

RESEARCH AND INNOVATION CENTRE

# REPORT

2013/2014

AGRICULTURE  
FOOD  
ENVIRONMENT



FONDAZIONE  
EDMUND  
MACH

CENTRO RICERCA  
e INNOVAZIONE



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# PRESENTATION



Mauro Fezzi  
General Director of FEM

Andrea Segré  
President of FEM

Roberto Viola  
Director of Research and Innovation Centre

.....

During its 144 year history, the Fondazione Edmund Mach has contributed to the improvement of agriculture and viticulture in Italy. This citadel of agriculture, with research, education, consulting and wine production, is a unique institution not only in Italy, but perhaps globally.

A thousand students, 250 researchers, 150 technologists and a hundred teachers constitute the formidable wealth of know-how of the Fondazione Edmund Mach which, thanks to its human resources, has reached important goals at an international level. Always with an eye towards the future, but without losing sight of its roots, we maintain high international standards with more than 200 publications per year and 44 university teaching qualifications of first and second level.

I think that advanced research and technical consulting are the two souls that can and should live together, combining excellence in research at San Michele all'Adige with technical solutions catering to the needs of Trentino agriculture, with the common goal of contributing to a sustainable Trentino region.

*Andrea Segré*  
President  
Fondazione Edmund Mach





# FOREWORD

In the five years since its constitution in 2009, the Research and Innovation Centre (CRI) of the Fondazione Edmund Mach (FEM) has been able to consolidate itself as one of the best agro-food and environmental research centres in Italy. This was possible because FEM is a powerful example of a functioning “knowledge triangle” - excellence in science, education and innovation.

Scientific excellence at FEM has received an independent validation by the Agency for the Evaluation of National Universities and Research Institutes (ANVUR). The results, published in 2013, have seen the Departments of CRI ranked first place for non-academic research institutions in Chemistry and Agriculture and fourth place in Biology. The National Scientific Qualifications (ASN), also conducted by ANVUR in 2012, led to a further recognition of the scientific quality of CRI researchers with seven Full Professor and 37 Associate Professor certifications awarded.

This documents the scientific quality reached by the CRI staff, presently consisting of about 200 employees and collaborators, which are joined by a large community of “staff in formation”. A hundred of them are students of FIRS>T, our research school, as well as undergraduates, trainees and interns. A young community, with an average age of 36 years, cosmopolitan, with more than 25% of the members from more than 40 countries. In 2013-2014 the research community has published over 370 articles with Impact Factor in ISI scientific journals and 700 non-ISI articles.

A community perfectly adapted to the history of FEM. A unique institution with a strong international propensity and focused on three major themes that strongly characterize our land: agriculture, food and environment. In addition to its scientific endeavour and the dissemination of expertise, the Centre has also distinguished itself for its ability to develop innovative products such as new genotypes and varieties of grapes and fruit trees developed in our breeding programs and supported through an innovation consortium promoted by FEM. Furthermore, during 2013-14 the intellectual property portfolio held by FEM was integrated with 7 new patent deposits. Finally, the Centre continues to represent for local companies, organizations and agricultural associations a centre of excellence and expertise as shown by 65 industrial and cooperative research projects.



*Roberto Viola*  
Director of Research and Innovation Centre  
Fondazione Edmund Mach



# Fondazione Edmund Mach



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 organisation 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.

## The Research and Innovation Centre



Since 2008 the Experimental station has had a new organisational structure and is now known as the Research and Innovation Centre (CRI). Originally, it was organized in specialised research Areas covering the fields of Agriculture, Food and the Environment. In January 2011, a new organizational restructuring concerned the Centre, and resulted in a new arrangement based on a Research consortium (in participation with the National Research Council) and five Departments, which in turn are organized in Research Groups and Technological Platforms. CRI research focuses on: genetics and genomics of fruit plants, agri-food and nutritional quality, biodiversity and molecular ecology, sustainable agro-ecosystems and bioresources, and computational biology. These research areas were selected to meet the interests and needs of local economy. A brand new Campus with 200 m<sup>2</sup> 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 internationally-recognised results.

# FIRS>T

## FEM International Research School

The FEM International Research School (FIRS>T) was initiated by the joining of the Genomics and Molecular Physiology of Fruit Network (GMPF) with training activities in other strategic fields of action: agro-biosciences, food biosciences, ecology, agro-biology, eco-biology etc. Since its creation, FIRS>T has emerged as one of most ambitious and innovative initiatives launched by CRI in the last years.

Until 2013, the scope and number of FIRS>T activities has progressively expanded, with the selection and recruitment of a growing number of doctoral students. In 2013, FIRS>T also launched a collaboration with the Università di Udine for the joint accreditation by ANVUR of a doctoral programme on Agricultural Science and Biotechnology.

