RESEARCH AND INNOVATION CENTRE

REPORT

2015/2016

AGRICULTURE
FOOD
ENVIRONMENT

FONDAZIONE
EDMUND
MACH

CENTRO RICERCA
e INNOVAZIONE

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PRESENTATION

Fondazione Edmund Mach: the right place to “think locally, act globally”

This report - the second I have had the pleasure to oversee since becoming President of the Fondazione Edmund Mach - is a stimulating overview of the internationally-recognized work carried out here in the laboratories of the Research and Innovation Centre.
FEM’s four “souls” – education, research, consulting and wine production – study the relationships between agriculture, food, environment, and human and animal health using an interdisciplinary approach or, even better, a circular one. As a result, we have recently been declared the first Italian OneHealth Centre.
Many of the research results generated at San Michele all’Adige have already had concrete impacts on the local economy and government policy. However, I am convinced that we need even greater integration between research and local enterprise. To this aim, in the past two years, FEM has increased its joint ventures with manufacturers, joined the Innovation Hub Trentino (HIT) Consortium, and founded the Centre of Agriculture, Food and Environment (C3A) with the University of Trento.
Borrowing from the famous motto, I firmly believe that Trentino is the right place to “think locally, act globally”. We at FEM are dedicated to building on the best practices of our Province to help solve the broader problems of society at large.

Andrea Segré
President
Fondazione Edmund Mach

Fondazione Edmund Mach: an innovative organization that integrates research and education

In order to improve agriculture in what was then Tyrol, in 1874 the Austro-Hungarian Empire approved the institution of an agricultural school to be located in the Augustinian monastery of San Michele all'Adige. The school opened in the autumn with a programme established by its first director, Edmund Mach. He was an efficient organiser and from the very outset fervently supported the plan to turn the institute into an innovative organization where teaching and research would together contribute to the development of agriculture in the region. After the First World War, the Agricultural Institute of San Michele (IASMA) came under the control of the Italian government which in turn passed it over to the authority of the Autonomous Province of Trento since 1948. In 1990 a local Law transformed IASMA into a functional agency of the Autonomous Province of Trento, integrating the land services into the pre-existing structure based on training and research. On 1st January 2008 the Institute's organisations and activities were transferred to a new legal body, the Fondazione Edmund Mach (FEM), a public agency under private law.
The existing three centres were inherited by FEM and given a more flexible structure geared to the specific aims of Education and Training, Research and Innovation, and Technology Transfer, which became not just the new names for the centres but also described the most salient aspects of their respective missions.

Sergio Menapace
General Director
Fondazione Edmund Mach

The Research and Innovation Centre: the first Italian "One Health Centre"

Annapaola Rizzoli
Director
of Research and Innovation Centre
Fondazione Edmund Mach

Since its foundation in 2008, the Centre for Research and Innovation (CRI) has become nationally and internationally recognized as a leader in the fields of agrifood and environment. Reaching this objective has also promoted the Fondazione Edmund Mach as a prime example of the power of a 'triangle of knowledge', where functional interactions between excellence in scientific innovation, education and technological transfer is translated into concrete impacts at a local level, both in terms of culture as well as development. The results of the national evaluation on the quality of research carried out by the Agenzia Nazionale di Valutazione del Sistema Universitario e della Ricerca (ANVUR) for 2011-2014 were particularly positive for the Fondazione Mach.

With an evaluation of 'Excellent' for more than 85% of our scientific output (scientific publications, etc.) in the areas of chemistry, agricultural and veterinary sciences and biology, our institute ranked third, fourth and fifteenth out of all similar institutes in Italy.

Scientific research at CRI focuses on three areas - agriculture, food and environment – all considered 'grand challenges' for the future of the alpine region in all its complexity.

Global change, including that caused by natural phenomena, but also socio-economic dynamics, requires the development of resilient systems, capable of responding to, and where possible, anticipating, the repercussions of extreme events.

One approach is to take this knowledge, innovation and resource management and apply it to a 'virtuous circle', a global movement recognizing that human health depends on animal health, and a healthy environment, including sustainable production systems and the conservation of traditional cultures and landscapes.

Given that its multidisciplinary research aims exactly in this direction, CRI has been recently declared the first Italian "*OneHealth Centre*", with major initiatives ranging from new synergies between institutions of higher education and research within the Trentino STAR (*Sistema Trentino dell'Alta formazione e Ricerca*) consortium, to the activation of the new Centre of Agriculture, Food and Environment with the University of Trento, to the founding of new international networks of excellence within the European Region of Tirol - Alto-Adige/South Tyrol - Trentino (EUREGIO and EUSALP), as well as international cooperation projects.

A particularly pressing challenge is the current economic situation, which has caused a significant reduction in resources dedicated to research. To successfully compete for remaining funds will require us to focus carefully on frontier science, but also on the needs of citizens and various local industries; in parallel, there is a call for a different approach from researchers, exploring these changed socio-economic conditions.

This Report highlights the most significant research results obtained in 2015-2016, and therefore comprises a limited number of in-depth articles of general interest, with summaries of others ('highlights'). Curious readers are also encouraged to consult our web-site for more details and additional news. I very much hope that, in addition to documenting the research results obtained, this Report also meets the goal of communicating the passion and enthusiasm expressed daily by the CRI community in their laboratories, and in the field. Such is the true wealth of this centre, unique in Italy.

The new Scientific Committee of the Fondazione Mach

FEM's new Scientific Committee took office on 11 March 2016: Giulia De Lorenzo - President, is an expert in agriculture from the University of La Sapienza - Rome; Vincenzo Fogliano is an expert in food research from the University of Wageningen - Holland, and Filippo Giorgi is a climatologist at the International Centre for Theoretical Physics in Trieste, Italy. The Scientific Committee, an authority designated in the statutes of Fondazione Mach, has the role of stimulating, addressing, and advising on scientific activities at FEM.
The appointment of the Scientific Committee marks an important and much awaited moment for the Fondazione Mach after the re-organization of the Research and Innovation Centre. All three members of the Scientific Committee are amongst the first 100 in the list of "Top Italian Scientists", with over one hundred high-impact scientific publications, and all are forerunners in their respective fields. Giulia De Lorenzo carries out outstanding research on plant physiology, particularly on innate plant immunity. Vincenzo Fogliano is internationally recognised for his work on dietary anti-oxidants and the sensory quality of food. Filippo Giorgi is a key figure in IPCC, the Intergovernmental Panel on Climate Change, winner of the Nobel Prize in 2007. These scientists are collaborating with the Fondazione Mach to better position the Foundation's research, innovation and technology transfer.

THE STRUCTURE OF THE RESEARCH AND INNOVATION CENTRE

Since its establishment in 2008, the "Experimental Station" has had a new organisational structure and is now known as the Research and Innovation Centre (CRI). The original specialised research Areas were maintained, covering the fields of Agriculture, Food and the Environment. Since February 2016 it is based on four Departments, and a cross-cutting Computational Biology Unit. Departments are organized in Research Groups and Technological Platforms. CRI research focuses on: genetics and genomics of fruit plants, agrifood and nutritional quality, sustainable agro-ecosystems and bioresources, biodiversity and molecular ecology, and computational biology. These research areas were selected to meet the interests and needs of local economy. A brand new Campus with 200 m^2 of greenhouses, 30 hectares of breeding fields and state-of-the-art technologies are other relevant traits. Pioneering organisations, a young and dynamic environment, international researchers, collaborations with universities and institutions throughout the world, and the institution of high-level specialised training initiatives: all these together place the Centre in a global context, which encourages the exchange of ideas and the development of innovation and produces both internationally-recognised and locally relevant results, in the frame of sustainable development. The Research and Innovation Centre is led by the Chief Scientific Office that is responsible for the strategic development of the excellence of the scientists, facilities and technological resources. CRI Director helps to set the research and scientific priorities so that they line up with the overall mission and goals of FEM. The CRI Directorate comprises of five teams, namely: Communication and Events, Finance, Projects and Funding, Welcome and Secretariat.

Department of Genomics and Biology of Fruit Crops (DGBPF)

Coordinator
Riccardo Velasco
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The Department has remarkable experience in the genomics of the fruit crops (grape, apple, pear, but also strawberry and raspberry), comprehensive olistic approaches to modern biology, and marker-assisted breeding. Up-to-date technologies have been acquired in order to lead the sequencing of two genomes (apple and grape), and to participate to other genomic projects (pear, raspberry, olive, strawberry) and they currently are used to refine the listed genomes and resequencing varieties (genotyping and RNAseq) with various purposes. Parallel interests in several "omics" (genomics, transcriptomics, metabolomics) aim to dissect biological events, with particular attention to fruit and flower development, plant-pathogen interaction, plant habitus, dormancy break, post-harvest as other events correlated to plant management, plant productivity and fruit shelf-life. Olistic approaches are supposed to supply a strong support to the breeding activity, and also high-throughput phenotypic analysis has been set up to implement marker development. Finally, the study of small and microRNA has been recently introduced to identify the role that these small molecules have in the biological events listed above.

Plant Biology and Physiology

We study the function of the genes found in the genomes of grapevine, apple and strawberry to understand how they direct the biology and physiology of these fruit crops. Final aim is to provide "resistance genes" and "quality genes" for breeding of grape and Rosaceae either by assisted breeding or by biotechnological means, as well as new knowledge to help crop management in the field.

Genetics and Fruit Breeding

It aims at understanding the genetical and biological bases of the most interesting traits in apple and other fruits and berries belonging to the Rosaceae family, such as strawberry and raspberry, blueberry, cranberry, apricot and cherry. Genomic knowledge will help identify genes for traits that may be useful in the development of new varieties and their breeding, from plant management to fruit preservation.

Grapevine Genetics and Breeding

The Unit aims to provide new grapevine cultivars and genetic knowledge for sustainable and smart viticultural production under a climate change context. We investigate associations between genetic and phenotypic variation in segregating populations, germplasm collections and somatic variants to gain a better understanding of resistance to downy and powdery mildews, resilience factors to abiotic stress (drought) present in *Vitis* spp. and quality traits that increase the economic value of wine and table grapes, such as flavonoid composition, aromatic precursors and seedlessness. Functional validation of candidate genes, oriented to the next-generation breeding, is performed by genetically engineering microvine plants. In parallel, a classical breeding program for resistance and wine quality is conducted possibly assisted by molecular markers.

Genomics and Advanced Biology

It performs functional genomic studies of grape and apple to increase protection from diseases and improve the quality of the fruit. The Unit is very committed to developing and applying the "new plant breeding technologies" in grape and apple in view of improving the classical protocols of genetic engineering routinely used for different grapevine and apple cultivars. Moreover, the unit developed innovative analytical methods for the characterization of the genetically modified lines, for the ex-vitro cultivation, plant phenotyping (thanks to the equipment of a modern greenhouse) and the sequencing of entire genomes, the transcriptome studies, gene expression analysis and metagenomics through the most advanced technology platforms of Next Generation sequencing (Illumina, 454, Life technologies).

Department of Food Quality and Nutrition (DQAN)

Coordinator

Fulvio Mattivi (until January 31st, 2017)

Kieran Tuohy (since February 1st, 2017)

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The research activities are carried out using new study methods, based on advanced technological platforms and infrastructures (metabolomics, stable isotopes, sensory panels, innovation incubators), and by adopting an integrated approach of a multidisciplinary nature. Innovative technical platforms and a systematic approach make it possible to carry out studies of fundamental significance, generate new study methods and obtain improved knowledge of agri-food products. The Department aims to support product and processing innovation based on knowledge of the food and agriculture sector. It promotes the use of research in the fields of biological sciences, consumer science, metabolomics and traceability as tools for innovative production. Provides a human nutritional research nucleus for the emerging strategic area of nutrigenomics. It carries out research, both in the laboratory and at the pilot project and company levels, providing scientific support for the creation of products and processes with added value, based on knowledge, ideas and innovation.

Metabolomics

The metabolomics unit generates new methods of study and knowledge about nutritionally and sensorially significant compounds, even participating in nutritional intervention studies, tracing the path of natural bioactive compounds inside the human body. Such information has the ultimate goal of improving the understanding of the impact of diet on human health and the production of higher value-added foods. It pursues the study of the molecular mechanisms that underlie the biosynthesis of secondary compounds in plants, knowledge of which is essential to progress in the field of biotechnology applied to plants and micro-organisms and breeding programs.

Nutrition and Nutrigenomics

The mission of the NN Unit is to measure how food and diet modulates host health and protects against chronic disease through interactions with the gut microbiota. We examine how microorganisms impact on food nutritional composition and also, how diet shapes and regulates the gut microbiome. We have a special interest in fermented foods (e.g. fermented dairy products), whole plant foods, their bioactive fractions (fibers, prebiotics and polyphenols) and probiotics, and aim to provide mechanistic insight into how these functional foods work.

