon dioxide enrichment (FACE) is one of the best ways to investigate the effects of elevated carbon dioxide concentration on the phenological and physiological properties of plants. The aim of the visit to VTI-Braunschweig was to study the combined effects of drought and elevated CO2 in a FACE experiment and to learn methods for root system analysis. Roots are often more stimulated by the CO2 concentration than leaves, stems and reproductive structures, making accurate investigations on the root system essential. Previous studies showed that the roots become more numerous, longer and thicker in a CO2-enriched environment. The root system of CO2-enriched crops is often highly branched, especially at shallower soil depths, compared to the roots of crops grown at the ambient CO2 concentration.

4. Long-term crop production experiments

Györgyi Micskei PhD student spent 3 months in the Sustainable Soils and Grassland Systems Department, Rothamsted Research, Harpenden, Hertfordshire, AL5 2JQ, United Kingdom (17. 01. 2011-15. 04.2011).

She did her training in soil and plant analysis as a visiting scientist under the supervision of Dr Andy Macdonald in the Department for Sustainable Soils and Grassland Systems at Rothamsted Research from 17 January 2011 to 15 April 2011. The aim of her stay was to become acquainted with the Rothamsted Classical Experiments, which are the oldest continuous agronomic experiments in the world. She received training in soil and crop sampling and sample preparation, grain quality measurements, general plant and soil analytical techniques and data compilation and analysis, the collection and preparation of drainage water samples and the general management of long-term and other field experiments.

5. Phytotron research

Szilvia Bencze, PhD, spent 6 months in the UK (Plant Science Department, Rothamsted Research, Harpenden) as a post-doctorate fellow from 1 Oct. 2008 to 31 Mar. 2009. Dr Bencze has worked on problems related to global climate change since joining the staff of ARI HAS in 1998. Her special field has been the effect of enhanced CO2 concentrations and climatic extremes on cereals, and the results of this work formed the basis of her PhD thesis in 2007. During her study trip Dr Bencze took part in the research in progress in the team led by Martin Parry, and also participated in experiments in the framework of a new European Union project (Bioenergy and Climate Change) under the leadership of the biochemist John Andralojc.

6. Breeding of field crops

István Molnár PhD spent 3 months in the John Innes Centre, Norwich Research Park, Colney, Norwich, United Kingdom (03.01.2011 - 30.03.2011).

The wild relatives of wheat represent a large reservoir of useful genes and alleles for wheat improvement, which can be transferred by interspecific and intergeneric hybridization. Within the Aegilops genus, the allopolyploid species Ae. biuncialis Vis. (2n = 4x = 28, UbUbMbMb) and Ae. geniculata Roth. (2n = 4x = 28, UgUgMgMg) originated from hybridization between the diploid species Ae. comosa Sm. in Sibth. & Sm. (2n = 2x = 14, MM) and Ae. umbellulata Zhuk. (2n = 2x = 14, UU). Several genes for resistance to rusts and powdery mildew (Lr9, Lr57, Sr34, Yr8, Yr40, Pm 29) have been transferred into wheat from these species and tolerance of salt, drought, frost and heat stress was observed in these genotypes. The use of PCR-based molecular markers significantly accelerates the selection of wheat-Aegilops introgression lines, the mapping of stress tolerance QTLs in the Aegilops species and the positional cloning of genes responsible for these traits. Unfortunately, few markers specific for these Aegilops species are available, if at all.

The aim of the short visit was to determine the chromosomal locations of the conserved orthologue set (COS) markers developed by the research team headed by Dr. Simon Griffiths on the allotetraploid species Ae. biuncialis and Ae. geniculata, together with their diploid progenitors Ae. umbellulata and Ae. comosa.

Klaudia Kruppa PhD student spent 3 months in the Gene and Genome Mapping Group of the Department of Cytogenetics and Genome Analysis, Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Germany (10.01.2011-10.04.2011).

The aim of this visit was to study the microsatellite marker technique and to analyse wheat x barley and wheat x Agropyron introgression lines with SSRs. Various types of biological material, all produced in Martonvásár, were used for SSR marker analysis: the wheat x barley translocation lines 6B.4H, 4D.5H and 7D.5H, the homozygous wheat/barley centric fusion line 4HL.5D, BE-1 × wheat progenies and wheat x Agropyron glael introgression lines. Two Thinopyrum species, Thinopyrum ponticum and Thinopyrum intermedium were also tested with wheat SSR markers.

Rakszegi Mariann PhD spent 3 months in the Plant Science Department of Rothamsted Research, Harpenden, Herts, AL5 2JQ, United Kingdom (17. 01. 2011. - 15. 04. 2011.)

The aim of the visit was to compare the amount, solubility and structure of wheat and barley ?-glucans, including variation between wheat varieties. This included the determination of the total ?-glucan in wheat and barley flour and in wheat fractions extracted with water at increasing temperatures (Megazyme kit), the determination of the ratio of (1-3) to (1-4) bonds by enzyme digestion (HPAEC), the determination of the molecular weight distribution by SE-HPLC and the determination of the structure by NMR. The determination of the effects of heat and drought stress on the properties of wheat ?-glucan and the properties of a number of oat and barley lines was also planned.

7. Crop protection

Emese László PhD student spent 2 months in the Department for Agrobiotechnology, IFA-Tulln, Institute of Biotechnology in Plant Production, Austria (08.10.2010-03.12.2010).

The aim of her stay at IFA was to study:

- Classical methods in Fusarium taxonomy
- Species-specific markers for fungal identification
- Identification of Fusarium isolates derived from naturally infected kernels.

As a result of her visit to the Department of Agrobiotechnology, Institute of Biotechnology in Plant Production, IFA Tulln she became familiar with classical methods in Fusarium taxonomy and the use of species-specific markers for fungal identification, which will allow ARI-HAS to monitor changes in the pathogen composition or changes in the toxin profiles of the most predominant species.

The exchange visits made possible by the project contributed greatly to improving the already high level of methodology used in the Martonvásár institute for research on the abiotic stress tolerance of cereals. The mutual exchange of the most up-to-date experimental approaches and analytical methods, and the forging or reinforcing of relationships between individual scientists will greatly increase the range of joint

research projects and grant applications in the future. The acquisition of new methods and their application in ongoing research can open up new vistas for solving problems related to climate change.

The experience gained in foreign laboratories will also be of great service in advancing the careers of the young scientists.

The forging of new professional contacts and friendships will ensure a continuous exchange of opinions in the fields of both science and culture.

WP2 Recruitment of experienced researchers working in the field of environmental stresses. Coordinator: Dr. Gábor Galiba

From the 4 persons whose recruitment was planned only Balázs Tóth accepted the offered position while the others rejected for different reasons (see below). Actually through advertisement and networking we could fill all of the remaining 3 positions in 2009.

It was not possible to carry out Task 2.1. as it was originally planned, because Dávid K?szegi received meanwhile a research position in the Institut für Pflanzengenetik und Kulturpflanzenforschung in Gatersleben, Germany. Instead of Dávid K?szegi another scientist, Gergely Gulyás (Hungarian) was recruited. Gergely Gulyás works in the laboratory of Prof. László Láng at the Department of Cereal Breeding in the Agricultural Research Institute of the Hungarian Academy of Sciences. He returned from Japan to Martonvasar in 2009 to begin the analysis of wheat genes related to adaptability and tolerance of biotic or abiotic stresses.