This suspension offers the oppor-

tunity for an examination of FIRS>T activities and performance. FIRS>T proved to have an essential role in boosting research excellence within the Fondazione. Its role in the selection of most innovative CRI research proposals and of most competitive young talents, and the support provided by the scholarship programme have played a fundamental role in this regard. Indeed, since its creation, FIRS>T has selected and supported about 115 pioneering research projects proposed by CRI researchers. Through the recruitment of young researchers from all over the world, and by putting in contact CRI research groups with national and international institutions, moreover, FIRS>T has played a key role in the internationalization of CRI. In 2013-2014, FIRS>T has supported young researchers from 5 continents, and

## FEM CAMPUS

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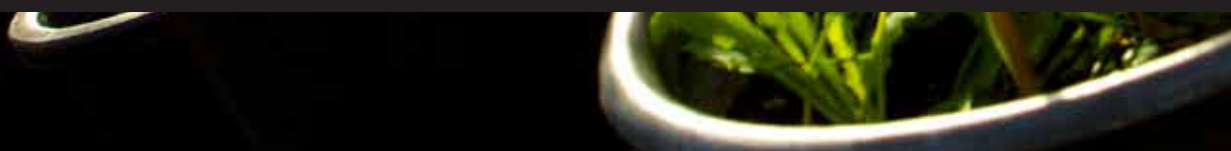


of 20 different nationalities. These young researchers have been enrolled in the doctoral programmes of more than 50 different partner institutions. In addition, by favoring the turnover of young researchers, FIRS>T has ensured an enduring inter-generational exchange among CRI researchers.

More than anything else, in conclusion, it is the growing number of former FIRS>T scholarship holders who have joined CRI research groups or have been recruited by prestigious institutions that confirms the strategic role of FIRS>T for the future of CRI and the Fondazione.



- 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
- 14 Plant Protection Laboratories





**AGRICULTURE**



## How to develop a biopesticide: new concepts, approaches and technologies

.....  
ILARIA PERTOT  
GIANFRANCO ANFORA  
URSKA VRHOVSEK

In the last decades concerns have been raised on the negative impact of synthetic chemical pesticides on humans and environment. As a result of that the European Union has adopted a new directive (2009/128/EC), which establishes a framework to achieve a sustainable use of pesticides. On the other hand, a strict regulation exists on the maximum level of residues of pesticides on food and plant protection products should be registered according strict guidelines. In addition, some active substances of particular concern to public health or the environment have been identified with the objective of being replaced by more suitable alternatives over time. This context has pushed science to find safer tools to control pest and pathogens

of crops. A new generation of plant protection products is going to born and replaces in the coming years several synthetic chemical pesticides. FEM has a long experience in developing eco-friendly and low impact plant protection solutions. Thanks to that the Province of Trento was one of the first regions in the world to adopt technologies as pheromone mating disruptions in its farms to replace insecticides. A biopesticide is a plant protection product based on molecule(s) that exist in nature or microorganisms and/or their metabolites. Currently FEM has an innovative pipeline for the development of the new generation of biopesticides, which are characterized by high innovation and technological content compared to the



previous one. The new compounds are selected with a targeted high throughput approach (i.e. among endophytes or by-products from edible plants) among botanical extracts and rare natural compounds extracted or produced with industrial processes and beneficial microorganisms/their metabolites obtained in fermenters. Candidate beneficial microorganisms are identified and their genome is sequenced to exclude pathways resulting in metabolites of concern and characterize their mechanism of action. The botanical extracts are characterized by chromatographic

and spectroscopic profiles (chemical fingerprint) and the extraction processes are optimized based on the identified active molecule(s). Because most of these new generation biopesticides are quickly degraded in the natural environment the combination with specific protective compounds is customized based on the nature of the ingredient. The new generation of biopesticides is expected to provide growers with powerful, but safe, tools to protect their crops.