Sensory Quality

Research activity aims at understanding the mechanisms underlying the perceived quality of food and the physiological and psychological factors that influence perception, preference development and consumer behaviour. Moreover, the Unit offers support to the food choices associated with health and wellness. Finally, it maintains and develops a sensory / instrumental / statistic facility to support innovation in the agroindustry.

Traceability

The unit is a competence centre for the development of research in the field of the application of stable isotope ratios analysis of bio-elements (H, C, N, O, S). It provides fundamental scientific and technological support to national and European research programmes concerning food traceability, aiming to enhance and safeguard products of certified origin within the context of the global market. Research activity is carried out also in the fields of ecology, hydrology, plant physiology and paleo-climatology.

Department of Sustainable Ecosystems and Bioresources (DASB)

Coordinator
Ilaria Pertot (until January 31st, 2017)
Damiano Gianelle (since February 1st, 2017)
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In order to design and develop systems, which can sustain human welfare and the preservation of natural capital for future generations, the knowledge of the complex relationships and interactions in the ecosystem and the interpretation of their reactions to disturbances are crucial. The objective of the Department is the promotion of a sustainable use of the natural and agricultural ecosystems to link the needs of modern society and the protection of the environment. Research focuses on innovative technologies based on low impact processes to answer to the standard of quality and production of the modern society. Thanks to the most innovative approaches in chemistry, physiology and molecular biology, a careful planning of resources use can be achieved and, in case of disequilibria in the ecosystems caused by anthropic activity counterbalancing actions can be put on place. The understanding of the mechanisms regulating the stability of ecosystems will help in their protection and in a sustainable development of agriculture.

Forest Ecology and Biogeochemical Cycles

We study the interactions between vegetation, soil and climate in order to evaluate the effects of climate change on ecosystems and to identify the more appropriate management methods to mitigate them. The research unit develops different types of biogeochemical models and innovative approaches, from ecosystem to regional scales (Lidar, hyperspectral fluorescence, eddy covariance, phenocam).

Agricultural Entomology

We study the biological mechanisms of perception and processing of the sensory stimuli involved in both intra- and inter-specific communication of the most economically important insect pests in order to manipulate their behaviour. The long-range aim is to develop innovative technologies for the agro-ecosystems and biodiversity protection. This research makes use of a

multidisciplinary approach, from molecular biology and comparative genomics to neurobiology and physiology up to behavioural observations in open field.

Hydrobiology

Our research focuses on biodiversity and on the long-term ecological evolution of lakes and rivers in the Alpine and perialpine region. In particular, we study the effects induced by climate change, eutrophication and changing hydrological and thermal regimes on aquatic ecosystems and communities. For this purpose, alongside traditional limnology we also use a multidisciplinary approach based on metabolomics, molecular biology and NGS, stable isotopes and high frequency data, and for catchment level studies, an eco-hydraulic approach.

Plant Pathology and Applied Microbiology

This research unit's mission is reducing chemicals inputs in agriculture (phytosanitary products or fertilizers), by developing low-risk active substances and products based on the metabolites produced by microorganisms, on the microorganisms (such as biofungicides, biostimulators, and/or biofertilizers), and on plant antifungal molecules. Such products are devised and tested in cooperation with manufacturers, in order to test for human health and environment risks.

Department of Biodiversity and Molecular Ecology (DBEM)

Coordinator
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A high level of biodiversity, defined as the number of species or total genetic variability in a population or community of plants or animals, is crucial for maintaining ecosystem function, their resilience in the face of global change, and their resistance to pathogen and parasite invasion. In order to maintain and manage this natural resource, the Department measures diversity at all levels – genetic, species and ecosystem – to understand the basic processes of adaptation, speciation and extinction. We also study the impact of global change on biodiversity and ecosystem function, the presence of autoctonous and invasive species, and on human and veterinary health. Using a combination of state-of-the-art molecular technologies (e.g. molecular screening, genomics, metagenomics, transcriptomics), as well as spatial/temporal modelling and statistics, we formulate hypotheses about future scenarios, and suggest how to improve strategies for managing natural environments, to maintain genetic and species diversity, and as a consequence, for human well-being.

Ecogenomics

The mission of the Ecogenomics Unit is the characterization and study of natural plant biodiversity, with particular reference to Trentino and the alpine environment. The integration of taxonomy, phylogenetics, physiology and molecular ecology in a comparative and genomic framework allows us to elucidate the main mechanisms underlying the generation and maintenance of natural biodiversity, and to estimate how the alpine flora could evolve and adapt in the medium to long-term to environmental stress and global change.

Applied Ecology

The mission of the Applied Ecology Unit is to study the effects of global change and biodiversity loss on Alpine species and related ecosystemic interactions, including host-pathogen dynamics. These objectives are pursued with a multi-disciplinary approach that combines molecular epidemiology, movement ecology, spatial ecology, geostatistics, mathematical modelling, statistics and big data analysis that requires the use of innovative IT platforms.

Conservation Genetics

This Unit focusses on the conservation and restoration of genetic biodiversity in wild populations, from microorganisms to large mammals and forest trees, in order to provide scientific support for management decisions aiming to protect these natural resources. Our long-term objective is to estimate how the distribution of genetic variability changes in time and space in relation to environmental factors and human activities. Our research has important impacts on animal and forest conservation, sport fishing and game management, tourism, and livestock farming.

Computational Biology Unit

The advent of –omics technologies is changing biology and life sciences from descriptive disciplines into data-intensive sciences.
Within the Research and Innovation Centre (CRI), the Computational Biology Unit is the reference for the analysis and statistical modeling of data, with a particular emphasis on "omic" technologies. The Unit conjugates original methodological research with the collaboration with the other groups of CRI in a variety of projects. The main research areas are: genomics, in particular of plants and bacteria, metagenomics, metabolomics, transcriptomics, statistical modeling and data integration. In addition, the Computational Biology Unit manages the High Performance Computing infrastructure of CRI and guarantees the storage and traceability of data generated by high throughput technologies.

Supervisor
Claudio Donati
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The PhD School (FIRS>T)

The International Research School of the Foundation (FEM International Research School of Trentino - FIRS> T) was founded in 2012 by merging the collaborative network 'Genomics and Molecular Physiology of Fruit (GMPF)' and training activities from other strategic sectors in the Foundation. Since its beginning, the School has been one of the most innovative and ambitious initiatives launched by CRI in recent years, offering about 140 scholarships and creating a strong network of international collaboration within the academic world, other research institutions and the private sector.

In particular, FEM has recently focused its attention towards the private sector to promote a direct economic fallout from basic and applied research. Receiving EU funding for a dozen industrial grants is a clear example of the success of this approach.

The new doctoral courses, along with those already started in 2016, will be part of other initiatives undertaken by FEM in recent years (see the C3A presented below).

These, in particular, strengthen the organizational architecture of FEM (with the creation of more specific schools) and increase opportunities for mobility in Europe.

FEM CAMPUS

The Agriculture, Food, Environment Center (C3A)

In September 2015, an agreement was signed between Fondazione Edmund Mach and the University of Trento to launch a new Center in San Michele all'Adige: Center Agriculture, Food and Environment (CAFE). The goal of the agreement is to further valorize the well-established collaboration between the two organizations. The Center, which covers academic education and research, will be a common space for the professors and the researchers of the two Partner organizations in the sectors of agriculture, food and environment. The topics will cover sustainable agriculture, aiming at high quality food production and mitigation of environmental impact.
Research activities will target the creation of an agricultural system able to reach to abiotic and biotic stress, the valorization and transformation of food products and the protection of the environment. Synergism between the two institutions will benefit scientific productivity and the joint participation to project, increasing the international competiveness of Trentino's research sector.

01 Guesthouse
02 Historical Cellar
03 Chemical Laboratories
04 Augustinian Monastery - Administrative headquarter
05 Food and Nutrition Laboratories
06 Main Hall
07 Education and Training Centre (CIF)
08 Logistical Centre
09 Research and Innovation Centre (CRI)
10 Technology Transfer Centre (CTT)
11 Experimental cellar
12 Fishing Centre
13 Research and Knowledge Palais / C3A
14 Plant Protection Laboratories

AGRICULTURE

Unraveling the dynamics in the agro(micro)biome for a more sustainable crop production

GIANFRANCO ANFORA
DARIO ANGELI
OSCAR GIOVANNINI
CLAUDIA LONGA
GERARDO PUOPOLO
MICHELE PERAZZOLLI
ILARIA PERTOT
OMAR ROTA STABELLI

The use of synthetic chemical pesticides and fertilizers is a highly debated topic because of its negative impact on human health and the environment. For these reasons, sustainable crop production is quickly becoming a research priority and a challenge for the future.

A promising approach is to exploit plant-associated microorganisms and/or their metabolites to produce sustainable pesticides and fertilizers; not surprisingly, the exploitation of plant microbiome is receiving increasing attention. Plants are naturally colonized by a large number of microorganisms (endophytes and epiphytes): they live in either temporary or stable relationships on and within all plant tissues and provide a wide array of functions. The biology, ecology and evolution behind these microbe-plant interactions could be the basis to define next-generation biopesticides or solutions to control pests and new fertilizers to enhance plant growth.

In this context, widely unexplored plant-associated microorganisms may offer a new source for active ingredients of novel biopesticides. An attractive solution may come from the manipulation of natural microflora by using specific nutritional factors to favor the presence of natural biocontrol agents.

Exploring the dynamics of microbial communities may also lead to the discovery of new active compounds, which are released only in the presence of possible competitors. In addition, the use of volatile organic

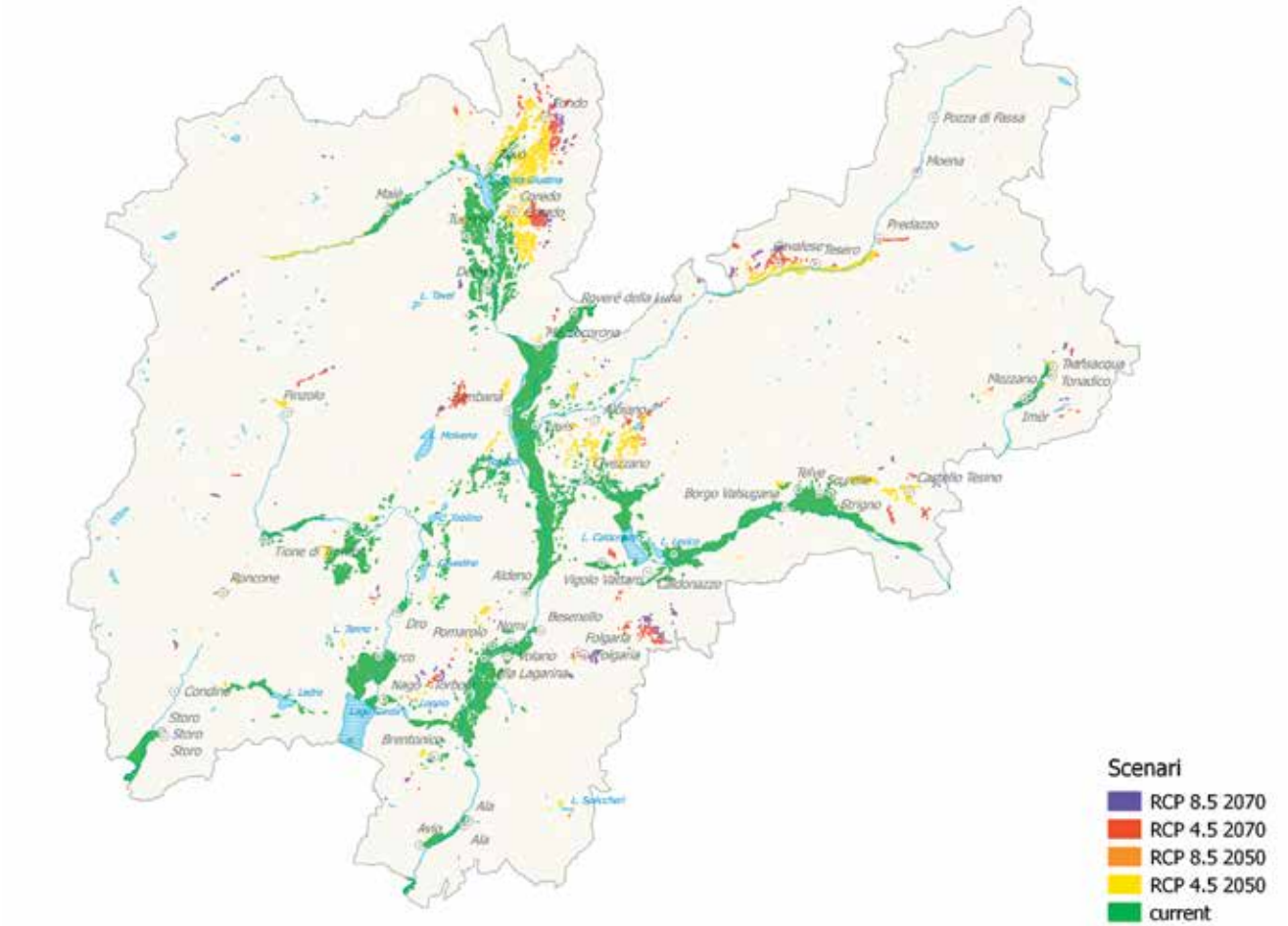
compounds produced by microorganisms as either antifungal compounds, plant resistance inducers or attractive compounds for insect trapping, may open new and unexplored ways to control plant diseases and pests. 'Omic' technologies are accelerating our comprehension of the microbe interactions and shall improve the efficacy and consistency of microbial biopesticides. In particular, these technologies help in identifying genome, transcriptome and proteome features of a key beneficial strain: this in turn allows a quicker characterization of the strain mechanism of action. The simultaneous study of the transcriptome/proteome of the microbial pathogen, of its host plant, and the microbial biopesticide shall clarify further the complex bi- or tri-trophic interactions in agroecosystems. The knowledge of microbial communities' composition and their dynamics is also crucial in the choice of the most appropriate agronomic practices to preserve soil biological quality and health.
FEM has already developed several solutions against pests and diseases based on microbial active substances in partnership with companies and has several options under development in the pipeline.