His personal background

His master and doctoral degrees were obtained at the Tokyo University of Agriculture and Technology (TUAT), Tokyo, Japan. During the 2-year master and the 3-year doctoral courses he worked on cytoplasmic male sterility (CMS) in chilli pepper. Even though the profile of this lab was basic plant research, it was an excellent place to acquire molecular techniques which can be used also in cereal research. During his stay at TUAT, he investigated the nuclear-mitochondrial interaction using cytoplasmic male-sterile chilli pepper lines. The available restorer, maintainer and CMS lines allowed him to identify the segregation ratio of restorer gene. In addition, the comparison of the molecular marker information linked to restorer gene and the phenotypic data revealed important information on physical distance between the marker and the gene. Moreover, during the search for the candidate gene for CMS phenotype in the mitochondria he was able to identify an extended transcript of a sterility-related gene named orf507 in the mitochondria of chilli pepper.

Experimental work

Adaptation of the new varieties to the changing environmental conditions caused by the global climate change is essential to ensure food supply. Rainfall and temperature extremes in Central and Eastern Europe are getting more frequent. According to the climate change forecasts, plant productivity will suffer a significant loss in great part of Europe. Therefore, it is extremely important to improve varieties

for better adaptability to the changing environment. Studies on the molecular background of adaptation, genes that control flowering including vernalization and the response to photoperiod genes, are essential to utilize such abilities of plants.

Analysis of adaptive characteristics of plants

Flowering time is one of the most important adaptive characteristics of plants. Genetic regulation of physiological processes acts to ensure that flowering occurs at seasonal optima for pollination, fertilization, and seed development. Photoperiod and vernalization regulate the vegetative to reproductive phase transition, and photoperiod regulates the expression of key vernalization genes.

Differences in the rate of development (ear emergence and ripening time) of cultivars of common wheat (Triticum aestivum L.) are the main components contributing to their adaptation to a wide range of environmental conditions. The Vrn genes (growth habit) and the Ppd genes (response to photoperiod) contribute to these differences.

Analysis of genetic background of extreme earliness

The control of flowering is fundamental to reproductive success in plants, and has a major impact on grain yield in crop species. Temperate environments with a long growing season allow cereal crops to flower late in the year and thus exploit an extended vegetative period for resource storage. Conversely, early flowering has evolved as an adaptation to short growing seasons.

The aims are to explore the genetic components of the extreme earliness of the winter wheat variety "Mv Toborzó" and to identify the environmental factors causing this unique reaction. For this reason Mv Toborzó was crossed with eight different wheat varieties selected from diverse ecological conditions. In their F1 and F2 populations the earliness showed continuous frequency distribution and was determined by the PPD-D1 allele constitution of the given parents. In the insensitive x sensitive crosses the earliness of F1 and F2 populations was the same as the average heading of the parents. In this experiment the extreme early heading of Mv Toborzó might be caused by one or more recessive gene(s) that is/are down regulated by the PPD-D1 sensitive allele. When Mv Toborzó, the photoperiodic insensitive variety, was crossed with the sensitive one called Tommi, the PPD-D1 allele structure was determined by gene-allele specific markers in the segregating F2 population. Since the segregation ratio was not significantly different from the suggested 1:2:1 ratio, the effect of PPD-D1 gene on plant height, on heading date and some other agronomical characteristics could be analyzed. The results showed that the PPD-D1 gene significantly influenced plant height and heading while the insensitive allele caused reduced height and earlier heading. In this population the heterozygotes flowered later than the homozygotes. The homozygous insensitive individuals in this populations showed late heading and the same insensitive allele (Mv Toborzó allele) in different genetic background showed different heading dates. These results suggest that some other minor genes of earliness can be segregating as well.

In the last year of the Agrisafe project, the effect of the insensitive allele of the PPD-D1 gene on plant height was further analyzed in order to examine the interaction with some plant height determinant genes. In wheat, 21 genes with major effects on reducing plant height have been identified and assigned to Rht designations. These are grouped into two categories, insensitive and sensitive to exogenous gibberellic acid (GA). The GA insensitive alleles Rht-B1b (Rht1) and Rht-D1b (Rht2), derived from Norin 10,

reduced plant height by 15% and increase yield by 24%. The GA-responsive Rht genes, Rht8 and Rht9, derived from the Japanese cultivar (cv.) Akakomugi, were introduced into Italian germplasm and spread into South European countries where high temperatures and drought are normal in summer. It was reported that Rht8, in close association with the photoperiodic insensitivity gene Ppd-D1a, reduced plant height by around 10% without significant negative effects on yield. The Rht8 gene also has the potential to increase the early vigour of semi-dwarf wheat although its effect on plant height was not as significant as those of Rht-B1b and Rht-D1b. A 192 bp allele of wheat microsatellite marker Xgwm261-4A, in combination with the pedigree information, is diagnostic for Rht8.

The homoeologous genes Rht-B1 and Rht-D1 were molecularly characterized and both mutations involve single base-pair changes leading to a TAG stop codon shortly after the start of translation. Furthermore, PCR-based specific markers were developed to discriminate between the dwarf genes Rht-B1b and Rht-D1b and their wild type tall alleles Rht-B1a and Rht-D1a. Therefore, both seedling tests for the lack of responsiveness to GA and molecular markers can be used to detect the presence of these two genes in the breeding program. The presence of RhtB1b and RhtD1b was determined in both F2 and F3 generations of Mv Toborzó x Tommi. Determining the distribution of the Rht8 gene in the segregating population (F2 and F3) will be the next step in order to get closer to the understanding of the molecular background of the adaptation ability.

Better understanding of the genetic components of the flowering time regulation will help to improve the agricultural productivity in new production zones or in conventional regions which are subjected to greater climatological fluctuations.

Summarizing his research activities: He has analyzed the adaptive characteristics of flowering time in some varieties and in their offspring generations at the Department of Cereal Breeding in the Agricultural Research Institute of HAS. Finding new regulating genes, identification of new regulatory processes, a better utilization of genetic resources in the development of new varieties and the elaboration of a marker assisted selection system can be the possible outcome of this research.

Balázs Tóth works in the laboratory of Prof. Gábor Galiba at the Department of Plant Molecular Biology, in the Agricultural Research Institute of the Hungarian Academy of Sciences. He returned from the USA to Martonvasar in 2008 to begin the analysis of different lipid classes which play crucial roles in the environmental stress tolerance (especially cold and drought stress) in cereals.

His personal background

Balázs Tóth obtained his PhD degree at the Szent István University, Gödöll? in 2004. His PhD thesis was based on the genetic studies of frost tolerance in cereals. As a postdoc he spent four years (2004-2008) in the laboratory of Dr. Tamas Balla at the National Institute of Child Health and Human Development (National Institutes of Health (NIH), Bethesda, Maryland, USA). Although the profile of this lab was basic medical research, it was an excellent place to acquire a lot of scientific techniques for the mammalian system which can also be used in plant research. During his stay at the NIH he took part in several projects while working on lipid signalling and lipid research. He investigated the regulatory role of phosphatidylinositol 4-kinases in the ceramide transport from the endoplasmic reticulum to the Golgi. Moreover, he performed subcloning, purification and kinase assay of a phosphatidylinositol 3-kinase, He was involved in studies with pleckstrin homology domains, in experiments investigating the STIM1-

Orai1 complex and in designing the mutant PtdIns4Kinase. He carried out also other experiments to characterize a newly discovered protein family which is involved in the glycosphingolipid metabolism of the cell.