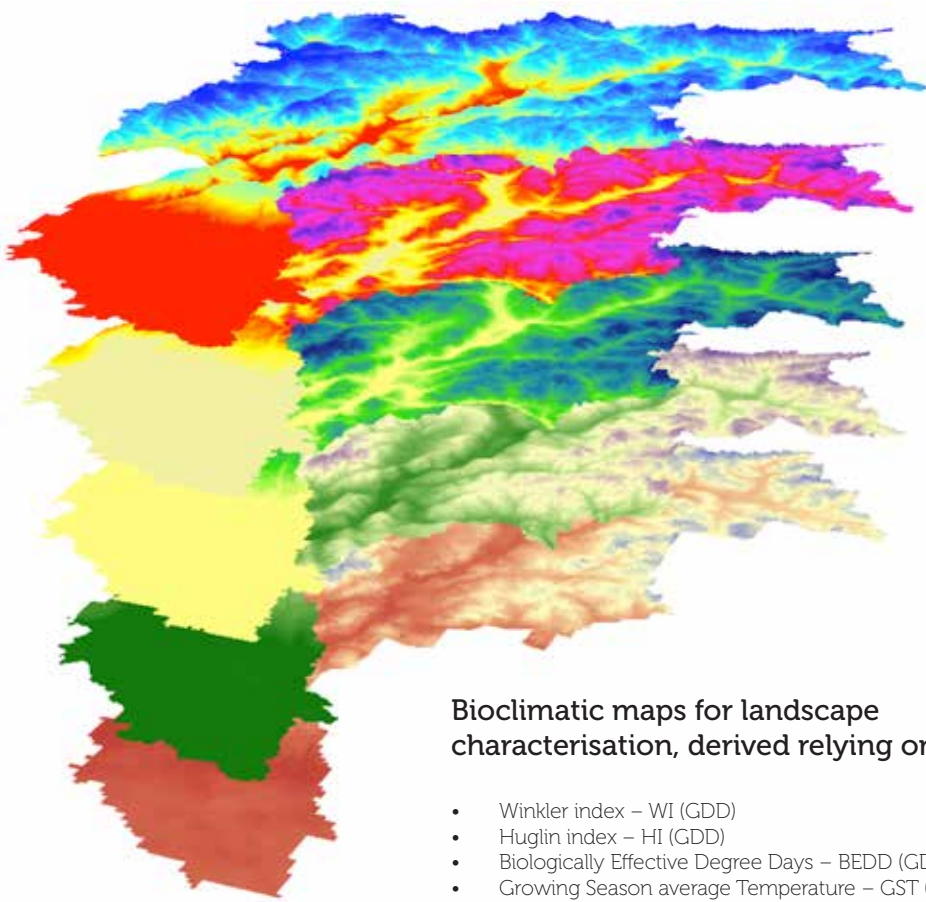
## 30.000 possible numbers to dial: understanding how grape phenotype is shaped by its genes' behavior

The grapevine (*Vitis vinifera*) genome has been sequenced for some time, but exactly how it determines phenotypic variation remains an open question. With around 30.000 genes in its genome, there's a staggering complexity of how grapevine physiology can be altered in response to its environment: 30.000 knobs that can be dialed to turn genes' "expression" up or down. Measuring the behavior of thousands of genes in parallel, using technologies as RNA-seq or microarrays, is a staple of systems biology and the analysis of such data has been central in computational biology and bioinformatics. There is enormous potential in such transcriptomics studies, but they are usually very specific and isolated, and their results not trivial to reconcile. Using the proprietary COLOBOS framework, we have been able to integrate all grapevine transcriptomics data sets available around the world, combining experiments for almost 2000 different samples. In a joint effort of several research groups at CRI-FEM, all of these samples were also comprehensively annotated using a controlled vocabulary of 'condition properties', which was specifically

developed for grapevine in-house. Unlike the cryptic, non-standardized descriptions accompanying the publications of the original experiments, this enables computational comparison and automatic organizing of samples and has the potential of revealing the input-output relationships that drive the expression responses of genes to specific biological stimuli. This unique grapevine "gene expression compendium" is now helping us elucidate gene expression coordination at a genome-wide level. It is helping us to prioritize roles for genes with previously unknown functions, and is generating a deeper understanding of how the concerted behavior of grapevine's 30.000 genes shape the plant's physiology, development, and responses to its environment. The *Vitis vinifera* expression compendium is available through a web application at [vitis.colombos.fmach.it](http://vitis.colombos.fmach.it), and includes an extensive tool suite to explore, analyze and visualize the data.

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KRISTOF ENGELEN  
MARCO MORETTO  
PAOLO SONEGO  
LAURA COSTANTINI  
GIULIA MALACARNE  
STEFANIA PILATI  
CLAUDIO MOSER  
LUKASZ GRZESKOWIAK  
STELLA GRANDO  
DUCCIO CAVALIERI



**Bioclimatic maps for landscape characterisation, derived relying on open data**

- Winkler index – WI (GDD)
- Huglin index – HI (GDD)
- Biologically Effective Degree Days – BEDD (GDD)
- Growing Season average Temperature – GST (°C)
- Cold night Index – CI (°C)