The past, present, and future of viticulture in Trentino

ROBERTO ZORER
ALESSANDRA LUCIANER
EMANUELE ECCEL

The origins of Trentino viticulture are well-documented in the book "Antichi vitigni del Trentino" by Stefanini and Tomasi (2010) in which the first findings are dated to the beginning of the Bronze Age (1800-1600 BC). Retics, Etruscans, and especially Romans contributed to the spread of the vine in the larger Trentino valleys.
As in the rest of Europe, viticulture in Trentino had to overcome several critical moments caused by environmental factors, such as the Little Ice Age, with the great frost of 1709, and by parasitic disasters such as powdery mildew (since 1850), downy mildew (since 1884) and phylloxera (since 1907), all which caused severe economic crises, abandonment of the countryside, and emigration. A detailed description of the geographical distribution of vineyards at the beginning of the 1900s is present in the "Guida viticola illustrata del Tren-

Viticultural map of Trentino in early 20th cent. after Comai and Obeziner



Simulation of potential viticultural areas in Trentino for different scenarios

tino" by A. Comai and L. Oberziner (1901) and in "Il Trentino" by C. Battisti (1915).

Founded in 1874, the Agricultural Institute of San Michele all'Adige was a driving force behind the revival of viticulture in Trentino. Worthy of note was the work of Rebo Rigotti, with his publication of the viticulture map of Trentino (1950 to 1962), consisting in a set of documents from a survey commissioned by the Trento Wine Committee in 1950. This map was recently reorganized, digitized and published online (cartaviticola.fmach.it) by the Library of the Fondazione Edmund Mach and by the Consortium of Trentino Wines with the contribution of Caritro Foundation.

The goal was to obtain analytical data and information about the status of Trentino viticulture in the crucial moment after the Second World War, in order to guide and govern subsequent developments in the sector, addressing technical and productive improvements both to zonation and to new consumer expectancy. Current varietal distribution within the province is continuously monitored on the basis of winery declarations, with precise land registry references. An example of a digital vine map is represented by the WebGIS portal of the PICA project (CAVIT sc, MPA Solutions, FEM, with the contribution of PAT-APIAE LP 6/99), covering an area of about 5,500 hectares, just over half of the total vineyard area.

Based on the current distribution of vineyards (from the "Real Land Use Map 08/2003" by the PAT-SIAT Planning Office), and on the availability of climate change scenarios, downscaled to Trentino, it was possible to formulate hypotheses on the future of viticulture in Trentino, and to identify suitable areas for potential expansion.

Not only leaves: a novel method to assess downy mildew resistance on grapevine inflorescence

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LUCA CAPPELLIN
CHIARA DOLZANI
RICCARDO VELASCO
ELISA PERESSOTTI
SILVIA VEZZULLI

Grapevine is cultivated worldwide for the production of wine, fresh fruit and raisins, and plays a pivotal role in the economy of many countries. Unfortunately, viticulture is endangered by numerous pathogens including downy mildew (DM), caused by the oomycete *Plasmopara viticola*. The most cultivated species of grapevine (*Vitis vinifera* L.) is highly susceptible to DM causing epidemics and yield losses, especially in regions with temperate-humid weather during the growing season (Figure 1a). To control the disease frequent applications of fungicides are required resulting in environmental pollution and hazards for human health. During the last decades, some hybrids (*Vitis* spp. × *V. vinifera*) showing durable resistance to DM in field were obtained. So far, most of the *in vitro* tests developed so far for DM resistance assessment are focused on leaf disc bioassays, which do not always correspond to a proper prediction of the disease extent on grapevine inflorescence or bunch, and therefore on final production and quality. Indeed the organ-specific nature of the higher or lower susceptibility to DM revealed in some hybrid cultivars makes it complicated to deduce the response from foliage to fruit and *vice versa*.

During a PhD project, based on observations in an untreated vineyard, we developed a new *in vitro* method for DM resistance assessment on grapevine inflorescence of ten *Vitis* hybrids. We identified the phenolog-

ical stage of flower buttons as the most reliable and suitable for *in vitro* evaluations, namely based on inoculation on detached inflorescences, using in parallel leaf disc bioassays to finally compare the different pathogen response between leaf and inflorescence (Figure 1c). In general, hybrids with resistant leaves showed resistant inflorescences, those with susceptible leaves presented susceptible inflorescences, while some hybrids (e.g. Cabernet Cortis) with mid-resistant leaves had mid-susceptible inflorescences. Thus, we confirmed our results also *in vivo* on inflorescences grown in greenhouse under environmentally controlled conditions. This was possible thanks to the production of fruiting cuttings, a particular agronomic technique allowing us to get inflorescences in three months only (Figure 1b). The identification of hybrids showing different response to the pathogen opens the way to further studies towards the understanding of the molecular mechanisms which underpin this phenomenon of agronomical and commercial relevance

Genetic control of flavonoid content and composition in grape berry

LAURA COSTANTINI
GIULIA MALACARNE
MARIA STELLA GRANDO
CLAUDIO MOSER

Flavonoids are a class of secondary metabolites with different functions in plant development, reproduction, and defense against biotic and abiotic stresses. From a human perspective, they are natural compounds displaying antioxidant, antimicrobial and anticarcinogenic activity, and protective effects on the cardiovascular system, for which reason they are used in the food and pharmaceutical industries.

The red colour of grapes is due to anthocyanins within flavonoids. Among other functions, they have been conserved in the berry throughout evolution to attract birds which accomplished seed dispersion by eating them. Nowadays the same red colour attracts the eye of wine lovers when they taste a glass of their preferred wine. Flavonol compounds have a more hidden role, they act as UV-protectants in different parts of the plant, including flowers, leaves and fruits. At the same time, they stabilize the colour of red wine by co-pigmentation with anthocyanins. Their complex profile in terms of concentration and relative abundance varies among cultivars and contributes to wine typicity.

In the last decade, great progress has been made in clarifying the main determinants of anthocyanin and flavonol accumulation in grape berry skin.

However, several aspects are still not completely understood, like the molecular details of their fine variation among cultivars at harvest and the interdependency in the synthesis of the two compound classes.

To shed light on these issues, we adopted an integrative approach combining metabolic, genetic and transcriptional sources of information based on a 170 plant progeny from 'Syrah' x 'Pinot Noir' cross, displaying extensive variation in the content and composition of these compounds. Significant results were obtained by collaboration and sharing of expertise between people from different research groups in FEM.

In particular, new candidates involved in the genetic control of anthocyanin biosynthesis were identified by exploring the gene predictions within several mQTL (metabolic Quantitative Trait Loci) regions and their expression profile during ripening in individuals with contrasting metabolic accumulation. New information was acquired on some aspects scarcely investigated so far, like anthocyanin sequestration and degradation, or completely neglected such as the addition of carboxylic groups. Interestingly, the analysis of the flavonol genetic control led to the completely novel discovery of a major regulation step in common with the anthocyanin biosynthesis. Flavonol-specific mQTL regions were also found containing genes for factors responsible for gene activation, transfer of methyl and glucose groups, and UV-B signalling proteins, which do not seem to be associated to the anthocyanin metabolism.

The identification of new genetic determinants of anthocyanin and flavonol varietal composition at technological maturity has great scientific relevance for further characterization. They additionally represent a valuable resource for selecting new varieties with desirable content of specific flavonoids impacting on wine growing industry.

Cisgenesis and genome editing: new tools for fruit breeding

LORENZA DALLA COSTA
STEFANO PIAZZA
CLAUDIO MOSER
RICCARDO VELASCO
MICKAEL MALNOY

The recent application of "new plant breeding technologies" to some important horticultural crops will likely have a great impact in the future on the way we grow them.

These technologies allow to obtain pathogen-resistant plants or plants with enhanced qualitative traits in shorter times compared to traditional breeding programs by means of minimal targeted mutations in the plant genome. While tangible and remarkable progress have recently been made in the application of cisgenesis and genome editing in annual plants, in fruit trees these objectives are far more distant. Concerning cisgenesis, which is based on the integration of a species-specific gene in the plant genome without the use of a selection marker gene (i.e. antibiotic resistance), here at FEM a successful strategy has recently been set up in grapevine. This employs a traditional gene transfer process via *Agrobacterium tumefaciens* with the involvement of a marker gene for the selection of the modified cells/embryos (antibiotic or herbicide resistance genes). After the selection phase the undesired exogenous sequences are removed by means of a heat-shock treatment leaving no trace of them in the plant tissues. One of our current goals is the application of this technology in apple to transfer disease resistance genes against apple scab like *Vf*, *Vr2*, *Vm*, *V25*.

Regarding the second approach, genome editing, FEM is strongly committed to the evaluation of different strategies for delivering the CRISPR/Cas9 system in grape and apple with the aim of knocking-out target genes without introducing exogenous DNA in the plant genome. This is a very ambitious goal because it implies no-

use of a marker gene, which is still fundamental to the selection step of the modified plants. Along with the optimization of the methodology, FEM, in cooperation with international private partners, aims to obtain a proof of concept of the feasibility and effectiveness of the CRISPR/Ca9 system for the inactivation of susceptibility genes. These genes are very important because they may block the plant-pathogen recognition process preventing the development of the disease. For grapevine we are focused on *VvMLO7* gene which has been proved to have a key role in powdery mildew susceptibility. For apple the target genes are *MdDIPM* and *MdHIPM*, responsible for the susceptibility to *Erwinia amylovora.*

Breeding Programmes at FEM

PIERLUIGI MAGNAGO
MARCO STEFANINI
LARA GIONGO
RICCARDO VELASCO
IVANA BATTOCLETTI
GIULIA BETTA
MARCO CALOVI
ANDREA CAMPESTRIN
SILVANO CLEMENTI
MONICA DALLASERRA
CINZIA DORIGATTI
TIZIANO TOMASI
MONICA VISINTIN
LUCA ZULINI

Breeding a new variety is a long-term process of selection, starting with the crossing of two chosen genotypes, selected for their interesting features. This long process may take over twenty of thirty years for apples and grapes, or a few years less for soft fruits.
In order to have a high success rate, a breeding programme must anticipate the future expectations, needs and desires of producers and consumers. Among new goals of "apple project" it is worth highlighting the lower environmental impact and the implementation of nutraceuticals, naturally higher in older varieties. Other goals are smaller apple size, long or flat shapes, red or orange flesh, slow browning after cutting, different sweet/sour tastes and self-thinning varieties. The aforementioned programmes have released five products (registered varieties) and several intermediate genotypes. All these intermediate genotypes present novel features and progress towards our goals, to obtain new varieties with distinguishing and intriguing traits in the medium term, conferring added value to future varieties as compared to traditional varieties.
The vine breeding programme has been developed by crossing *V. vinifera* varieties/genotypes, on the basis of the crop features. For this purpose, over 20,000 seedlings were selected, 250 of which are being evaluated with wine and about 20 are being tested in different environments in Italy and abroad. The first results have led to the recognition of four genotypes in the Italian National Register of Grape and Vine Varieties , with plant pat-

ents in Europe and the USA. Crosses between *V. vinifera* and non-vinifera species resistant to fungal disease, downy mildew and powdery mildew were also carried out in 2008. The main purpose was to obtain high quality genotypic lines by pyramiding resistance genes, coming from different genetic resources. Currently, about 200 genotypes exhibit disease resistance and are undergoing qualitative assessment. The breeding turnover is about 30,000 seeds per year and phenotypic selection results in 12,000 seedlings.