Experimental work

Since lipids are structurally (as components of the lipid membranes) and functionally (as components of the lipid signalling pathways) in the front line of the cells being exposed to different environmental changes, their role in the response to the challenging growing conditions during the climate change appears to be obvious. This is the reason why he designed a long-term experimental plan to introduce lipid research in Martonvásár.

Identification of lipid signal transduction components

In the last year he identified signal transduction components involved in cold acclimation and frost tolerance in barley and einkorn wheat using the pharmacological approach. He investigated the possible utilization of callus cultures as an experimental system to study frost tolerance. He observed that barley callus has altered the cold response because of its different hormone content, so he concluded that it is an inappropriate object for this kind of experiments.

In barley seedlings he proved the role of calcium in the recovery following freezing injury. In the gene expression level in barley he found that the cold induction of CBF14 and COR14b appears to be dependent on the intracellular calcium release, while CBF9 seems calcium independent and the whole system is regulated by phospholipase C.

In einkorn wheat he observed that the cold induced expression of CBF12 and COR14b was calcium dependent, while the expression of CBF14 was not affected by the decrease in the calcium response.

Using microarray techniques he identified a series of calcium dependent cold responsive genes including the components of the antioxidant defence system. He also investigated the effect of increased MAPK kinase activity on the cold response and noticed that the CBF-COR system was independent of MAPK induction.

Two PhD students (Ildikó Vashegyi, Zsuzsa Tóth) are involved in this project. The methodology and the scientific background of this work provide them with important knowledge, experience and new scientific results for the completion of their PhD studies.

Summarizing his research activities: he made significant progress in the identification of lipid signalling components during cold stress. In the third research year he obtained new results on the involvement of the phospholipase C pathway in cold acclimation and frost tolerance.

Additional benefits generated by the AGRISAFE project

The financial support of his employment by the AGRISAFE opened the door to applications for additional financial resources to support his research project. As a participant, he has received a research grant ('Identification of lipid components suitable for the improvement of freezing tolerance in cereals'; Id.#: K68894) from the Hungarian Scientific Research Found. As a project leader he obtained financial support for the identification of lipid signalling components in cold stress ('Identification of signal

transduction pathways involved in cold stress by gene expression studies in cereals'; Id.#: NNF78866) from the Hungarian Scientific Research Found and the Norwegian Research Found. This project involves also a position for a new PhD student, Zsuzsa Tóth. Moreover, a highly talented PhD student, Ildikó Vashegyi, is also working under his supervision in the lipid research area and these projects will be the base for her PhD thesis.

It was not possible to accomplish Task 2.3. as it was planned because Péter Sz?cs received a position in the SYNGENTA Hungary, meanwhile. He did not intend to return back to ARI HAS. So, instead of Péter Sz?cs, Robert Dóczi accepted the open position from 1st September 2009. He initiated a new research programme to study the MAP kinase-substrate networks at the Plant Cell Biology Department (Head: Prof. Beáta Barnabás) when he returned back from London. This goal is also supported by a Marie Curie Reintegration grant of the European Commission. His Task is 2.3 within Work Package 2. to facilitate the return of experienced researchers working in the field of environmental stresses to Hungary.

Personal background

Róbert Dóczi has a long-term research interest in signal transduction. He carried out his Ph.D. studies on characterizing the regulation of a drought-specific gene which can be found only in the potato crop plant and its close relative species. Subsequently he became a postdoctoral researcher in Prof. Heribert Hirt's lab at Max F. Perutz Laboratories, Vienna Biocenter, Austria (www.heribert-hirt.info). Here he got involved in a project that unravelled the cold/salt?MEKK1?MKK2?MPK4 signal transduction pathway. His most significant result in Vienna was the identification and characterization of the H2O2?(?)?MKK3?MPK7?PR1 pathway. These results were achieved within the framework of his own project and revealed connections between previously unknown plant MAP kinase components. Meanwhile he took also part in the describing of the molecular interactions of a MAP kinase regulatory phosphatase. These results contribute to our understanding of the importance and complexity of MAPK signalling in plant stress responses. He then successfully applied for a Marie Curie Intra-European Mobility Fellowship of the European Commission to join Prof. Laszlo Bogre's lab at Royal Holloway, University of London (http://www.rhul.ac.uk/Biological-Sciences/AcademicStaff/Bogre/index.html). Here he characterized the role of the MKK7/9?MPK(3)/6 pathway in meristem function and proved its negative regulatory role. An important goal of the Marie Curie fellowship application was to receive training in bioinformatics and systems biology. Accordingly he successfully joined the first systems analysis project of the Arabidopsis MAP kinase network, and got familiar with a range of the relevant methods.

Experimental work

The mitogen-activated protein kinase (MAPK) phosphorylation cascades are conserved signalling modules in all eukaryotes and known to have pivotal roles to regulate cell division and cell growth as well as stress responses in animals and plants. How can the same MAPKs regulate both defence and developmental responses is poorly understood. One of the major pitfalls in our understanding is the paucity of known target proteins (substrates) in plants through which MAPK signalling pathways connect to physiological responses. Most well-characterised MAP kinase proteins of yeast and animals have multiple substrates, for example human ERK1/2 have over 100 different substrates11. Our knowledge of plant MAP kinase substrates lags far behind and the identified substrates so far have been isolated on a

more or less random basis, mostly by yeast two-hybrid screens. This research programme aims changing this situation by systematically finding and characterizing novel plant MAP kinase substrates.

IIdentification of novel putative MAP kinase substrates by a bioinformatics-based approach

Kinase-substrate recognition specificities within complex networks are often provided by dedicated interaction surfaces outside the kinase active sites and target phosphorylation sequences. Protein interaction specificities thus remain highly evolvable without compromising the strict stereo chemical requirements for efficient catalysis performed at the active site.

MPKs possess an evolutionarily conserved common docking (CD) domain as a docking site for MKKs, phosphatases and protein substrates that contain the corresponding MAP kinase docking site. Our knowledge of actual MAP kinase substrates in Arabidopsis is rather limited, nevertheless all five characterized substrates contain putative MAP kinase docking domains with minor variations to the consensus motif13-17. Remarkably, the predicted MAPK docking motif (amino acids 244-252) of EIN3 was mutated in the ein3-3 mutant (K244D) that diminished EIN3 function18. Robert Dóczi took advantage of the conservation of MAP kinase docking sites in a bioinformatics screen to identify novel potential MAP kinase substrates. He searched for the presence of potential MAP kinase docking sites in Arabidopsis protein sequences, and filtered the resulting candidates for the presence of the MPK phosphoacceptor motif [S/T]P.

He has successfully set-up all the required experimental techniques, such as cDNA cloning, protoplast transfection, protein immunoblotting, etc. One PhD student (Magdolna D?ry) has been involved in the new project since May 2010. She has made an impressive progress by learning all the techniques for the execution of the experimental programme within this time-frame.

Summarizing his research activities: He has made a significant progress in establishing a new research project aimed to characterise molecular connections between stress-activated MAP kinase pathways and developmental regulation. During his 19-month period under AGRISAFE employment he initiated a project successfully via adopting new experimental techniques. Preliminary results indicate that at least one predicted MAP kinase substrate is genuinely modified by MAP kinase in planta.