## Application of open-source software and data for agriculture

ROBERTO ZORER  
 LUCA DELUCCHI  
 MARKUS METZ  
 DUCCIO ROCCHINI  
 AMEDEO FADINI  
 CLAUDIO FLORETTA  
 MARKUS NETELER

Geographic Information Systems (GIS), new applications for mobile devices (tablets and smartphones) and *open-data* nowadays provide technicians and farmers with new methods to study the particular vocation of the territory and to support the selection of appropriate crops and varieties. Most detailed studies concern viticulture but the approach can be extended to other types of cropland. For viti-viniculture, the guidelines for zoning methodologies on a soil and on a climate level have been defined and adopted by the international organisation of vine and wine (OIV-VITI Resolution 423-2012 REV1; OIV, 2012) following the definition of terroir. The characterization of the viticultural landscape is based on geographic

layers (elevation, slope, aspect, orographic profile, potential sun-hours, etc.) and bioclimatic indices (Huglin, Winkler, Gladstones, Fregoni, Growing Season average Temperature - GST, Cold night Index, CI, frosts and heat wave risk, etc.), introduced since mid '900 and based on the calculation of heat indexes during the vegetative period and taking into account the optimal temperature for the development of the vines and for the ripening of the grapes.

Jones et al. (2004) describe the suitability of the landscape for grapevine as the combination of topographic features, soil type, land use constraints, and, finally, bioclimatic conditions.

Following this approach, the increasing availability of open GIS software

and remote sensing data makes it possible to study the vocation of the territory globally and with high spatial resolution.

PGIS featured two regions in North-East Italy and the neighbouring territories of Slovenia within the P.I.C.A. project ([pica.cavit.it](http://pica.cavit.it)) and WineNet, a cooperative network to improve wine quality along the pro-

duction chain using innovative solutions, funded under the cross-border cooperation programme Italy-SLOVENIA 2007-2013 ([sites.google.com/site/progettowinenet](http://sites.google.com/site/progettowinenet)).

## Modern breeding on fruit crops

Since the release of the genome sequence assemblies of grape, apple and strawberry, a revolution has been taking place in the way fruit crop breeding is performed. This revolution has only been possible thanks to the genome sequences and the downstream tools that have been developed using them. For example, apple genome sequence data has been used by scientists working at FEM, and their collaborators, to develop high throughput genotyping arrays containing many thousands of (in some cases up to half a million) DNA markers known as single nucleotide polymorphisms (SNPs) which allow rapid and detailed characterisation of the chromosomes of individual varieties and their offspring. The complete chromosome characterization of the germplasm collection at FEM using these markers has permitted the initiation of genome wide association studies (GWAS) which are moving towards the association of many of these SNPs and agronomically important differences in the phenotype of the varieties studied.

This approach, together with standard QTL mapping, is leading to a detailed understanding of which markers in particular are inherited with particular traits, most notably fruit quality and disease resistance. This is enabling the breeders at FEM, and their contemporaries around the world, to identify superior seedlings from breeding crosses carrying

these traits whilst they are still in the seed tray.

Additionally, knowledge of the genome, the locations of genes and specific SNPs associated with them has permitted the identification of causal genes for both fruit quality and disease resistance, amongst other characters. Knowledge of the controlling genes gives a far greater degree of precision in the breeding and selection process. These enabling technologies and the research they are facilitating at FEM has led to fundamental changes in the way breeding is performed, with no seedling being planted in FEM fields without first being screened with a panel of markers. This process is leading to savings in time and costs in the breeding pipeline, and a far greater proportion of superior seedlings planted from which to select the sustainable varieties of the future.

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RICCARDO VELASCO  
DAN SARGENT  
FABRIZIO COSTA  
MICHELA TROGGIO

# HIGHLIGHTS

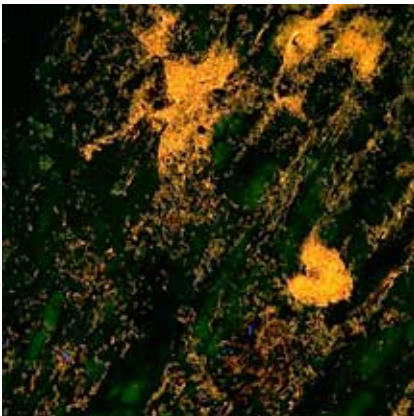


## Molecular control of cell and organ size in plants

.....

ATTILA CZIGAS-NAGY, AZEDDINE SI AMMOUR

We developed a bioinformatics tool that collects evolutionarily conserved proteins described as cell size regulators in genome-wide studies. The tool allowed us to identify a core conserved cell size regulatory network and predict novel cell size regulators for experimental tests.



## From root to fruit: metagenomics of the endophytic communities in grapevine

.....