Blueberry and raspberry breeding programmes at FEM were established in 2009 and are developing as decentralised programmes, with both environmental targets and cultivation techniques being included early in the selection process. Depending on the genetics of the progenies, sites at FEM in Trentino or at lower latitudes are exploited for selection and trials. Both breeding programmes are almost completely soilless, while multi-environmental trials are also carried out in soil. They are aimed at producing new varieties for Trentino and Italian growers, and also for different markets in Europe, involving farmers who make a precious contribution with their intimate knowledge of local environments and the crop.

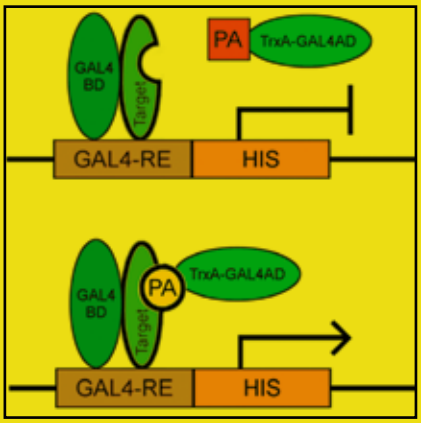
The main focus is on fruit quality, plant resistance being a pre-requisite for selection. The production of about 12,000 blueberry seedlings per year and 8,000 raspberry seedlings is aimed at selecting new genotypes with better texture, flavour and shelf-life, over a wide range of seasons.

NEW PROJECTS

GrAptaResistance: novel ideas to combat grapevine downy mildew

MONICA COLOMBO, MICHELE PERAZZOLLI, RICCARDO VELASCO, SILVIA VEZZULLI

Downy mildew, caused by *Plasmopara viticola*, is one of the most serious diseases of grapevine, responsible for significant losses. GrAptaResistance, a research project of the Edmund Mach Foundation and the University of Milan, aims to develop innovative environmentally friendly and non-toxic molecules against this pathogen.



VITISANA: introduction of new resistant grapevines in Trentino

SILVIA VEZZULLI, MARCO STEFANINI, LUCA ZULINI, RICCARDO VELASCO

The aim of this project is to develop and adopt molecular tools and protocols to identify those genomic regions associated with low quality traits in mildew and mould resistant grapevines. This is fundamental to understanding the genetics underlying negative quality traits in disease resistant grapevines, in order to pave the way to for breeding new varieties with outstanding taste and sustainable cultivation.

INTERFUTURE: from microbial interactions to new-concept biopesticides and biofertilizers

ILARIA PERTOT, MICHELE PERAZZOLLI, GERARDO PUOPOLO, GIANFRANCO ANFORA

The Interfuture Project is a PhD program financed by the European Commission's Marie Sklodowska-Cuire Actions. The project is implemented by a consortium of 11 partners (universities and industries) and is coordinated by the Edmund Mach Foundation. The focus of the research carried out by the PhD student will be on biopesticides and alternatives to chemical pesticides.

HIGHLIGHTS

New insights into the mechanism of resistance and the induction of polyphenols in downy mildew infection of grapevine leaves

SILVIA VEZZULLI, GIULIA MALACARNE, ANTONELLA VECCHIONE, CHIARA DOLZANI, DOMENICO MASUERO, ZERAYE HAILE MEHARI, PIETRO FRANCESCHI, ELISA BANCHI, RICCARDO VELASCO, MARCO STEFANINI, RON WEHRENS, URSKA VRHOVSEK, LUCA ZULINI, CLAUDIO MOSER

Using a segregating population derived from Merzling and Teroldego, we integrated genotypic and phenotypic (disease resistance degree and polyphenolic content) data upon downy mildew (DM) infection. We found that DM resistance is mainly mediated by the Rpv3 locus, and defined a number of novel regions associated with the traits of interest. We are currently investigating the candidate genes located in these regions to employ them for breeding activities.

Study of the Botrytis-grapevine interaction

ZERAYE HAILE, STEFANIA PILATI, GIULIA MALACARNE, PAOLO SONEGO, URSKA VRHOVSEK, KRISTOF ENGELEN, CLAUDIO MOSER

Grape bunch rot caused by *Botrytis* cinerea can severely impair grape quality and yield. Infection often occurs at flowering and the pathogen stays quiescent until fruit maturity, when symptoms become evident. The main phases characterizing this interaction have been studied at the molecular level (integrated transcriptomic and metabolic analyses, confocal microscopy) using a controlled infection system in order to elucidate the mechanisms of fungal pathogenicity and quiescence and plant defense.

Biocontrol of *Drosophila suzukii* by indigenous parasitoids

VALERIO ROSSI STACCONI, CLAUDIO IORIATTI, ALBERTO GRASSI, GIANFRANCO ANFORA

One of the reasons for uncontrolled outbreaks of invasive alien species, such as *Drosophila suzukii*, is the lack of specific natural enemies in the invaded areas. However, indigenous biocontrol agents may adapt over time to the new host. FEM has carried out both laboratory and field experiments in Trentino, identifying the most promising resident parasitoids. Extensive releases for augmentative biocontrol are planned for the 2017 season in order to verify their efficacy in host population control.

How to assess the risk of secondary plant pathogens with an eye towards fungicide reduction

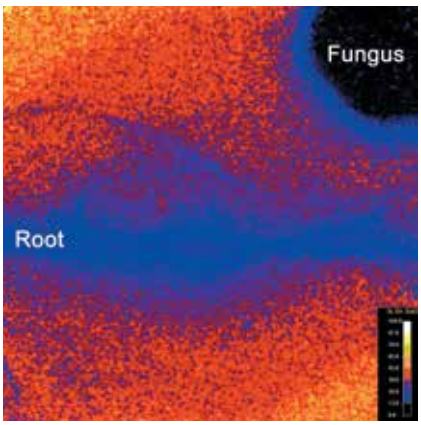
MICHELE PERAZZOLLI, ELENA ARRIGONI, DARIO ANGELI, CLAUDIO IORIATTI, ILARIA PERTOT

As a side effect, the reduction in the use of synthetic chemical pesticides may increase the risk of emergence of secondary pathogens, which were previously controlled by treatments against major ones. We are evaluating secondary disease dynamics and the risk of outbreaks of emerging apple pathogens in relation to different plant protection programs using functional and molecular approaches.

Imaging O_2 changes induced in tomato roots by a fungal pathogen

MIRCO RODEGHIERO, ELENA TURCO, SIMONETTA RUBOL, DAMIANO GIANELLE, ALBERTO BELLIN

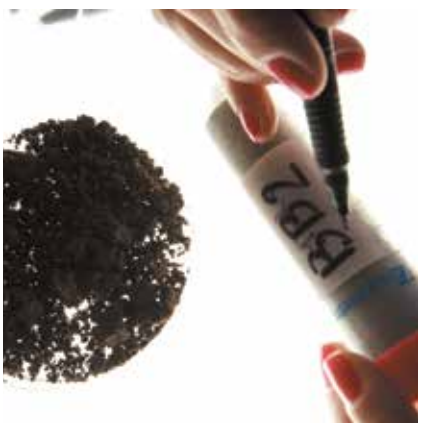
An optical, non-invasive, oxygen sensor (Visisens, Presens, Germany) was used in an *in vitro* experimental setup to study the effects of the colonization of tomato roots by the fungal pathogen *Fusarium oxysporum* f.sp. *lycopersici*. Oxygen consumption was considered a proxy for respiration and was monitored continuously during three phases: initial approach, root colonization and root death.



The role of soil microorganisms and metabolites in replant disease

ILARIA PERTOT, CLAUDIO DONATI, DAVIDE ALBANESE, URSKA VRHOVSEK, LIDIA NICOLA

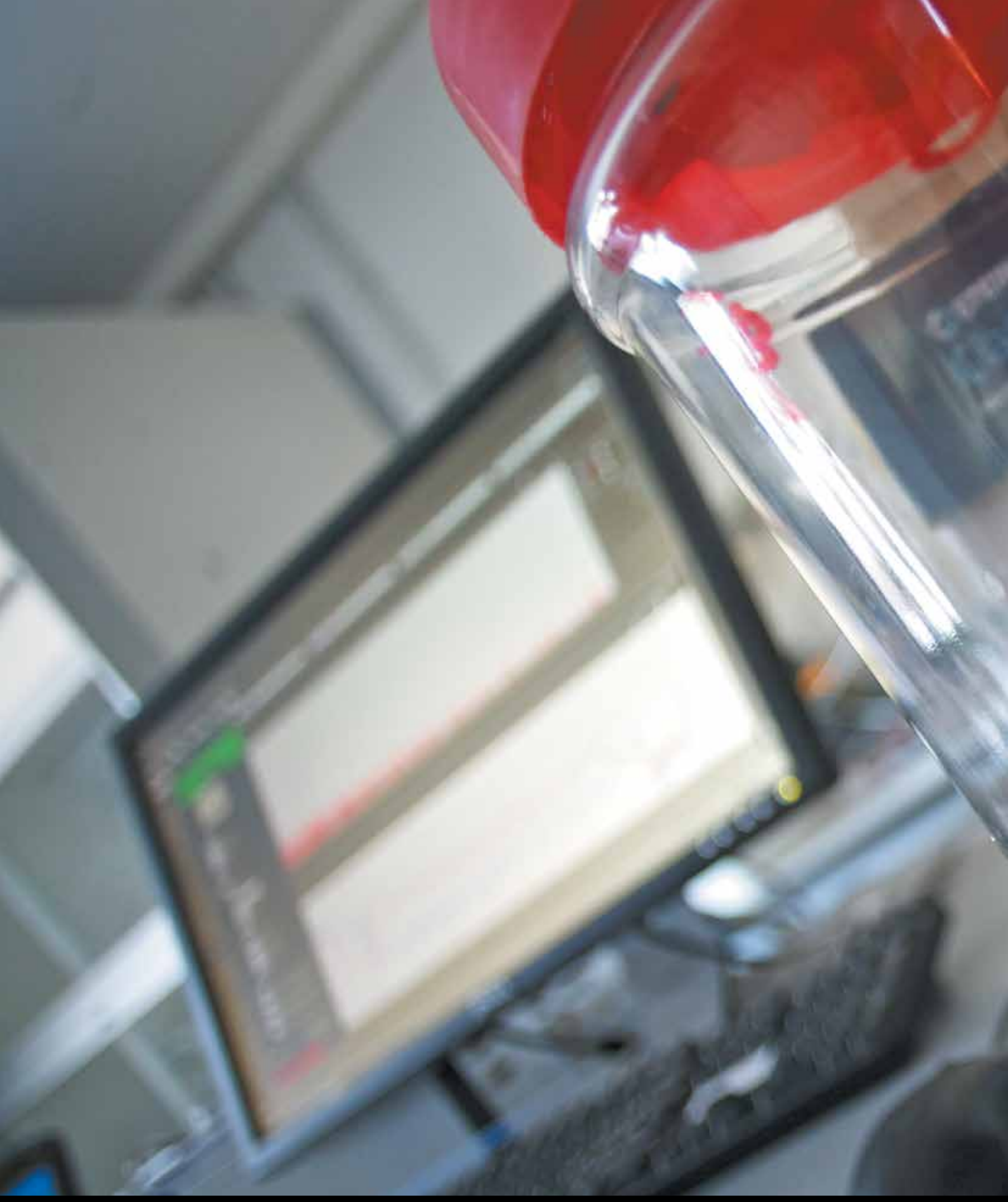
Apple trees are particularly susceptible to replant disease, which is a disorder that affects plants replanted in soil where the same species was previously grown. Although replant disease is most probably due to a combination of abiotic and biotic factors, targeted metabolomics and metagenome analysis associated the presence of phlorizin and the modification of the soil microbial communities to the syndrome.



Apple Illumina and Affymetrix SNP Arrays

LUCA BIANCO, GARETH LINSMITH, DIEGO MICHELETTI, ALESSANDRO CESTARO, RICCARDO VELASCO, MICHELA TROGGIO

High-throughput genotyping has facilitated the dissection of complex traits using thousands of phenotyped and genotyped individuals in a short time. Two new high-density SNP arrays (Illumina Infinium® 20K and Affymetrix Axiom® Apple480K) have been built at FEM for domesticated apple (*Malus* x *domestica* Borkh). These reference tools for Pedigree Based and Genome Wide Association Analysis are now publicly available worldwide.



FOOD

Wine-Oxygen-Antioxidants: how to address the winemaker choices more effectively

PANAGIOTIS ARAPITSAS
FULVIO MATTIVI

Both oxygen and antioxidants are crucial in winemaking and a good enologist has to find the optimum equilibrium to produce quality wines. In the winery, oxygen can be easily managed, but it is tricky to control it during the commercial life of the wine. Even minimum amounts of oxygen in the headspace on the post-bottling development of wine can either irreversibly damage or improve the quality of wine. The key factors to take in consideration are wine characteristics, packaging/bottling parameters (bottle and stopper type, inert gas etc.), expected commercial life length and antioxidants addition. Most often, the choices in bottling are based in empirical knowledge. Usually the consequence is an excess addition of SO_2 to prevent any possible problem, which results in increased concentration of the unwanted sulfites in wine.