Additional benefits generated by the AGRISAFE project

Since his employment at the Agricultural Research Institute, Dr. Dóczi's goal has been to initiate the new research programme. To achieve this he prepared applications to granting agencies and commenced establishing molecular biology and protein biochemistry methods required for the project.

He has received an EU 7th Framework Marie Curie Reintegration Grant (ERG 256554; support: 45,000, duration: three years). He has also successfully applied for an Infrastructure Development Grant at the National Office for Research and Technology (MVNOVPRO). Support: HUF 20,000,000, one-off payment for the establishment of new proteomics laboratory facilities with the participation of the members of the Department of Applied Genomics. Currently he has two grant applications pending.

Later this year a methodological book chapter, written together with former co-workers, on assaying MAP kinase activities in plant samples will be published:

Dóczi, R,. Hatzimasoura, E. and Bögre, L. Mitogen-Activated Protein Kinase Activity and Reporter Gene Assays in Plants. Methods in Molecular Biology (in press), preliminary view: http://www.springer.com/life+sciences/plant+sciences/book/978-1-61779-263-2?changeHeader.

It was not possible to execute Task 2.4. as it was planned because Mariyana Georgieva arrived to Martonvásár on the 16th of April 2009 for six months, instead of Dr. Svetlana Landjeva, who could not come because of health problems. The original plan was that Dr. Landjeva would bring wheat genetic materials developed from wheat-alien hybridization in Bulgaria and the plants would be analyzed by up-to-date molecular cytogenetic techniques in Martonvásár. As Dr. Landjeva had serious health problems since the end of 2008 it was suggested by Prof. Gecheff, director of the Institute in Sofia, and Dr. Landjeva that Mariyana Georgieva, a young research fellow from the Institute of Genetics in Sofia should come instead and carry out the planned experiments for 6 months.

Personal background

Mariyana Stamova Georgieva was born in 1980 and she has been working at the Department of Molecular Genetics in the Institute of Genetics in Sofia, as a junior research fellow since 2003. She has good experience in the field of molecular genetics of cereals. She carried out research in the field of DNA damage, DNA repair, Comet assay, oxidative stress. She has several publications at conferences and in scientific journals. As she is trained in the field of molecular genetics she is supposed to be able to learn fluorescent in situ hybridization (FISH) techniques soon to carry out the planned experiments.

Experimental work

The wheat-Agroypron intermedium amphidiploids produced in Sofia have several useful agronomical characteristics but the genome structure is not known. The amphiploids have high protein content (19-22 %). The parental Agropyron intermedium has good adaptability to extreme environmental conditions, so it is hoped that the abiotic stress tolerance of the parental Agropyron accession is inherited in the amphidiploids. This will be studied later. The main purpose of Georgieva's visit was to detect the Agropyron chromosomes in wheat background in the amphiploid and identify them using FISH/GISH techniques with the help of repetitive DNA probes. Besides, another aim of her stay is to learn up to date molecular cytogenetic techniques.

Summary of the achieved results during the 6 months training

One direct benefit of Georgieva's stay in the Agricultural Research Institute was the acquisition of the following useful methods and techniques which she will be able to apply in her work in Bulgaria:

- Mitotic chromosome preparations using Pseudoroegneria spicata, Thinopyrum intermedium, Triticum aesivum and two partial amphiploids (H95 and 55(1-57))
- Probe labelling- pTa71, Afa family, pSc119.2.

In order to study the genome composition of H95 and 55(1-57) genotypes a large collection of species were used from the Genebank, USDA, USA and Martonvásár Cereal Gene Bank, Hungary.

- 3. Multicolor fluorescence in situ hybridization (McFISH)
- 4. Genomic in situ hybridization (GISH).

Additional benefits generated by the AGRISAFE project

The visit of Mariyana Georgieva was the first step to establish long-term research collaboration between the Department of Molecular Genetics, Department of Cytogenetics of the Institute of Genetics, Bulgaria and the Department of Plant Genetic Resources and Organic Breeding in the Agricultural Research Institute, Hungary.

During Mariyana Georgieva's stay in Martonvásár, she also took part in the Symposium and the Training Course III: Impact of Climate Change on Crop Production within an Agrisafe programme held on September 7-11, 2009. Her participation in this course gave her an opportunity to expand her international contacts with other scientists mainly from Central and Eastern European research teams.

WP3 Development of scientific and other equipment for training courses on environmental stress research connected with global climate change. Coordinator: Dr. Béla K?szegi

Prior to the start of the project, the equipment available to the research institute was in part outdated, due to lack of funds, thus seriously hindering competitive research.

As WP3 was concerned with the purchase of the scientific and IT equipment required to achieve the aims of the project, it was intended that the vast majority of these items should be purchased as quickly as possible after the granting of the funds, so that they could be put into operation as soon as possible.

The laboratory instruments and the IT equipment purchased in the framework of WP3, and the improvements made in the IT structure, network and software were exploited by both basic and applied research to achieve the aims of the project.

The most important tasks were:

- the establishment of an automatic meteorological station
- the creation of an audiovisual lecture hall
- the purchase of new laboratory instruments, or in some cases the improvement of existing equipment
- the purchase of IT equipment and software licences, and the expansion and improvement of the institute's IT network.

Information on the implementation of these improvements, including details of the public procurement procedure, was provided in the first annual report.

In the course of the project, regular calculations were made on the use of the funds available to WP3, and after the first round of purchases had been completed, it became clear how much of these funds had been utilised. Thanks to the public procurement procedure the sum actually spent was less than the funds made available on the basis of the original budget. This allowed equipment costing a total of around 8.4 million forints to be purchased during the second period, based on the experience gained during the operation of the new equipment purchased during the first year.

Since only the amortisation of the purchased equipment can be funded from the grant, a calculation of the amortisation rate of the equipment already purchased revealed that further equipment could be purchased during the third year of the project, thus expanding or renovating the IT background of the institute in order to promote the implementation of the aims of the project. The complete list of equipment purchased from the grant is given in Appendix .

The benefit gained from the improvements can be summarised as follows:

Equipment purchased for basic research

The equipment detailed in the first annual report, including microscopes, microtomes and the software required for data processing continues to be used by the staff of the Plant Cell Biology Department to investigate changes in plant tissues as the result of environmental stress, especially drought and heat. The evaluation, processing and publication of the results are carried out with the help of the notebooks and computers purchased from the grant.

The instruments were used to study the effects of drought and heat stress on the sexual processes of wheat, particularly on tissue development in the anther, pistil and developing grain. Investigations were also made on the effect of water withholding and increased CO2 concentration on the epidermal structure of wheat. Simultaneous water withholding and elevated temperature were found to cause alterations in embryo and endosperm development.

Supplementation of the existing instruments to allow plant stress responses to be analysed at the molecular level

The equipment purchased from project funds was used to continue existing research and also to initiate investigations on new topics, all involving the analysis of crop responses to environmental stress at the molecular level.

In the Cereal Resistance Breeding Department the effects of various abiotic (heat and drought, geographical adaptation) and biotic (various leaf diseases) stress factors on the physiology, phenology and yield production of wheat and barley genotypes were studied under phytotronic and field conditions.