CLAUDIO DONATI, DAVIDE ALBANESE, ANDREA CAMPISANO, ILARIA PERTOT

Plants are in constant interaction with a complex microbial community that influences all phases of their life cycle. Metagenomics allows us to study these communities and highlights how in turn they change under the influence of the environment.



## Plant - pathogen communication by volatile organic compounds in apple and grapevine

.....

LUCA CAPPELLIN, VALENTINA LAZAZZARA, ALBERTO ALGARRA ALARCON, PIER LUIGI BIANCHEDI, ILARIA PERTOT, FRANCO BIASIOLI, MICHELE PERAZZOLLI

Volatile organic compounds (VOCs) play a major role in the plant defense responses. We identified specific VOCs emitted by apple and grapevine plants upon insect and pathogen attacks. Our results are the basis for developing innovative molecules for a sustainable control of plant pathogens.

## Identification of apple-pear hybrid and the potential in pome fruit breeding

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MICKAEL MALNOY, LUISA PALMIERI, STEFAN MARTENS

Hybrids of apple and pear have been bred and described. Unlike these reports, an offspring of five F2 plants from maternal plant are meanwhile flowering and regularly set fruits. These vital and fertile hybrids offer the opportunity to combine various parts of the genomes by classical breeding.



## Grape berry transcriptome dynamics associated with seed development

---

CHINEDU CHARLES NWAFOR, RON WEHRENS, MARIA STELLA GRANDO, LAURA COSTANTINI

Transcriptome comparison of a seeded grape variety and its seedless somatic variant highlighted significant differences in gene expression during berry development and provided a rich genomic resource for characterization of genes that potentially underpin seedlessness in grapevine.



## New Breeding Technology for fruit crops

---

CHIDANANDA NAGAMANGALA KANCHISWAMY, RICCARDO VELASCO, CLAUDIO MOSER, MICKAEL MALNOY

Commercialization of GMOs is hindered by numerous regulatory and social hurdles. We are currently developing next generation genome editing tools for fruit crop improvement. These tools will permit the insertion, modification or mutation of genes of interest without involving foreign DNA.







FOOD



## Stable isotope ratios of wine vs climate and geography of the production area

FEDERICA CAMIN  
RON WEHRENS  
MARKUS NETELER

The stable isotope ratios measured in wine are those of H (D/H) analysed site-specifically in the methylic and methilenic site of ethanol: (D/H)<sub>1</sub> and (D/H)<sub>2</sub>, the ratio of carbon (<sup>13</sup>C/<sup>12</sup>C) in ethanol and that of oxygen (<sup>18</sup>O/<sup>16</sup>O) in water. They have been analysed in wine since 1987 to determine fraud, such as sugar addition or chaptalisation, watering down and mislabelling, i.e. false declarations of origin. The variability of these isotopic ratios is indeed related to the botanical origin of the sugar (grape, cane or beet) and to the climatic and geographical characteristics of the area where the

plant grows. The relationship between the isotopic data of wine and physical variables describing the climate and geography of the production area is an interesting topic, as reflected in the high number of related papers published in the last 20 years. However, only a few of these studies considered a large number of samples and more than one isotopic ratio, and none took into account a high number of physical variables which could influence the isotopic values of wine.

In this study, we considered around 4.000 Italian wine samples produced



all over Italy in 11 consecutive years from 2000, the four isotopic ratios and a large number of potentially influential factors reflecting the geography and climate of the production locations, i.e. date of harvest, latitude, longitude, elevation, distance from the sea, amount of precipitation, maximum, minimum and mean daily temperature, the isotopic ratios of O and H of precipitation, which are analogous to those of soil water and thus of source of grape water.

Exploratory visualisation tools, regression analysis and linear modelling were used in our study to investigate

the most significant relationships and define multivariate models able to infer isotopic values from climatic and geographical data.  $^{18}\text{O}/^{16}\text{O}$ , followed by  $(\text{D}/\text{H})_1$ , was shown to have the strongest relationship with climate and location. The dominant variables were latitude, with a negative relationship, the isotopic ratios of O and H of precipitation and temperature, both with positive relationships.

The identified correlations and models could be used to predict the isotopic composition of authentic wines, offering increased possibilities for detecting fraud and mislabelling.