A modern metabolomics experiment conducted on 216 bottles of 12 different white wines produced new knowledge concerning wine chemistry, especially highlighting the reactions between SO_2 and various wine metabolites. Specifically, SO_2 reacts with other antioxidants present in wine, like oxidized glutathione, by depleting each other concentration. So instead of having a synergic or additive protection due to the presence of multiple antioxidants, the protection from oxidation given to wine is reduced in terms of capacity, because of the antagonism between the antioxidants. This phenomenon, unknown until today, was often pushing winemakers to increase the dose of SO_2 thus increas-

ing the sulfites concentration in wine. In addition, compounds related with the metabolism of amino acids (i.e. indolic metabolites of tryptophan) also react with SO_2. The amount of these indoles in wine was recently found to be relatively high, increasing their importance as SO_2 binders and underlining their role in wine making and wine chemistry.
The consumption of SO_2 mediated by these sulfonations was promoted by the presence of higher levels of oxygen on bottling and all these reactions were reported for the first time. The better knowledge of such mechanisms can help enologists make a better use of SO_2 in wine and to decrease the sulfites in wine. This is currently one of the major challenges in oenology, since SO_2 remains the gold standard for the protection of wine against oxygen and microbial spoilage.
This project was conducted in collaboration with one the largest Italian wineries (Mezzacorona) and a major player in the wine stopper market (www.nomacorc.com).

From fruit to yeast: a synthetic platform for combinatorial synthesis of bioactive compounds

STEFAN MARTENS

The relative abundance of plant secondary compounds such as polyphenols in the human diet and their potency against a range of chronic diseases have made them the subject of intense research in experimental and preventive medicine. Dihydrochalcones, major polyphenols found in apples, comprising molecules of significant commercial interest as antioxidants, antidiabetics, or sweeteners while anthocyanins are water-soluble pigments that colour the fruit and flowers of many plants. Variations in anthocyanin decoration account for differences in colour stability and hue of the pigments. This further underpins the need for developing production systems for pure anthocyanins for investigating the effects of chemical specificity on uptake, signalling and physiology, toxicity of anthocyanins for medical applications and for developing new formulations in the natural colours industries. However, the limited range of these polyphenols commercially available and the expense of pure preparations mean that most research is done with crude extracts of plants which are not

standardised with respect to the particular compounds they contain, nor the amounts of each metabolite in the extract.

Novel procedures for sustainable, high level production of diverse natural products in heterologous hosts like microorganisms show a high yield and can be up scaled to industrial production. Although all major genes coding for enzymes for the polyphenol biosynthesis were successfully expressed in yeast, so far the multistep combinatorial synthesis of these polyphenols was only described for bacterial systems. Advanced and state of the art strategies to genetically modify bakers yeast (*Saccharomyces cerevisiae*) as an innovative host for the combinatorial synthesis of various polyphenols were successfully established for dihydrochalcones and anthocyanins only recently within ongoing coopaeration between industry and the BPN group (Biotecnologie Prodotti Naturali). Challenges and bottlenecks as native degrading and/or competing proteins (e.g. b-glucosidases) and the described side activities of flavonoid pathway proteins need to be overcome to further increase the productivity and yield of targeted compounds. In short term, these strategies aim to establish a robust, stable pre-industrial production system for new, pure polyphenols with different decorations of basic structure.

Phenomics of volatile compounds: a first step to unravel, improve and control the quality of strawberry, raspberry and blueberry

BRIAN FARNETI
IULIIA KHOMENKO
MARCELLA GRISENTI
MARCO AJELLI
PAOLO MARTINATTI
ALBERTO ALGARRA ALARCON
FRANCESCO EMANUELLI
EMANUELA BETTA
LUCA CAPPELLIN
EUGENIO APREA
FLAVIA GASPERI
FRANCO BIASIOLI
LARA GIONGO

Aroma is one of main factors impacting fruit and vegetables quality and, consequently, consumer appreciation and this is particularly relevant for berries. Studies focusing on fruit quality improvement have to consider the complexity of the aroma profile, its evolution in time and its interaction with consumers. Volatile Organic Compounds (VOCs) are produced and released in most stages of the food-production chain, "from farm to fork", therefore they play a relevant role in agro-industrial processes.

Since aroma involves the perception of a plethora of VOCs, their assessment is crucial to guarantee the selection and marketability of high quality fruits. High priority should thus be given to replacing poor flavor cultivars with favorable ones, exploiting the genetic variability already available in nature.

Enhanced knowledge about berries germplasm diversity (i.e. blueberry, raspberry, and strawberry) and genetic relationships among plant breeding materials was one of our priorities in this two years study as an important support to crop improvement strategies. Indeed, the simplest way to select superior parental lines is to choose them, based on their performance related to the traits of interest. However, the analysis of aroma in a large number of samples, necessary to overcome the usually massive biological and genetic variability among samples, may be laborious and time consuming. The instrumental characterization of VOCs is essential to have a precise, reliable, and reproducible estimation of food aroma and, therefore, of the overall product quality.

The application of Proton Transfer Reaction -Time of Flight- Mass Spectrometry (PTR-ToF-MS) has been recently demonstrated to be a powerful high-throughput phenotyping tool suitable both for genetic and quality related studies. The rapidity and the moderate cost of PTR-ToF-MS analysis allowed us to perform a detailed aroma characterization of each species with a peculiar attention to the

VOC fold changes caused by *ad hoc* storage experiments tailored to simulate the "from farm to fork" chain. The results obtained in these preliminary investigations gave important explanatory information to be implemented in the FEM breeding programs of blueberry (*Vaccinium* spp), raspberry (*Rubus* spp.) and strawberry (*Fragaria* x *ananassa* spp.). In our opinion this accurate and rapid VOC phenotyping will increase the possibility to obtain and select higher quality progenies in the near future.

Tracing volatile compounds in the dairy industry

EUGENIO APREA
MATTEO BERGAMASCHI
EMANUELA BETTA
LUCA CAPPELLIN
IULIIA KHOMENKO
FRANCO BIASIOLI
FLAVIA GASPERI

Volatile compounds, already present in milk or produced during the cheese making process, are key quality features of dairy products.
Monitoring such compounds permits the tracing dairy products quality along the production chain and, in the case of typical products, to valorize them.
The Sensory Quality group has unique competence in the analysis of volatile compounds from gas-chromatography (GC) to direct injection mass spectrometry based on proton transfer ionisation (PTR-MS). While GC is considered the golden standard for compound identification, PTR-MS allows the online, direct, rapid, non-invasive and high sensitivity monitoring of volatile compounds.
The Quality Sensory group has long applied both techniques also in association with sensory analysis to dairy products. A few examples can be found in recent papers concerning:

- the effects of pasture type and cow feeding supplementation level on volatile compounds, physicochemical and sensory characteristics of cheese produced in

alpine hut in collaboration with the University of Udine.

- Studies, in collaboration with University of Padua, on the effects of dairy systems and individual cow-related factors on the flavor profiles of cheeses from Brown cows reared in Trento province. These studies are illustrative examples of the approach adopted by the Sensory Quality group: accurate information on the identification of compounds by GC and high-throughput screening (more than a thousand samples per week) by direct injection mass spectrometry. This last aspect is necessary to bring the analysis of volatile compounds in the omics field
- non-invasive monitoring of lactic fermentation in yogurt driven by different commercial starter cultures in order to identify markers for bioprocess optimization and evaluation of their aromatic potential. This study is an example of the methodology developed by the Sensory Quality group for the efficient e non-invasive monitoring of microbial processes of agro-industrial and bio-technological interest.

Integration of genetic, isotopic and chemical approaches for authenticity assessment and protection of high-quality Italian wines

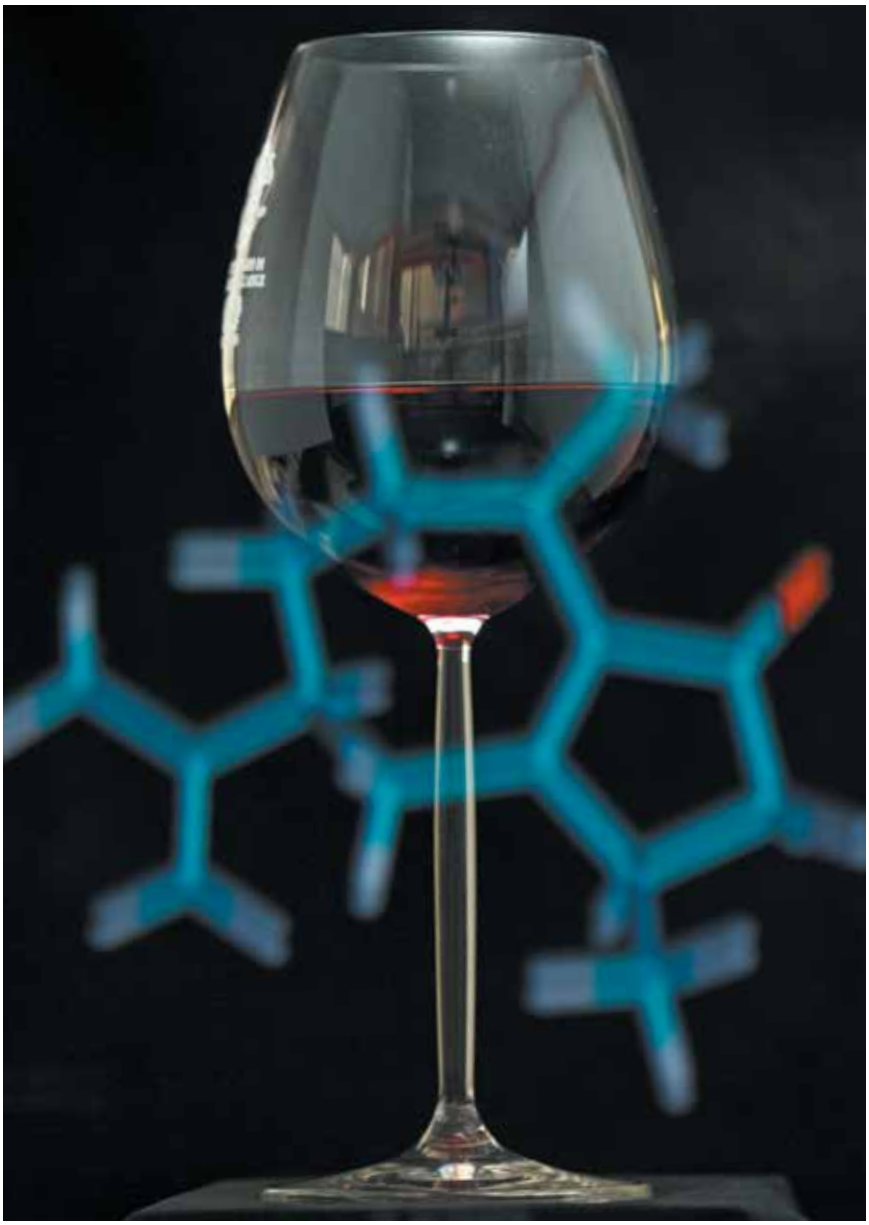
MARIA STELLA GRANDO
FEDERICA CAMIN
FULVIO MATTIVI

Wine is one of the most complex and appreciated alcoholic beverages, the quality of which is highly dependent on different factors. Wines labeled with a specific labels have to respect strict rules governing the types of grapes used, the area in which these grapes are grown, as well as vineyard and winemaking practices.

Currently, diverse and complementary techniques based on stable isotope ratios, genomics and metabolomics can detect and identify components of grape and wine from the level of single atoms and small molecules up to the level of proteins and nucleic acids, thus providing information on all possible attributes of the product: provenance, *terroir*, identity, cultivation, processing history, contamination or possible adulteration, and ageing.

The importance of a good traceability system throughout the winemaking process, both for characterization of the typicality and detection of fraud, was considered in our recent studies relating to the renowned Italian wines Brunello di Montalcino, Lambruschi Modenesi, and Trentodoc.

DNA fingerprinting technology is a well-established practice in grapevine variety identification from direct plant material - leaves, canes, fruits, and roots - but recognition of the varieties in the actual wine is still controversial.



We demonstrated not only that grape DNA loss is produced by the fermentation process but also that wine-making operations contribute to the reduction of double-stranded DNA content in wine. Therefore no PCR amplification or consistent results can be obtained from samples collected at the end of fermentation or in commercial wines.

The stable isotope ratios of H, C and O have been analyzed in wine since 1991 to detect mislabeling and the unpermitted addition of water and exogenous sugars. Our in-deep investigation has quantified the effect of stopping fermentation, dealcoholization and grape withering on the H and O isotopic values of wine.

Moreover we proved for the first time that stable isotope ratios of N in bulk product and proline keeps the isotopic variability of the provenance soil, and therefore can be proposed as a further isotopic marker for the geographical traceability of wine.