Little work has been done in cereals on how non-vernalising temperatures influence the genetic regulation of flowering. Work is underway to discover the effect of temperatures lower or higher than the optimum, and of daily fluctuations in these factors. Research topics include the sensitivity of individual genotypes

to such temperatures, the vernalisation- and daylength-independent regulation of major plant development genes and interactions between these genes, other chromosome regions involved in temperature sensing, the genetic background of differences in the regulation of flowering in wheat and barley, and the relationship between the haplotypes of major plant development genes and the geographical spread of different genotypes. For this purpose, phytotron experiments and molecular genetic analyses are carried out on two-parent populations and on large numbers of barley and wheat varieties. This work is expected to lead to the identification of new regulatory genes and processes, the more efficient use of genetic resources in variety development and the elaboration of methods for marker-assisted selection.

Research is also underway on the effect of higher temperature or drought combined with an increase in the atmospheric CO2 level, the effect of enhanced atmospheric CO2 concentration on host plant-pathogen relationships, and the joint effect of nutrient supplies, temperature and enhanced CO2 level.

Equipment purchased for applied research

Purchase of additional instruments and software for analysing the effect of drought on the leaf area and the intensity of photosynthesis and for processing the data of field experiments.

In the Crop Production Department the equipment purchased from the AGRISAFE project was used mainly in analysing the effect of treatments in the long-term fertilisation experiments set up fifty years ago. The portable leaf area meter was used for growth analysis on the rate and intensity of maize shoot development, while the up-to-date root washing equipment was essential for characterising root development in order to determine the effect of nutrient treatments and the damage caused by the larvae of the western corn rootworm. Differences in the N supplies of wheat varieties and maize hybrids were determined on the basis of numerous measurements using the chlorophyll meter.

The Rotina 420R refrigerated centrifuge was used to prepare extracts from maize stalk tissue samples taken from plants artificially inoculated with Fusarium strains in the field. The cellulase enzyme activity of the extracts was then determined using the Colim 4.0 image analysing program. The results were published in a number of scientific and non-scientific journals, indicating funding from AGRISAFE.

The DU 730 Life Science spectrophotometer purchased from the project is used in marker-assisted analysis. It enables the DNA concentration of different genotypes to be determined after DNA isolation. In order to optimise PCR reactions, the DNA extracted from different samples must be adjusted to approximately the same concentration, and the data obtained using the spectrophotometer allow the necessary dilutions to be made.

The spectrophotometer can also be used to check the concentrations of primers and ALF sizers.

Establishment of a meteorological station for the collection and analysis of local data on meteorological changes In the framework of a cooperation agreement, the new meteorological station was linked up with the data-collecting network of the Hungarian National Meteorological Service, which means that not only local data, but also up-to-date national meteorological data are constantly available. The data provided by the new station are continuously uploaded to the institute website (www.mgki.hu), where they can be accessed by institute staff and PhD students. These data can be used for planning field experiments, for

analysing the effect of climate change on the experimental results and in writing papers. If required, the meteorological data from the station can also be utilised by those attending the training courses organised in the framework of the project. The agreement reached with the National Meteorological Service also ensures the regular, expert maintenance of the station. Construction and installation of an up-to-date audiovisual lecture room as a venue for the courses planned in the project This air-conditioned lecture room, seating 40 people and containing up-to-date audiovisual equipment, is located in the phytotron building and is used not only for the training sessions held as part of the project, but also for the regular meetings required in preparation for these. The room is equipped with microphones, projection equipment and a digital video camera. Wireless internet and access to the electricity network are available to the course participants both in the lecture room and throughout the institute. Notebooks were also purchased from project funds for the use of course participants, allowing both internet access and the possibility of recording and replaying the lectures. The courses held as part of the project provided not only theoretical, but also practical knowledge for the participants. The equipment purchased in the framework of Tasks 3.3 and 3.4 was used during the practical sessions to give the participants detailed knowledge on the stress tolerance of cereals and on their physiological responses to abiotic stress. In the framework of WP3 special efforts were made to improve the IT structure of the institute and to purchase the IT equipment required to achieve the project aims, thus significantly improving the bio-informatics background of the AGRISAFE project. The IT equipment purchased from AGRISAFE funds (servers, work stations, notebooks and improvements to the institute's IT network) makes a day-to-day contribution to achieving the aims outlined in the project by ensuring a satisfactory IT background. All in all it can be said that the tasks outlined for WP3 were successfully implemented. The scientific and IT equipment required for the planned research on the effects of climate change were purchased. These developments led to a considerable improvement in the competitiveness of the institute both within and outside the EU. This improvement in competitiveness made a great contribution to achieving the main aim of the AGRISAFE project, namely to develop the Agricultural Research Institute of the Hungarian Academy of Sciences into a EU regional research and training centre for the study of climate change.

WP 4. Organization of training courses and symposiums related to climate change for researchers, breeders, crop producers and managers. Coordinator: Dr. Ervin Balázs

Agriculture is the sector exposed to the greatest extent to the unfavourable effects of climate change. The profitability and sustainability of crop production sectors are decisive factors in food safety, so negative influences are quickly felt. Scientists engaged in applied plant biology, breeders, crop producers, agricultural lecturers, experts and consultants, and last but not least the farmers, all need to prepare for the likely effects of climate change in order to meet new challenges, avoid negative effects and moderate damage and losses. This will only be possible if they learn how to fight the effects of climate change in good time. The five one-week training courses planned in the framework of the project were designed and organised with this in mind, and included not only theoretical lectures but also laboratory and field sessions. The courses covered a wide range of questions related to climate change. The work on this topic that has been underway in the Martonvásár institute for almost twenty years, based in large part on the facilities available in the phytotron, provided a sound foundation for this task. One aim of the courses was

to acquaint young scientists from the region with the possibilities available in the Martonvásár research, training and service centre and to present them with up-to-date knowledge on this topic from recognised experts from Hungary and abroad. The basic aim of the first course (Climate change: facts and fictions, October 27-31, 2008) was to present observations and scientific approaches to climate change, including information on sceptical opinions and on the conflicts between facts and fictions. In addition to becoming acquainted with the Hungarian efforts to counter the effects of climate change, already underway for a number of years, the participants were also informed of the changes occurring in the components of the atmosphere and were given a picture of international climate change programmes, models and simulations. This was supplemented by a showing of the film prepared by Nobel prize-winner Al Gore, which gave a clear demonstration of the effects of climate change on biological diversity. Experts from the FAO regional centre, who were among the lecturers, described the activities of the international organisation, which are of outstanding importance for cooperation on climate change within the region. Water was a central theme of the course, with lectures on water use and drought in the light of practices carried out in Hungary and in the European Union. The participants were also introduced to the most up-to-date climate change models and became acquainted with the prediction methods used by the National Meteorological Service. The effects of climate change on biological diversity were described in terms of agro-ecosystems and of natural habitats. This first introductory course closed with a report on plant breeding strategies based on the facts presented in the lectures. The second training course (Climate change: challenge for the training of applied plant scientists. Biotic and abiotic stresses, March 23-27, 2009) covered the correlations and effects of the biotic and abiotic stresses caused by climate change. Based mainly on stress physiology, the course presented information on fundamental concepts of stress physiology, molecular mechanisms involved in the perception of high temperature by plant cell membranes and in signal transduction, the effects of UV B irradiation on plants, the cold acclimatisation processes of cereals and the results achieved in the molecular biological approach to drought tolerance. The lectures provided a survey of a wide range of biotic stresses in the light of cereal and maize breeding, supplemented by plant pathology aspects. The drought adaptation in cereals was discussed in terms of the most up-to-date genomics and proteomics approaches, while in the practical laboratory sessions the participants were able to learn the modern instrumental techniques used in breeding, including the microarray technique and bioinformatic methods of evaluating experimental results. A 45-minute film entitled "Genetic modification in the shadow of misperceptions and in the light of facts" was shown, a copy of which was given to each of the participants. On the third occasion the subject of the training course was the effect of climate change on crop production (Climate change: a challenge for crop production, September 7-11, 2009). Lectures were held on precision crop production, based on the use of multi-variable data sets in professional agriculture, and on the influence of soil components, water reserves and the carbon dioxide concentration on the efficiency of crop production, providing answers to many of the practical questions raised by the negative effects of climate change. In addition to the lectures the participants were also taken to see a number of Hungarian long-term experiments, at Debrecen University, at the Georgikon Faculty in Keszthely and of course in Martonvásár, where they were able to practise measuring the photosynthetic activity of plants in the field. A practical demonstration was also given of the use of climate models in crop production. Lectures were also held on the changes caused by climate change in weed infestation and in the insect fauna, which are of particular importance to farmers. The main scientific aim of the fourth training course was to present the answers provided by biotechnology to the challenges raised by climate change (Challenge for plant breeding and the biotech response: Drought and yield, the role of high temperature on plant gametes. April 12-16, 2010). Special