## Diet-microbe interactions in the gut underpinning human health and nutrition

The gut microbiota is now emerging as an important metabolic and immunological organ in its own right, implicated in chronic age-related disease. The Nutrition and Nutrigenomics (NN) Group at FEM has recently performed a human dietary intervention at the University of Reading, UK, showing that eating 2 apples (Renetta Canada) /day for 8 weeks can reduce the risk of heart disease. Our *in vitro* experiments are providing new insight into the impact of other fruits (strawberries and raspberries) on gut microbiota. We are also conducting a randomized controlled trial in local volunteers measuring the impact of a dietary fiber on gut microbiota composition and metabolic activity and how this then impacts on markers of heart disease risk. We have isolated probiotic strains from local Trentino dairy products, including a strain producing high levels of the neurotransmitter gamma-aminobutyric acid (GABA), an important signalling role along the gut:brain axis and thought to control systemic inflammation. With the University of Padua, we are also looking at how foods which modulate the gut microbiota impact on the gut:liver:brain

axis in people with hepatic encephalopathy, a brain disorder brought on by liver failure. We have also recently shown that fungi isolated from the human gut are phenotypically adapted as commensal microorganisms with implications for conic disease such as Inflammatory Bowel Diseases and are not simply environmental passengers passing through the gut. Our work is confirming the important role of diet in shaping both the composition and metabolic activity of the gut microbiota, and elucidating novel mechanisms through which the gut microbiota impacts on host health and age associated diseases risk. We have recently explored these issues in more detail in the book, "Diet-Microbe Interactions in the Gut", edited by Kieran M. Tuohy (FEM) and Daniele Del Rio (University of Parma), published in 2014 by ELSEVIER.

.....  
KIERAN TUOHY  
CARLOTTA DE FILIPPO



## Discover the origin of flavours: new methods to investigate the dynamics of aroma and taste perception

.....  
MATHILDE CHARLES  
SINE YENER  
FRANCO BIASIOLI  
FLAVIA GASPERI

Flavour is an important food characteristic determined by the release of compounds, which have gustative and olfactive impacts. Being a complex dynamic multisensory process, flavour perception changes during food consumption due to various in-mouth phenomena such as mastication, salivation, breathing and swallowing. To grasp the complexity of flavour perception, dynamic methods are necessary. For this purpose, FEM researchers have proposed the coupling of two time-resolved techniques:

- Temporal Dominance of Sensations (TDS): it is a recently introduced sensory method that describes the evolution of flavour in terms of dominant sensations among a selection of attributes chosen by the panel in relation

with the investigated product;

- *In vivo* nose-space analysis (NS): direct injection mass spectrometry (PTR-ToF-MS) is used to sample the air expired by the panellists during tasting and allows the direct monitoring the volatile compounds that reach the olfactory receptors.

For the first time, these techniques have been simultaneously applied. In addition of the methodological issue, the effects of roasting degree and sugar addition on flavour perception and aroma release in espresso coffee were investigated. Both techniques demonstrated a good assessment of the effect of technological changes: more compounds and in larger quantity were released when increasing roasting

degree. This was described sensorially with different taste and smell sensations. In contrast, the sugar addition did not influence significantly the release of the volatile but changed completely the sensory dynamic description. As expected, taste perception changed but it also induced an increase of flavour complexity and a change in the dominance of different aromatic notes. This result shows the presence of taste-smell interactions due to a congruent effect between sweet taste and some coffee aromas. The study also demonstrates the poten-

tialities offered by the combination of these two techniques in order to investigate sensory perceptual processes. More generally, these techniques allow distinguishing and characterising consumers based on the way they consume and perceive food and can drive the development of tailored products. As a continuity of this study, the extension to other kinds of food is in progress. It was chosen to work on important products for the Trentino region like apples. In that case, the degree of complexity to handle is higher as texture properties and their interactions with flavour perception need to be taken into account.

## Influence of storage conditions on the “chemical age” of red wines

Inappropriate storage of wines is known to shorten shelf life while decreasing wine quality. Putative markers of ageing for red wines stored for two years at two different temperatures (cellar vs. domestic) were investigated using MS-based untargeted metabolomics, and further confirmed by additional metabolite profiling. The results of multivariate analysis clearly showed that wines stored in the cellar changed little even after two years of storage, while wines stored in typical domestic conditions developed approximately 3-4 times faster. Ageing in domestic conditions appeared to promote the polymerization of tannins and of the wine pigments, while inducing an accelerated decrease in native anthocyanins, and specifically promoting the formation of pinotin A-like pigments. The colorimetric measurements showed drastic changes in wines stored in domestic conditions. The wines lost part of their red tones and, even more noticeably, their yellow tones increased during storage. Interestingly, we observed a temperature-dependent pathway involving the addition of bisulfite to the flavanols and leading to the formation of several catechin and proanthocyani-

din sulfonates, along with hydrolysis reactions involving various phenolics, including flavonols. The stereospecific, temperature-dependent sulfonation process of flavanols was reproduced in a model wine system. Two main metabolites, epicatechin 4 $\beta$ -sulfonate and procyanidin B2 4 $\beta$ -sulfonate were structurally elucidated in collaboration with prof. Graziano Guella (University of Trento), using NMR measurements. These compounds, increased in wines aged in domestic conditions, are suggested as novel markers of wines stored at elevated temperature. A take-home message from this study is that the “chemical age” of a red wine stored in domestic conditions could differ from the age written on the label of the bottle: home storage leads to a sort of unwanted “accelerated ageing”, leaving chemical traces which now can be measured.