Furthermore, fingerprinting of wine volatiles by comprehensive bi-dimensional gas-chromatography coupled to a time-of-flight mass spectrometer allowed us to visualize the huge complexity of the volatome of Trentodoc sparkling wines, which consists of up to 1700 compounds measurable in the wine headspace. A subset of 196 biomarkers fully discriminated between Trentodoc and Franciacorta sparkling wines.

NEW PROJECTS

Project L. 6/99 "Innovation and research for extra virgin oil produced in the region of Alto Garda Trentino"

GINO ANGELI, FURIO BATTELINI, FEDERICA CAMIN, MASSIMO FIA, STELLA GRANDO, FULVIO MATTIVI, FRANCO MICHELOTTI, URSKA VRHOVSEK

The main goals of this project are to underline the unique characteristics of extra virgin oil produced by Casaliva and Alto Garda, and to help guarantee the quality of this extraordinary olive oil. This project is conducted by FEM researchers and technicians and is coordinated by Agraria Riva del Garda.
The project supports production chain innovation in order to enhance unique technological and quality features of Agraria Riva Del Garda Casaliva oil with the aim of protecting against counterfeits. In addition, an innovative defense system against damage caused by oil fly will be developed for the Upper Garda Trentino area. Finally, special attention will be devoted to preserving the quality of oil along the production chain: from the oil mill to the consumers table.

Project TrentinCLA

ILARIA CARAFA, KIERAN TUOHY

TrentinCLA is a fellowship cofunded by the Fondazione Cassa di Risparmio di Trento e Rovereto and the Fondazione Edmund Mach. The project will investigate the production of conjugated linoleic acids (CLA), a health promoting fat thought to offer protection against cancer, diabetes and heart disease. The aim is to understand how diet:microbe interactions regulate production of CLA in the rumen, in dairy products and possibly, in the human intestine.

This project is funded by Fondazione Cassa di Risparmio di Trento e Rovereto.

HIGHLIGHTS

Italian Taste: research on the preference and food choice of Italian consumers

ISABELLA ENDRIZZI, EUGENIO APREA, MATHILDE CHARLES, EMANUELA BETTA, JESSICA ZAMBANINI, FLAVIA GASPERI

The *Italian Taste* project is a large-scale study (3000 respondents in 3 years) coordinated by the Italian Sensory Science Society, which aims to explore the food preferences of Italian consumers. A wide number of variables – physiological, genetic, psychological, personality-related and socio-cultural – will be investigated to better understand the complex interplay of factors contributing to food choices.

New pigments found in grapes

PANAGIOTIS ARAPITSAS, FULVIO MATTIVI

For the first time we provided clear evidence that a) also the skin of white international grape cultivars contains measurable amounts of red pigments (anthocyanins); and b) pyranoanthocyanins, important pigments for colour stability of red wines, known to be formed during winemaking and aging, were quantified in fresh grapes.

Progress in ellagitannin biosynthesis in soft fruits

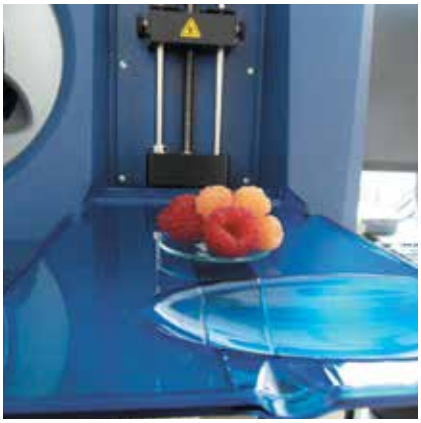
STEFAN MARTENS, ANTJE FELLER

Ellagitannins are bio-active, polyphenolic antioxidants that have been associated with a reduced risk of cancer and cardiovascular diseases. The identification and characterization of five glycosyltransferases from *Fragaria* and *Rubus* that catalyze the formation of 1-O-galloyl-β-D-glucopyranose, the starter compound in the biosynthesis pathway, enable future biotechnological production and breeding programs.

Correlation based data analysis for the discovery of metabolites in untargeted metabolomics

STEFAN MARTENS, PIETRO FRANCESCHI, SAMANTHA RICCADONNA

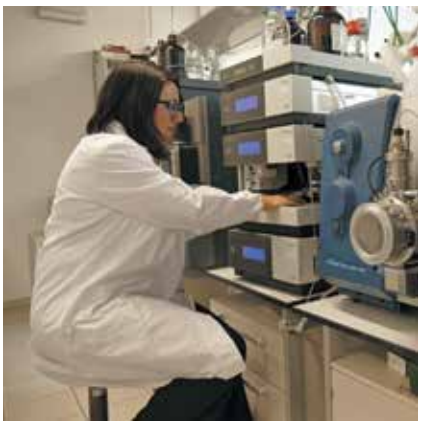
MS based metabolomics aims to characterize a set of metabolites in a biological system. Unfortunately, their automatic identification is a daunting challenge. We developed a correlation based data mining approach to extract the spectrum of unknown metabolites from untargeted datasets. Our approach allowed us to identify a series of new polyphenolic compounds present in yellow raspberries.



Non-*Saccharomyces* yeast and the wine flavor metabolom

MARGARET BECKNER WHITNER, URSKA VRHOVSEK

Until recently, most research surrounding the influence of yeast on the flavor of wine centered on *Saccharomyces cerevisiae*. We studied the impact of non-*Saccharomyces* yeasts on the volatile profiles and the sensorial properties of wines with the aim to improve sensory attributes and the overall complexity of wines. This research greatly increased the understanding of their role in wine making.



Sugars and volatile compounds: influence on the perception of apple sweetness

EUGENIO APREA, MATHILDE CHARLES, ISABELLA ENDRIZZI, EMANUELA BETTA, JESSICA ZAMBANINI, FLAVIA GASPERI

Sweetness is one of the key sensory features of apples. Breeding programs are selecting apples with higher sugar contents. This, however, does not automatically result in higher perceived sweetness. We recently confirmed the absence of a correlation between sugar content and sweetness in apple and highlighted the importance of the modulation effect of volatile compounds on perceived sweetness.

Sensory profiling of new FEM apple selections

MATHILDE CHARLES, MARIA LAURA COROLLARO, ISABELLA ENDRIZZI, JESSICA ZAMBANINI, PIERLUIGI MAGNAGO, FLAVIA GASPERI

The most promising new apple selections obtained from FEM breeding programs have been analyzed by a trained panel composed of FEM employees that provide an objective description of selection's sensory properties. The sensory profiles highlight distinctive attributes of the FEM selections when compared with their parent varieties and contribute to predicting their commercial potential.

ENVIRONMENT

A task force to face the threat posed by invasive alien species and the perspectives for their sustainable control through an integrated approach

GIANFRANCO ANFORA
DANIELE ARNOLDI
FREDERIC BALDACCHINO
STEFANO CORRADINI
MARIA CRISTINA CRAVA
OSCAR GIOVANNINI
ALBERTO GRASSI
CLAUDIO IORIATTI
VALERIO MAZZONI
ILARIA PERTOT
ANNAPAOLA RIZZOLI
ROBERTO ROSÀ
VALERIO ROSSI STACCONI
FAUSTA ROSSO
OMAR ROTA-STABELLI

Global economy and climate change has exposed local entities to the growing risk of alien species invasions. The introduction of insects, microorganisms and plants in new areas by means of trade and touristic flows is a major concern for biodiversity and poses serious problems for either human health or agricultural production.

Early detection, knowledge of the biology and ecology of the alien species in newly invaded environments, and rapid identification of the most effective control measures are hence crucial for an effective control. In the authors' opinion these actions require a multidisciplinary approach and cooperative networking among researchers, practitioners, growers, stakeholders and citizens.

An example of this approach is the invasion of *Drosophila suzukii*, a fruit fly endemic to South East Asia. Since 2008, it has spread throughout Europe and America and in a few years became a key pest that causes extensive economic damage to small fruits industries. FEM sequenced, first in the world, the *D. suzukii* genome from which derived genetic and evolutionary information that are currently supporting several research lines: development of efficient volatile attractants thanks to the fine characterization of sensory receptors; devel-

opment of forecast models; study of the multitrophic interactions between the pest, its host plants and microorganisms (e.g. *Wolbachia*) and between parasitoid wasps.
In the case of the brown marmorated stink bug, *Halyomorpha halys*, reported in Trentino during 2016, the task force in FEM is monitoring its spread and investigating its biology in our ecosystems. Moreover, studies are underway on the efficacy of bioinsecticides and resident natural enemies, and on the development of multistimulus traps combining olfactory, vibroacustic and visual cues.
Among invasive insect vectors, *Aedes* mosquito species are the most resilient and dangerous to humans since they can transmit several exotic arboviruses such as dengue, chikungunya and Zika. Among them, *Ae. albopictus*, *Ae. koreicus* and *Ae. japonicus* have colonized large parts of Europe including northern Italy. In collaboration with Fond. Bruno Kessler and Ist. Zooprofil. delle Venezie, FEM task force has developed mathematical models on mosquito species distribution and population dynamic based on original local sampling data. These models can be used to predict the risk of transmission of mosquito-borne viruses and to validate pest control strategies.
We advocate that only by pursuing Integrated Pest Management strategies it would be possible to face the complex threat posed by invasive alien species. Classic control methods should be integrated with more sustainable techniques, such as trapping based on specific attractants, biopesticides and biocontrol using natural enemies, but also with the support of "citizen science" programs favoured by the large diffusion of modern mobile devices.

Plants regulate the Planet's health: a proof of evidence from Fondazione Edmund Mach

ELENA GOTTARDINI
LUCA CAPPELLIN
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DAMIANO GIANELLE
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The role of plants in the regulation of the health of the Planet is nowadays a fact. Besides the results published by FEM researchers in the most prestigious scientific journals, recent TEDx-Trento talks definitively support this theory.
In particular, plants are crucial in "cleaning" the atmosphere from dangerous compounds, especially with an efficient management of plant resources. FEM researchers are engaged with international networks (European Cost Actions, ICP Forests) to assess air pollution effects on vegetation e suggest future guidelines for developing proper strategies for the conservation of plant biodiversity

ICP Forests

LIFE FutureForCoppiceS

Life

and protection of ecosystem services. The atmosphere contains not only the well-known main constituents (nitrogen, oxygen and carbon dioxide) but also several "trace gases". Many of them are harmless for human health at their typical atmospheric concentrations while others are harmful, especially where they are present at higher concentrations. Recent studies by the Fondazione Edmund Mach in collaboration with Harvard University has shown that plants play a fundamental role in cleaning the atmosphere from several harmful trace gases. Studies are carried out also at local level in collaboration with Forest and Fauna Agency of Provincia Autonoma di Trento to evaluate the role of plants in ozone removal and related biological costs.

Therefore, the proper management of plant resources is crucial. LIFE FutureForCoppiceS (http://www.futureforcoppices.eu/it/) aims to demonstrate how different management approaches may affect sustainability of coppice forests and their efficiency in supplying ecosystem services.

The project is based on sustainable forest management (SFM) indicators collected from 45 experimental sites. FEM is responsible for the assessment of forest ecosystem health and vitality and for data upscaling, from the local to a European level.

Connecting different projects related to the role of plants in regulating Planet's health by international networks (Cost Actions) is a priority for providing guidelines for an effective management of plant resources. For instance, MOUNTFOR EFI-Project Centre participated to Cost Action "*Enhancing the resilience capacity of SENSitive mountain FORest ecosystems under environmental change (SENSFOR)" dealing with treeline ecosystems that are indicators of environmental change, because of the heavy impact of environmental drivers of Climate Change (CC) and land use (LU).*

Scientific research on inland waters: the use of innovative approaches

NICO SALMASO
ADRIANO BOSCAINI
CRISTINA BRUNO
LEONARDO CERASINO
GIOVANNA FLAIM
ULRIKE OBERTEGGER
MONICA TOLOTTI

The research on the effects induced by climate change, eutrophication and alteration of hydrological regime on aquatic ecosystems have been enhanced with new and numerous research tools that have allowed to expand greatly the spectrum of the measured variables, while providing new interpretive tools to be used in restoration ecology and ecosystem-based management. Studies on populations and aquatic communities follow a multidisciplinary approach based both on traditional techniques (field measurements, microscopy, chemical analysis, eco-hydraulic approaches) and on a broad spectrum of modern tools of analysis (e.g. metabolomic profiling, molecular biology and NGS-metagenomics, stable isotopes, high frequency data recording). The use of an integrated approach allows to study the aquatic communities at a level of biocomplexity compatible with the presence of different ecotypes and with physiological adaptation processes and biosynthesis of different primary and/or secondary metabolites controlled by environmental gradients or by processes of "founder effect" (e.g. clonality in the case of the distribution of toxic cyanobacteria and rotifers).