emphasis was placed on the plant gametes and their hormonal regulation. In the introductory lecture, the participants were informed about the preparations being made for a Hungarian climate law. A lecture on the outstanding role of reproduction biology in plant breeding and crop production gave a comprehensive view of the subjects covered by the course. Human activities aimed at the genetic improvement of drought tolerance were presented in the light of myths and facts, and the speakers also provided information on gene manipulation techniques and the potential stability of genetic yields. Optimum pollination, the role of doubled haploids and the possibilities opened up by intergeneric and interspecific hybridisation all provide answers to the challenges of climate change. The participants also heard lectures on the role of plant hormones in plant development and of up-to-date methods for the detection of these hormones. A visit was organised to the Biological Research Centre in Szeged, where internationally renowned basic research is underway on biotic and abiotic stress resistance, and to the Cereal Research Non-Profit Company, where the participants were shown the breeding nurseries. The last course (fifth course) in the series (Climate change: challenge for the training of applied plant scientists: Genetic resources for high added value plant breeding, October 2010) concentrated on the importance of genetic resources in the response to climate change and in the achievement of high added value plant breeding. The introductory lecture presented data on the effect of climate change on food supplies, bioenergy production and environment safety, underlining the economic and scientific justification for the series of courses. The genetic diversity of rye, oil marrow, grape, potato, nuts, maize and of course cereals represents an enormous reservoir for breeding and crop production, which could be exploited to develop varieties with better adaptation to the environment. Plants bred for organic farming are of special importance, as they could lead to the spread of this farming method. Other important results are the development of new genetic resources for production under less intensive conditions, and breeding aimed at a balance between the requirements of the environment and of farmers. The participants were taken on a visit to the gene banks in Tápiószele and Martonvásár, and their attention was drawn to the importance of these collections. The closing event in the series of courses was the final conference (Climate change: Challenges and opportunities in agriculture), held on March 21-23, 2011. This was organised jointly with Eucarpia, the European Association for Plant Breeding Research, which ensured wider publicity, leading to a total of around 160 participants, who presented some 100 posters and several dozen oral presentations, summarising the results achieved so far in the search for responses to the challenge of climate change. The top experts in climate change, soil, water, plants and agriculture spoke at the conference, including many of those who had given highly popular lectures during the courses. The success and usefulness of the courses was clearly demonstrated by the growing numbers of applicants. Despite the fact that the number of participants was constantly increased, some 40% of the applicants had to be refused for the fifth course. The enthusiasm of the young scientists from the region was a clear indication of the success of the project. Many of them attended several of the courses. The common interest of scientists from Hungary, Slovakia, the Czech Republic, Bulgaria, Ukraine, Slovenia, Croatia, Romania and Austria in the climate change affecting the whole of the region resulted in the forging of new contacts that could form an excellent basis for future cooperation at a regional level. An average of 25-28 young scientists attended each course, and in addition to Hungarian experts, specialists from universities and research institutes from all over the region were involved in introducing them to the scientific and economic questions facing sustainable agriculture. A total of 140 young scientists (many of them PhD students) from 11 EU member states took part in the five courses, the majority of them from the Pannon ecoregion. Some of the most renowned experts on the effects of climate change presented lectures on the possible responses to this challenge, giving the participants an insight into the problems

facing not only their own region, but also other parts of the world, where the responses were often quite different. The speakers included experts from Spain, Italy, France, the UK, Germany, the Netherlands, Austria, Denmark, Israel, Switzerland and the United States. The programmes of the five training courses and the final conference, including summaries of the course lectures and the whole proceedings of the final conference, are available on the project website at www.agrisafe.eu, where the power point slides of the lectures are also to be found.

Potential Impact:

Socio-economic impact and wider societal implications of the AGRISAFE project

Climate change scenarios forecast significant decreases in plant productivity, surpassing even 20%, for a substantial part of Europe. The productivity loss will be coupled with a general decline in ecosystem stability in agriculture. Agriculture and food safety are extremely sensitive to climate changes, so adaptability to stress is likely to gain priority over the quantitative aspects of yield. This will demand new approaches both to plant breeding and crop production, and in research strategy.

The Agricultural Research Institute of the Hungarian Academy of Sciences (ARI HAS) is one of the leading centres for crop research and breeding in Central and Eastern Europe. The institute was involved in the Hungarian VAHAVA project on the effects of global climate change and the responses to these changes, and is an active participant in the follow-up project KLIMA KKT (2006-2009).

The institute aims to develop into a regional research centre capable of offering practical help to farmers in Central and Eastern Europe encountering the unfavourable effects of predicted climate change. The research focuses on agricultural risks of predicted climate change and on ways of mitigating the unfavourable effects, which can be modelled in the phytotron operating in the institute. The detailed objectives are:

- Study of stress tolerance using molecular genetic tools and cell biology
- Identification of candidate genes for stress tolerance by means of functional genomics
- Agro-ecological research
- Long-term crop production experiments
- Phytotron research
- Breeding of field crops
- Crop protection

The strategic impact of the AGRISAFE project was to improve research capacity by complex training to prepare researchers, breeders and crop producers to cope with the challenges raised by climate change.

The continued maintenance and expansion of the bilateral research between Hungarian scientists and various European research centres and universities contribute to turning our institute into a centre of excellence for the whole Central and Eastern European region.

The aim of the training actions in the project was to make specialists and future specialists in agriculture and crop production aware of the possible effects of climate change on farming, after which they must be taught how to reduce or eliminate the unfavourable effects of these changes.

At the European level, the knowledge and experience available in individual institutes and universities on climate change and the investigation of its effects will be available for the whole of Europe. The magnitude of the problem does not respect national boundaries.

Food safety is a priority issue in the EU and has a considerable influence on the health and living standards of European citizens. It is therefore essential that the present project was aimed also to make the experience gained in this region available to other parts of the Union.