.....  
FULVIO MATTIVI  
PANAGIOTIS ARAPITSAS  
DANIELE PERENZONI  
ANDREA ANGELI  
GIUSEPPE SPERI

# HIGHLIGHTS



## Authenticity of balsamic and wine vinegar

---

FEDERICA CAMIN, LUANA BONTEMPO, URSKA VHROVSEK

Wine vinegar and Aceto Balsamico di Modena cannot contain acetic acids obtained from synthesis or from the fermentation of beet or cane sugar and cannot be produced from dried grapes diluted with water. We experimentally showed that isotopic analysis is able to detect these frauds.

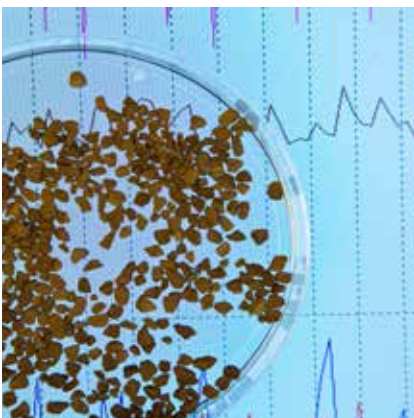


## Improving apple aroma

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LUCA CAPPELLIN, FABRIZIO COSTA, FRANCO BIASIOLI

Fruit flavour is a main driver of consumer appreciation. We used an innovative approach to validate the role of Md-AAT1 as a major gene in the control of flavor in apple. This result will support FEM apple breeding programs in the development of apple varieties with improved flavour.



## Volatile compound fingerprint as a marker of food origin related to sensory quality

---

SINE YENER, LUCA CAPPELLIN, EUGENIO APREA, FLAVIA GASPERI, FRANCO BIASIOLI

The Volatile Compound Facility at FEM applies direct injection mass spectrometry for the rapid and non-invasive assessment of the effect of origin on volatile compound release by agri-food. This allowed identifying origin markers related to perceived quality of, for instance, tea and coffee.

## Grape and wine metabolomics: show me the data!

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PIETRO FRANCESCHI

Mass Spectrometry based metabolomics is revolutionizing grape and wine research. We are committed in making metabolomics data available for the scientific community, contributing to the progress of science and promoting innovation.



## Quantitative metabolic profiling of grape, apple and raspberry volatile compounds (VOCs) using a GC/MS/MS method

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URSKA VHROVSEK, CESARE LOTTI, DOMENICO MASJERO, SILVIA CARLIN, FULVIO MATTIVI

New versatile and selective GC/MS/MS method for metabolite profiling of volatile compounds in apples, raspberries and grapes was developed. The method can be easily extended to volatile compounds in other fruits and can therefore be widely used for profiling studies in the field of fruit aroma.



## Pigmentation "clue" in Yellow Raspberries An Insertion/Mutation in Anthocyanidin Synthase Gene

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MUHAMMAD ZUBAIR RAFIQUE, LUISA PALMIERI, STEFAN MARTENS

Fruit color is an important quality trait in raspberries and other fruit species. Therefore, the prediction of a pathway map for pigmentation in raspberry will be interesting at industrial and agronomical level. A block of the anthocyanin pathway was identified in the yellow variety.







**ENVIRONMENT**



## Health and Global Change: an integrated approach

.....  
ANNAPAOLA RIZZOLI  
DANIELE ARNOLDI  
FREDERIC BALDACCHINO  
FRANCESCA CAGNACCI  
HEIDI HAUFFE  
MARKUS NETELER  
CHIARA ROSSI  
FAUSTA ROSSO  
VALENTINA TAGLIAPIETRA  
ROBERTO ROSÀ