The recent application of metagenomic is opening up new horizons in the evaluation of biodiversity and function of aquatic communities, and (in the near future) in the development of innovative bio-indication tools for the assessment of the effects caused by anthropogenic and climatic stressors on the perialpine and alpine ecosystems. The use of different mass spectrometric techniques in the study of in-

dividual cyanobacterial strains, still rapidly evolving, is leading to the continuous discovery of new bioactive molecules, including toxic compounds and others with therapeutic potential. XRF based detection techniques (X-Ray Fluorescence) applied to the study of lake sediments allow to reconstruct the temporal dynamics of the pollutants at secular and millennial scales, providing further support to the definition of reference ecological conditions based on the analysis of classical proxies (diatoms and subfossil cladocerans). The study of the hydrographic network uses a multidisciplinary approach that combines ecology, hydraulic studies, hydrology, river morphology and mathematical modeling, allowing to evaluate the forcing agents that affect the biological communities, and to predict the changes induced by anthropogenic activities and climate change. The use of these new integrated approaches allows a better understanding of the role of natural biodiversity in aquatic ecosystems and the identification of objectives and measures to mitigate the impacts on lake and river ecosystems.

Conservation Genetics. Case Study: the Capercaillie (*Tetrao urogallus*)

BARBARA CRESTANELLO
FANNY D'AMATO
HEIDI HAUFFE
CRISTIANO VERNESI

In the last few decades, the number of capercaillie has decreased dramatically in the Province of Trento, prompting the activation of several monitoring and management plans for this species and its habitat. To complement these interventions, this project analysed the pattern and level of genetic diversity in several populations of capercallie in Trentino-Alto Adige with the aim of improving current conservation strategies.

Genetic variability constitutes the basis of a population's ability to survive and evolve in the face of global change, including climatic and environmental changes. Therefore, the conservation and/or restoration of biodiversity at this level is crucial for the conservation of a species. In recent years, thanks to technological advances, conservation genetics can now be performed on samples collected 'noninvasively'; that is, the DNA necessary for estimating genetic variability can now be obtained from any tissues with a sufficient number of attached animal cells (e.g. feathers, droppings, eggshells) without trapping or harming the individual that deposited them. The Conservation Genetics Research Unit (CRI, FEM) has optimized for the capercaillie (as it has in the past for many other wildlife species) a laboratory protocol for genotyping noninvasive samples collected in the field by the technical personnel of the Provinces of Trento and Bolzano during their routine surveys. The genotyping of the capercaillie was done using ten 'microsatellites', genetic markers that are frequently used by researchers to estimate the level of genetic variability in a population.

Genotypes were obtained for a total of 235 capercallie individuals: 95 from the Parco Naturale Paneveggio – Pale Di San Martino, 126 from the Stelvio National Park and 14 from the Parco del Monte Corno. Our results show that genetic variability is high in our study populations compared to that of other Alpine populations and also higher than that of other smaller, isolated populations.

However, our analysis also showed the populations we studied are somewhat isolated from one another. This result underlines the importance of maintaining as wide a distribution of this species as possible, in order to promote adequate exchange of individuals between them (pre-

serving gene flow and high genetic variability in each population), especially important in a species characterized by a low dispersal capacity. Valleys that are particularly urbanized and influenced by human activities, such as the Adige Valley, may act as partial barriers to gene flow in this species.
Therefore, it is important for managers to decide how to maintain connectivity between populations in order to maximize the survival of capercallie in the long term.

New health hazards arising from global change in mountain ecosystems

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DANIELE ARNOLDI
HEIDI C. HAUFFE
DUCCIO ROCCHINI
ROBERTO ROSÀ
CHIARA ROSSI
FAUSTA ROSSO
ANNAPAOLA RIZZOLI

The ecological characteristics of mountain ecosystems are changing rapidly: climate change together with land use changes and biodiversity loss represent an ideal combination of factors enhancing hazards for human and animal health.
In the last few decades, the prevalence of diseases transmitted by wildlife to humans (called 'zoonoses') has been steadily increasing, thanks in part to improved diagnostic techniques (such as molecular screening), but also due to increased exposure of humans to zoonotic pathogens, especially farmers and forestry workers. This increased risk is consequence of higher direct exposure to the pathogen (for example, in the case of rodent-borne diseases which are transmitted through their excreta), or following the bite of a competent vector, such as ticks or mosquitoes carrying viral pathogens. At the same time, the density of rodent and arthropod vectors depends on a combination of biotic and abiotic factors (such as climate and availability of other feeding hosts like deer), and the biodiversity of the entire ecosystem (the higher the diversity of non-competent species, the lower the risk). The case of zoonotic diseases clearly illustrates the now globally-recognized concept of 'One Health'; that is, how human well-being is linked to animal and environmental health.
In this context, rodents and rodent-borne viruses are particularly important. Rodents are a large group of mammals that play an important role in forest and agriculture ecosys-

tems. They are also key reservoirs of many zoonotic pathogens, such as tick-borne encephalitis virus (TBEV), Ljungan virus (a candidate virus for several human pathologies), and hantaviruses (causing hemorrhagic fever with renal syndrome with more than 10,000 human cases diagnosed annually in Europe). Our internationally-recognized team of researchers at CRI has studied rodents and rodent-borne diseases for the last two decades, in close collaboration with APSS in Trento and other European colleagues, in order to compare our field and laboratory data from wildlife with that collected by public health authorities. Our studies have revealed the circulation in the Province of Trento of two species of hantaviruses, Puumala virus transmitted by the bank vole (*Myodes glareolus*) and Dobrava virus transmitted by the yellow-necked mouse (*Apodemus flavicollis*). Puumala virus is the most diagnosed hantavirus in Europe and infection may cause a mild disease called nephropatia epidemica, while Dobrava virus is considered the most pathogenic European hantavirus with a case fatality rate up to 12%. So far, we have detected these hantaviruses in both voles and mice in the Province of Trento, and our long-term monitoring shows that the number of rodents carrying the virus has increased through time, as well as geographically, augmenting the risk to humans. In fact, our serological screening of humans, in collaboration with APSS, has also revealed an increase in exposure of humans to of both hantaviruses in the last decade. However, we must emphasize that, up to now, no clinically documented cases of hantavirus illness have ever been reported in the Province of Trento or in Italy thus far. Nonetheless, our data suggest that the situation is evolving and that continued monitoring is necessary to keep medical practitioners and public health authorities abreast of disease risk, so that they may act accordingly. As well as hantavirues, we are also monitoring the prevalence of TBEV: in this case rodents favour the maintainance of the main reservoir of this flavivirus, the tick *Ixodes ricinus*. However, TBE can also be transmitted by raw milk, so we are also shifting our attention to this potential mode of infection. In addition, a project led by the APSS on the association of rodent-borne Ljungan virus with type 1 diabetes (T1D) in the Province is currently in its final stages; these results are highly anticipated for their possible repercussions on how T1D is perceived and treated.

Finally and most importantly, using field, laboratory, and even satellite data, we are currently developing models that may help the APSS predict disease outbreaks associated with ticks, rodents and mosquitoes so that preventative measures may be put in place.

NEW PROJECTS

ZIKAlliance - A Global Alliance for Zika Virus Control and Prevention

ROBERTO ROSÀ, ANNAPAOLA RIZZOLI

FEM-CRI is part of the international multidisciplinary consortium, recently funded by the European Union, to create a cutting-edge research project to face the recent global Zika virus epidemic. One of the main goals of the project is to implement a research platform capable of establishing early warning systems to face ongoing and future epidemic risks.

A multidisciplinary approach to predict subclinical mastitis risk (MASTIRISK)

HEIDI HAUFFE, MARGHERITA COLLINI , FRANCESCA ALBONICO, MATTIA MANICA, DAVIDE ALBANESE, LUCA BIANCO, CLAUDIO DONATI, ELENA FRANCIOSI, MATTEO KOMJANC, ERIKA PARTEL, ANGELO PECILE, ANNAPAOLA RIZZOLI, KIERAN TUOHY, ROBERTO ROSÀ

The MASTIRISK project, funded by the Fondazione CARITRO, in collaboration with the Federazione Provinciale Allevatori, will use metagenomics and statistics to develop new tools to help prevent mastitis in dairy cows. The main goal is to render these tools cost-efficient, so that they may eventually be offered to dairy farmers as a kit or service, with the aim of improving their net income.

CALICE: Calibrating Plant Biodiversity in Glacier Ice

ANTONELLA CRISTOFORI, CRISTIANO VERNESI

The CALICE project, just funded by the Euregio Science Fund, aims at reconstructing plant biodiversity and its trend archived in the first 40 m of the Adamello glacier ice. The ice core, retrieved during the 2016 POLLiCE campaign, will be analyzed for pollen and environmental DNA content and biodiversity estimates obtained by these proxies will be validated by historical biodiversity assessments on the catchment area on the last five decades.

HIGHLIGHTS

POLLiCE (POLLen in the iCE): biodiversity changes revealed by Adamello glacier ice cores

ANTONELLA CRISTOFORI, CRISTIANO VERNESI

POLLiCE aims at estimating plant biodiversity changes in the last centuries, by DNA metabarcoding of pollen and leaves trapped in Adamello glacier ice cores. It is the largest and deepest Italian glacier, being a complete and effective climate and biological archive, severely threatened by climate change. A middle core (45m), was retrieved in 2016, and will be analyzed under the CALICE project (see highlight CALICE).

LEXEM PROJECT facing the invasion of invasive alien species

ANNAPAOLA RIZZOLI, ROBERTO ROSÀ, GIANFRANCO ANFORA, CLAUDIO IORIATTI

The LExEM project, started in 2014, focuses on the production of new strategic knowledge and innovative tools useful for supporting decision-making procedures in the field of risk assessment, prevention, mitigation and control of some Invasive Alien Species (IAS), including their transmitted pathogens. These IAS have a heavy impact on human, animal health and fruit production. Financed by the Autonomous Province of Trento and coordinated by the Fondazione Edmund Mach, the project includes several national and international research institutes and cooperates with the World Health Organization and the European Center for Disease Prevention and Control.

ClimClass: assessing climatic and bioclimatic indices by an R Open Source library

EMANUELE ECCEL, EMANUELE CORDANO, FABIO ZOTTELE, GIAMBATTISTA TOLLER

Starting from precipitation and temperature data series, package ClimClass was built to calculate climate indices. It includes the popular Köppen – Geiger's climate classification and the main aridity and continentality indices known in the literature. Furthermore, it implements the calculation of viticultural bioclimatic indices and a simplified model for soil water balance.

POSTCARD FROM THE WORLD

From Fondazione Edmund Mach to Harvard, and return!

FRANCESCA CAGNACCI

I walk down the long aisles of the Harvard Museum of Comparative Zoology, joining the Herpetology Section Open day, reserved to Harvard scholars. The MCZ conservators illustrate the collections with enthusiasm and competence: 'The red ribbons indicate the new species identified at MCZ'. Cabinets show a continuum of red ribbons. 'This Giant Tortoise shell from Galápagos is carved underneath with an inscription that was used as 'shipping document'. It reads: "exported by Charles Darwin on the Beagle" '. I have spent one year at Harvard as the 2015-2016 recipient of the prestigious 'Sarah and Daniel Hrdy Fellowship' in Conservation Biology. Living Harvard means harmonize a consolidated tradition with the uttermost advanced innovation. I have done my research in the Organismic and Evolutionary Biology Department, where Edward O. Wilson is Emeritus, Louis Agassiz founded the Evolutionary Biology Library, and Ernst Mayr wrote his masterpieces. A Department that has also hugely advanced the understanding of cognitive processes, or contributed the world with the first evidence of iron bacteria symbiotic communities in the vents of the mid-Atlantic rift, a parallel world without light nor oxygen. In the same historical building, the just renewed Harvard University Centre for the Environment gathers scholars across Faculties and Departments to address the urgent challenges imposed by climate change and habitat degradation from every perspective: ecosystems, economics, politics and policy. Teaching the College students of one of the very Top Score Universities in the world implied a continuous and intense 'search and research' of motivations and stimuli able to inspire a group of young people that, with high probability, will have the opportunity to change the world for real. What about Italy, then? What is the future of young students relying on the experience of the few ones that had the opportunity and luck to make of scientific research their professional life, in a Country resilient to invest on innovation and acknowledge the social role of research? I asked myself these questions on my way back to San Michele, thinking of how to transfer to the Fondazione Edmund Mach the baggage of experiences and opportunities I was exposed to in Harvard. It is what I have accomplished in Trentino, at FEM, that after all led me to such an important award!

Daily obstacles are numerous, and negative or dismissing messages from the general context do not spur motivation. Despite the difficulties, though, we should go back to trust our long-standing cultural tradition of excellence and creativity as a powerful tool to inspire, innovate and improve the quality of life and respect of the environment. We should not give up and keep 'spreading the mentality' (locally, regionally, internationally) to rely on scientific knowledge as the ineludible stepping stone to address the changing dynamics of the Planet. The Research and Innovation Centre at Fondazione Edmund Mach can be, and should be, a working lab of this endeavor.