In the framework of the AGRISAFE project 5 international training sessions were held. These attracted increasing interest. The 140 young scientists whose participation was financed came from 10 EU countries. During these training sessions both the foreign participants and the young scientists working in ARI HAS had the opportunity to become acquainted with each other and forge new research contacts, which will hopefully lead to the design and implementation of joint research projects. During the course of the AGRISAFE project, 19 young staff from ARI HAS spent several months in prestigious research institutes in various parts of the EU, where they were able to learn new techniques and become acquainted with new instruments. The project led to closer relationships with our partners and to new forms of cooperation. The knowledge acquired by ARI HAS staff during these study trips has improved the research potential of the institute. Visiting scientists from other countries were made acquainted with the operation of the phytotron, one of the largest research facilities in the EU, and with how it can be used for research on climate change.

The field days held in neighbouring countries allowed us to pass on our research results to foreign farmers, providing them with information on plant varieties with better resistance to climate extremes and on how they could purchase them, and on cultivation techniques that help mitigate the yield losses caused by weather extremes.

The project made it possible to establish far closer relationships with end-users (now maintained through our homepage and email), by improving our ability to provide extension services to the representatives of agricultural small, medium and large enterprises, helping them to prepare for the unfavourable effects of global climate change, partly by recommending varieties and hybrids with better stress resistance and partly by acquainting them with new cultivation techniques with which the losses caused by extreme weather events can be mitigated.

Both when writing our application for the AGRISAFE project and during its implementation, maximum attention was given to the fact that the complete innovation chain, from basic and applied research to the practical utilisation of the results, has been in place in ARI HAS for several decades. The increase in research potential foreseen within the AGRISAFE project was thus designed in such a way that it would improve the first two elements (research, development) of the innovation chain, thus influencing the whole of our innovation capacity.

The wheat and maize varieties bred by ARI HAS are cultivated on over a million hectares in Hungary a year. The quantity of commodity wheat produced is 2-3 million tonnes/year, with a value approaching 90-100 thousand million HUF/year. Choosing to grow the latest ARI HAS wheat varieties may result in surplus income of 2.5-3 thousand million HUF/year for wheat farmers, which is many times more than the sum spent on research. The economic advantage can be attributed to the higher yield potential of the new varieties, to their better tolerance of unfavourable environmental effects, and especially to their excellent breadmaking quality, which means they can be sold at a higher price. The cultivation of resistant varieties reduces not only costs, but also the chemical pollution of the environment, and leads to the production of nutritious, healthy crops. The cultivation of varieties with excellent or special quality makes wheat exports more profitable. Seed sales of Martonvásár wheat varieties in Hungary amount to over 3

thousand million HUF a year. Martonvásár wheat are being multiplied on increasing areas in eight countries, chiefly in Romania and Slovakia, but some of the varieties are also familiar to farmers in France, Italy, Spain and Canada.

Seventeen modern maize hybrids from Martonvásár are under cultivation in 10 European countries. More seed is exported to these countries than is used in Hungary, and in recent years there has also been a rise in the seed exports to CIS countries

Farmers in Hungary work in a much more difficult economic environment than those in Western Europe. However, the use of varieties capable of adapting to extreme weather conditions represents an advantage for Hungarian farmers. For this reason, they were not threatened with bankruptcy even in years with extreme weather events, and many of them even managed to make a profit under such conditions.

Between 2003 and 2006 the institute was involved in the Hungarian VAHAVA project on the effects of global climate change and the responses to these changes, and was an active participant in the follow-up project KLIMAKKT (2006-2009). Within the framework of these projects work is underway on the agricultural risks of predicted climate change and on ways of mitigating the unfavourable effects. Thanks to this strategic preparatory work, Hungary is preparing a Climate Protection Law, which is currently awaiting debate by the Hungarian Parliament. The draft outlines the most important measures required for climate protection, including research on this topic. If it is shortly passed, it will make Hungary the second country in Europe, after the United Kingdom, to pass a climate protection bill.

In addition to the research on the unfavourable effects of global climate change, work has also begun with the leadership of the coordinator of the AGRISAFE project on how the CO2 emitted by oil refineries can be fixed by utilisation in the greenhouse production of vegetables. This work was commissioned by the MOL NYRt Company, the largest oil company in Central Europe. In the two experiment done so far, new analytical methods and assays were applied which were acquired by Szilvia Bencze, one of the institute workers, during her study trip sponsored by the Agrisafe project in Rothamsted Research, Harpenden, UK.

Changes in the weather pattern and in the frequency of extreme weather events can most probably be expected in the future resulting from the changing climate. This has a considerable impact on the vulnerable living communities across Europe. Policy communities within the EU have begun to consider the appropriate response to these changes. In particular, there are EU initiatives on water shortage and heat waves, and, at a regional level, how to plan for flood and storm events.

The "Impacts of extreme weather" working group within EASAC Environment Programme: Projects on Adaptation to Climate Change was established as a part of a new EASAC initiative to provide support for European policy communities on issues of adaptation to climate change. The AGRISAFE project coordinator was nominated to the EASAC Extreme Weather Working Group in 2011 by the Hungarian Academy of Sciences.

Main dissemination activities and exploitation of results

1. Importance, aims and tools of knowledge dissemination

Climate change has a complex influence on the future of mankind: some economic and social effects are felt directly, while others act indirectly by changing the components and processes of various environmental systems. Within this far-reaching system, there is a very close connection between the factors influencing human living conditions and health, environment protection and agricultural production.

Both crop production, which provides the raw materials for human nutrition, and the natural vegetation respond very sensitively to extreme changes in environmental conditions, which may destroy all or most of the yield. In other cases over-production may cause marketing and logistic problems. The mitigation of unfavourable abiotic effects is a key question in field crop production and depends to a decisive effect on the use of technologies adapted to local growing conditions, on the breeding of varieties with better tolerance of extreme conditions, and on the cultivation of varieties with improved adaptability.

Field crops provide raw materials for both foodstuffs and industrial use. The regulation of production processes and the achievement of ecological and economic sustainability through the application of new research results is thus of prime importance to the specialists directly involved (producers of input materials, farmers, traders, etc.). At the same time, as a sector influencing the living conditions of the whole of society, general information must also be made available to the wider public.

On the grounds of the above, the main aim of the dissemination foreseen in the project was to provide information to present and future generations of agriculturalists, particularly crop producers. Efforts were made to make them aware of the effects of climate change and to recommend ways in which the unfavourable effects could be avoided or mitigated.

The Agricultural Research Institute of the Hungarian Academy of Sciences made use of a number of different channels to pass on the knowledge gained in the project. The most effective form of propagation is the forging of personal contacts, (1) personal communication, which creates a genuine interactive relationship between the people involved. This was made possible by the scientific symposia and specialist meetings. The staff of the institute were also constantly available for telephone consultations, allowing farmers to obtain direct information on practical ways of coping with the negative effects of climate change, and press conferences were held for journalists, decision-makers and state officials. Personal contacts were almost always accompanied by the provision of (2) written materials, in the form of conference proceedings, scientific journals or brochures. Throughout the project period constant use was also made of the (3) electronic media, in scientific or agricultural programmes on radio and television. Use was also made of the most up-to-date form of communication, (4) online news outlets. The project website was used to full advantage, exploiting the rapid flow of information, interactivity, and the ability of readers to select what information they need.