FACTS AND FIGURES

SELF-FUNDING, PATENTS, IMPACT-FACTOR PUBLICATIONS

Gross self-funding capacity 2015-2016:

€ 5.019.177,28

33 projects with an overall amount of € 2.950.000,00

In 2015-16, 128 contracts were signed, for a total amount of € 2.069.177,28. Contracts were signed with major food companies, wineries, national and international fruit and other private and public entities.

Patents

N. 7 registered patents

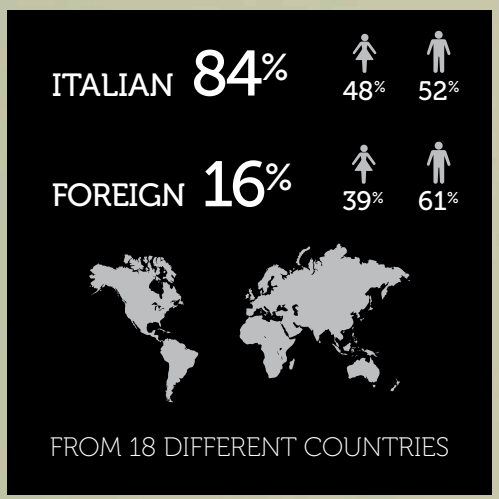
Articles published in scientific journals

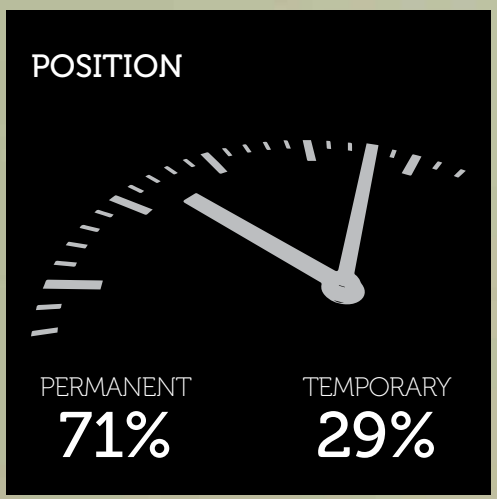
2015-2016

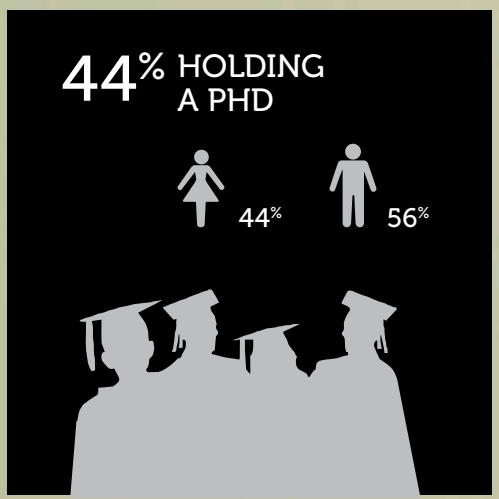
421

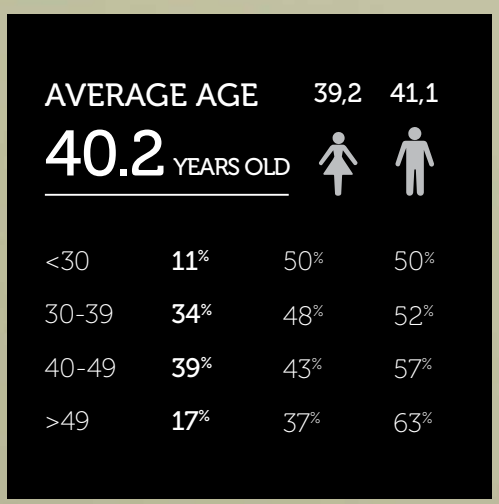
STAFF

AT 31/12/2016









MAIN EVENTS ORGANIZED BY CRI

2015-2016

5 big events
1.850 people involved

Abstract submitted
more than 700

26 seminars

10 educationals

13 dissemination events
20.000 people involved

In 2015 and 2016, about 60 registered events were organized by CRI alone or in collaboration with partner institutions. Here is a brief outline of the major initiatives, divided by category, together with a very concise overview of the main results achieved.
Five big events with an overall participation of 1.850 people. An amount of 26 seminars and 10 educational initiatives dedicated to PhD students and researchers careers' and expertise: specialist courses, workshops and summer/winter schools. Finally, 13 dissemination events that engaged the non-expert public and citizens and saw the participation of about 20.000 people.

Kudos to all our supporters, staff and volunteers who helped us last two years!

ORGANIZATION CHART 2015/2016

A

Agostini Romina, Ahrar Mastaneh, Ajelli Matteo, Albanese Davide, Albonico Francesca, Algarra Alarcon Alberto, Andreo Veronica Carolina, Anfora Gianfranco, Angeli Andrea, Aprea Eugenio, Arapitsas Panagiotis, Arnoldi Daniele, Asquini Elisa.

B

Bagnara Maurizio, Baldacchino Frederic Alexandre, Baldi Paolo, Barakova Ivana, Barbaro Enrico, Barelli Claudia, Bastiaanse Heloise Sophie, Bastien Geraldine Liliane, Battistel Gian Antonio, Battocletti Ivana, Bergamaschi Matteo, Betta Emanuela, Bianco Luca, Biasioli Franco, Bontempo Luana, Boscaini Adriano, Bozzi Emiliano, Brilli Matteo, Bruno Maria Cristina, Bull Matthew John, Busatto Nicola, Buti Matteo.

C

Cagnacci Francesca, Calliari Valentina, Camin Federica, Campbell-Sills Hugo, Campisano Andrea, Capelli Camilla, Cappelletti Valentina, Cappelli Anna, Cappellin Luca, Carafa Ilaria, Carli Josè, Carlin Silvia, Carotenuto Federico, Caset Marisa, Castellani Cristina, Cattaneo Alberto Maria, Cattani Andrea, Cavagna Mauro, Cavalieri Duccio, Cavazza Agostino, Ceppa Florencia Andrea, Cerasino Leonardo, Cervantes Gonzalo Ricardo, Cestaro Alessandro, Charles Mathilde Clemence, Chincarini Roberto, Chini Isaac, Chitarrini Giulia, Cieplinski Adam, Clementi Silvano, Colla Elisa, Collini Margherita, Colombo Monica, Conter Luigi, Costa Fabrizio, Costantini Laura, Covelli Laura Tiziana, Crava Maria Cristina, Crestanello Barbara, Criscuoli Irene, Cristofolini Fabiana, Cristofori Antonella, Csikasz Nagy Attila.

D

Dalla Costa Lorenza, Dallago Chiara, Dalponte Michele, De Filippo Carlotta, De Groeve Johannes, De Marchi Fabiola, Delucchi Luca, Deromedi Marco, Di Bella Emanuele, Di Gangi Iole Maria, Di Guardo Mario, Dolzani Chiara, Donati Claudio.

E

Eccel Emanuele, Emanuelli Francesco, Emeriewen Ofere Francis, Endrizzi Isabella, Engelen Kristof Arthur, Esposito Elisabetta.

F

Fambri Letizia, Farneti Brian, Fava Francesca, Feller Antje Christin, Fevola Cristina, Fietta Alice, Filippi Raffaele, Flaim Giovanna, Fontana Paolo, Fontanari Marco, Fracaro Francesco, Franceschi Pietro, Franciosi Elena, Franzoi Alessandro, Frizzera Lorenzo, Frizzi Andrea, Fu Yuan.

G

Gandolfi Andrea, Garzon Lopez Carol Ximena, Gasperi Flavia, Ghaste Manoj Shahaji, Gianelle Damiano, Gillingham Emma Louise, Giongo Lara, Giordan Marco, Giovannini Oscar, Girardi Matteo, Goremykin Vadim, Gottardini Elena, Gramazio Tiziana, Grando Maria Stella, Gretter Alessandro, Grisenti Michela, Guidi Claudia.

H

Haile Zeraye Mehari, Hauffe Heidi Christine, Herrera Valderrama Andrea Lorena.

I

Iversen Daniel.

K

Kandare Kaja, Kaur Rupinder, Kerschbamer Emanuela, Khomenko Iuliia, Komjanc Matteo, Koutsos Athanasios, Kreisinger Jakub.

L

La Porta Nicola, Larger Simone, Lazazzara Valentina, Leida Carmen Alice, Lello Joanne, Lenti Paolo Francesco, Lenzi Luisa, Leonardelli Elisabetta, Leonardi Gino, Leontidou Kleopatra, Lewke Bandara Nadeesha, Li Mingai, Linsmith Gareth, Loche Alessia, Lona Emma, Longa Claudia Maria Oliveira, Lopez Fernandez Juan Sebastian, Lorenzi Silvia, Lotti Cesare.

M

Magnago Pierluigi, Maiolini Bruno, Makhoul Salim, Malacarne Giulia, Malnoy Mickael Arnaud, Mancini Andrea, Marcantonio Matteo, Marchesini Alexis, Marcolla Barbara, Marin Floriana, Marini Giovanni, Marrano Annarita, Martens Stefan, Martinatti Paolo, Masuero Domenico, Mattivi Fulvio, Mazzoni Valerio, Metz Markus, Micheletti Diego, Micheli Susanna, Miglietta Franco, Min Min Thaw Saw Nay, Minoli Lucia, Molinatto Giulia, Montanari Sara, Moretto Marco, Mosca Elena, Moser Riccarda.

N

Nagamangala Kanchiswamy Chidananda, Narduzzi Luca, Nesler Andrea, Neteler Markus Georg, Nicola Lidia, Nicolini Daniela, Nieri Rachele, Nikiforova Svetlana, Nissen Lorenzo, Nwafor Chinedu Charles.

O

Obertegger Ulrike, Ometto Lino, Ossi Federico.

P

Padmarasu Sudharsan, Paieri Francesca, Palmieri Luisa, Paolini Mauro, Pareeth Sajid, Parisi Veronica, Pascoe Emily Louise, Pasini Luca, Paternoster Genny, Pavarini Lorenzo, Pavlovcic Petra, Pedrotti Michele, Perazzolli Michele, Perenzoni Daniele, Peressotti Elisa, Perini Elisabetta, Perkins Sarah Elizabeth, Pertot Ilaria, Pessina Stefano, Peters Wibke Erika Brigitta, Piazza Stefano, Pighini

Sylvie Florence Anne Laure, Pilati Stefania, Pindo Massimo, Pironti Arturo, Pizzini Ilaria, Polajnar Jernej, Poles Lara, Poletti Valentino, Poli Michele, Pollastrini Martina, Pozzi Carlo Massimo, Prada Germano, Prasad Mridula, Prazzoli Maria Lucia, Pullens Johannes Wilhelmus Maria, Puopolo Gerardo.

R

Rafique Muhammad Zubair, Ramasamy Sukanya, Ranc Nathan Geoffrey, Ress Lorena, Reyes Francesco, Riccadonna Samantha, Rizzetto Lisa, Rizzoli Annapaola, Rocchini Duccio, Rodeghiero Mirco, Rosà Paola, Rossi Carlo, Rossi Stacconi Marco Valerio, Rosso Fausta, Rota Stabelli Omar, Rubert Bassedas Josep Vicent.

S

Sakowska Karolina, Salmaso Nico, Salvagnin Umberto, Samad Samia, Sargent Daniel James, Savoi Stefania, Scholz Matthias Uwe, Segarra Braunstein Guillem, Shams Shiva, Si Ammour Azeddine, Sicher Carmela, Simoni Marco Claudio, Soini Evelyn, Sonego Paolo, Sordo Maddalena, Stefani Erika, Stefanini Irene, Surbanovski Nada.

T

Tadiello Alice, Tagliapietra Valentina, Tait Gabriella, Tarter Milva, Tattoni Clara, Ting Valentina, Tocci Noemi, Toccoli Silvia, Tolotti Monica, Tomasi Tiziano, Tonazzolli Giorgio, Tonon Agostino, Trapin Eleonora, Troggio Michela, Trost Kajetan, Tudoroiu Marin, Tuohy Kieran Michael, Ulaszewska Maria Malgorzata.

U

Ulaszewska Maria Malgorzata.

V

Vaggi Federico, Valentini Chiara, Van Leeuwen Katryna Agatha, Varotto Claudio, Velasco Riccardo, Velikova Violeta Borisova, Vernesi Cristiano, Vescovo Loris, Vezzulli Silvia, Viola Roberto, Vishwanath Vinay, Vrhovsek Urska.

W

Weil Tobias Franz Anton Ludwig, Whitener Margaret Elizabeth Beckner.

Y

Yener Sine, Yu Xiaoguang.

Z

Zagari Nicola, Zambanini Jessica, Zampedri Roberto, Zanon Flavia, Zanotelli Livia, Zatelli Alessandra, Ziller Luca, Zorer Roberto, Zulini Luca.

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