2. Practical implementation of knowledge dissemination

2.1. Presenting the AGRISAFE project to the wider public

Climate change may have a complex effect on society, the economy and the natural environment. It may result in a greater frequency and intensity of extreme meteorological and environmental phenomena and processes, and the extent of damage may increase substantially. In addition to direct consequences, there may be other negative effects to human health and the natural environment, which make their effect felt over a longer period and whose cost is difficult to calculate.

The main goal in efforts aimed at preparing people for these problems is to ensure that the members of society know how to act to protect their health and to prevent or reduce material damage. However, the dissemination of knowledge is not only about emergencies. The AGRISAFE project was a good example of how passing on the necessary knowledge may have an important, reassuring effect on various parts of the population. This form of communication is designed to show the general public what efforts are being made by scientists to mitigate the unfavourable effects expected in the future. This is particularly important in field crop production, as the plant breeding process takes many years, if not decades to produce results.

In order to disseminate the aims of the project to as broad an audience as possible, the Agricultural Research Institute of the Hungarian Academy of Sciences employed a wide variety of information-sharing methods:

(1) At the beginning of the project period, in June 2008, the project website (www.agrisafe.eu) was set up to provide detailed information on the project, on related research topics and on upcoming events. The basic quality principles of the Minerva Project were followed in setting up and maintaining the website, with the help of European experts. In this way a link to the website was created on numerous other websites.

(2) Official surveys indicate that among the institutions and social and professional groups in Hungary, the public has the greatest confidence in the Hungarian Academy of Sciences. It was thus of especial importance that the President of the Academy launched the project at a press conference attended by representatives of all the major regional and national media, both print and electronic. In the course of the 3-year project, the Project Head held a number of press conferences on the implementation of the aims, and the results were reported in a large number of printed and electronic media (Greenfo, T?zsdefórum, Fejér Megyei Hírlap, Észak-Magyarország, etc.).

(3) One of the most popular environment protection programmes on the MR1 Hungarian radio station mentioned the project on a number of occasions, discussing its aims and role and the scientific results it led to.

2.2. Role of dissemination in training and informing undergraduates, PhD students and scientists and in publication

The work plan accepted for the project laid great emphasis on the organisation of courses and training sessions related to climate change (WP 4). Some of the most important of these were the one-week courses held in Martonvásár, which provided a high level of theoretical and practical training and were

attended by young scientists and PhD students from Central and Eastern Europe. The AGRISAFE website was of indispensable help in the organisation of these courses and in informing readers of the detailed programmes. Thanks to the interactive nature of the website, it enabled the young scientists to register online. The fact that the scientific materials used in the theoretical training were uploaded to the website as pps files at the close of each session made a valuable contribution to the increasing popularity and recognition of these courses. The 65 lectures now available on the website not only allow the participants to refresh their knowledge, but also provide a source of useful information for those with general knowledge on the subject who wish to acquire more specific information on the climatic problems facing agriculture in this region and on how these can be overcome.

The website not only makes the project available internationally, but also draws attention to the scientific papers published with funding from the project in high-ranking journals or in conference proceedings. Over the three-year period, the staff of the Agricultural Research Institute of the Hungarian Academy of Sciences, either alone or in cooperation with colleagues from other institutes, published over 120 papers on the expected effects of climate change and on how they can be mitigated.

These publications include 34 papers published in English-language journals, with a total impact factor of 13.57. These were written mainly on the topic of plant breeding and related fields of basic research, such as genetics, cell biology and plant physiology.

Many of the publications presented the practical results of breeding, including agronomic research on the utilisation of new varieties and hybrids. Eighteen of these were published in 2010 in a special issue of the journal Acta Agronomica Hungarica, also funded by the AGRISAFE project.

University students and scientists also made good use of the 15 papers related to climate change published in Hungarian with English summaries in the 2009/12 issue of the journal Növényvédelem (Plant Protection). These discussed the effect of biotic and abiotic factors on plant diseases, pest damage and weed control.

Scientists from Martonvásár presented the results of their research at numerous international and national conferences, always acknowledging funding from the AGRISAFE project. These results were published in 48 book chapters (20 in English and 28 in Hungarian) and in 5 English and 21 Hungarian conference proceedings. The sources are available on the project website, allowing the papers published by institute staff to be read on the internet in electronic format.

The proceedings of the final conference of the AGRISAFE project will prove a valuable long-term source of information for PhD students and for scientists working in this field. The 116 papers included in this volume contain not only the comprehensive analyses written by international experts on the relationship between climate change and agricultural production, but also the valuable results achieved by young scientists and PhD students.

2.3. Dissemination of breeding and technological knowledge applicable in practice

One strength of the project is that it uses an integrative approach to solving problems arising in crop production. This is manifested not only in the fact that the individual research areas outlined previously

are closely integrated, but also in the relationship between science and practice, in the whole of the innovation process. One of the major aims was to draw the attention of practical experts (policy makers, end users, stakeholders) to the expected effects of climate change on crop production and to provide them with the means whereby these unfavourable effects could be moderated.

Online forms of knowledge dissemination were again employed to carry out this task. An informative database was created on the project website, which could be easily adapted by crop producers to the agro-ecological parameters of the Carpathian Basin. Balanced plant nutrition is a decisive factor in reducing yield fluctuations caused by the weather. A joint team of scientists from the Agricultural Research Institute and the Research Institute for Soil Science and Agricultural Chemistry collected the results of mineral fertilisation experiments in Hungary, published over a period of more than four decades, and used them to elaborate a fertiliser recommendation system with a completely new approach. The structure of the new system, developed by processing several hundred thousand data, and the new limit values and correction factors calculated for the soil-plant system, are publicly available on the internet.

The possibilities presented by the electronic media were exploited to provide seasonal information for field crop producers in programmes broadcast by public service and commercial television channels and radio stations. As detailed in the annual reports, the majority of these were posted on the internet (www.youtube.com), thus allowing those interested in the specific questions raised to hear or see them again.

As regards the conventional offline media, publications were produced in several tens of thousands of copies during the three years of the project. The journal MartonVásár, published twice a year in 6000 copies, is distributed to both scientists and agricultural specialists. The issues published with funding from the project (2009/1, 2009/2, 2010/1, 2010/2, 2011/1, 2011/2, a total of 36,000 copies) included information on current effects in the AGRISAFE project, and detailed, clearly understandable explanations of the results obtained in relation to climate change. During this 3-year period, two title pages and 27 articles were devoted to the subject of climate change, all clearly acknowledging funding from the project.

One of the most effective ways of passing on the knowledge required to moderate the unfavourable effects of climate change is to distribute informative materials and marketing publications containing information on the adaptability of the varieties and on other agronomic parameters. The use of this knowledge in decision-making could lead to an increase in the productivity and stability of crop production in the Carpathian Basin at no extra cost. These publications, aimed primarily at agricultural experts in small and medium-sized farms, were printed in a total of 59,500 copies in Hungarian, English, Slovakian and Romanian.

Field days involving practical demonstrations are extremely useful, as the farmers are able to acquire knowledge on the significance of factors influencing crop production, and on their interactions, at various locations under a wide range of agro-ecological conditions. At the same time, in this interactive situation, scientists gain vital information on the problems faced by farmers in practice. The Agricultural Research Institute and its spin-off seed marketing companies organised a total of almost 350 field days in the Carpathian Basin during the project period, 80 in 2008, 156 in 2009 and 112 in 2010.

Project website:

www.agrisafe.eu

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