The modern concept of well-being is best defined by the “One Health” initiative, which maintains that human, livestock, wildlife and environmental health are strongly interconnected. In a period of intense socio-economic upheaval and global change, the maintenance and improvement of public health, including food production and security for all, represents a common challenge. Intensive agriculture, industry and other human activities affect natural ecosystem function and the services they normally provide, including protection from parasites and diseases. This is because in highly degraded areas, generalist animal species (i.e. those that can survive in a wide range of habitats, even degraded ones, and often the same that transmit pathogens, such as rodents and insects)

increase and expand; instead specialists (that adapt more slowly, and often feed disease vectors like ticks and mosquitoes but do not transmit disease, like shrews and deer) usually move away or go extinct. Examples of diseases that are increasing due to a loss of such biodiversity include those spreading both globally such as Avian Flu and West Nile Fever, and locally (e.g. we have recently published scientific results showing sharp increases in hantaviruses in small mammals and have shown that land use change has caused an increase in Tick borne encephalitis in humans in northeastern Italy). The “Eco-Health” research team at FEM (part of One Health focusing on the link between wildlife and public health) aims to predict the emergence and spread of zoonotic



diseases in Trentino and in the EU, especially those carried by ticks, mosquitoes and rodents. We develop and apply innovative research tools in animal behavior, molecular screening and remote sensing, with the development of mathematical models and the production of scenarios useful for risk assessment and the identification of mitigation strategies. The team is a partner in numerous networks and EU projects (EDE-Next [www.edenext.eu](http://www.edenext.eu); Eurowestnile [www.eurowestnile.org](http://www.eurowestnile.org); Eurodeer

[www.eurodeer.org](http://www.eurodeer.org); PARACORT, a Marie Skłodowska-Curie fellowship) and leads a laboratory of excellence for epidemiology and modelling (LExEM [www.lexem.eu](http://www.lexem.eu)) as well as an Incoming Team (ECOBIOOME) funded by PAT.

## Genomic approaches for added-value management of wild species

Trentino's wild fauna and flora species play a key and a not replaceable role in providing ecosystem services such as nutrient recycling, water purification, carbon sequestration, pest and disease control and all the so-called cultural services (e.g. ecotourism). It is thus extremely important that we value these species by assessing their genomic diversity. This ultimately gives each species the capacity to cope with climate and land use changes, thus guaranteeing ecosystems functionality.

Adding genomic information help set up more effective management and conservation plans, highlighting well in advance situations of potential risk such as inbreeding and gene flow disruption. The on-going advance in DNA sequencing technologies make it now possible to study the genome of non-model species at reasonable cost and time. Through different approaches (RAD-sequencing, SNP-array, resequencing) we are studying genomic variation at the population level. In our labs, recent and current research is focussing on a wide range of ecologically relevant species from annual plants (columbines) and conifers, to reptiles (common lizard) and birds (capercaillie). Genomic approaches are also useful for species

identification using DNA barcodes to support traditional morphological determination. We are currently characterizing the flora of Trentino with the goals of measuring alpha diversity and providing reliable and easy ways to identify wild plants and their derivatives for the certification of natural products and environmental management. We also make use of high-throughput RNA sequencing to study the transcriptional responses of wild species to environmental stresses in order to pinpoint the molecular mechanisms underlying plant adaptation. Besides having important implications for the long-term management of the regional flora making possible the development of mitigation measures against global change, the adaptation strategies discovered could in the future also inspire novel directions for the improvement of the most relevant crops of the region and the domestication of novel crops with low environmental impact. Current research lines are focusing on water and heavy metal stresses, as well as on biomaterials and bioenergy.

.....  
CLAUDIO VAROTTO  
CRISTIANO VERNESI



## New technologies to characterize the forest structure

.....  
DAMIANO GIANELLE  
MICHELE DALPONTE

Forest inventories are very important in order to have an optimized and sustainable use of our forests, but due to the high costs of accurate ground samplings, nowadays it is not possible any more to have full calliper surveys of the forests. In order to reduce inventory costs and to have an objective spatial distribution of forest inventory parameters, in the recent years remote sensing data have been increasingly used. Indeed remote sensing can provide a cheap and objective information over large areas, that integrated with some field measurements allow us to have accurate forest inventories. Many kinds of remote sensing data can be used (i.e. LiDAR, hyperspectral, RADAR), acquired from different platforms (aerial or satellite) and with differ-

ent characteristics (i.e. high spectral and spatial resolution). Among all of them the ones most commonly used are Light Detection and Ranging (LiDAR) data. With these data it is possible to accurately characterize the forest structure, as they provide a direct information of tree heights. Remote sensing based forest inventories can be carried out with two approaches: area based, and individual tree crowns based approaches. Area based inventories estimates forest attributes (e.g. basal area, volume) for areas of a given size (i.e. squares of 400 m<sup>2</sup>). Differently, individual tree crowns level inventories estimates forest attributes for each tree detected in the study area. Indeed, the rationale of these kind of inventories is to provide information, such as

height, volume, species, for each tree in the forest analysed. These methods are based on the automatic detection of the trees in the forest starting from remote sensing data, and they exploit LiDAR data (but also hyperspectral or multispectral data) to estimate all the parameters needed for forest inventories purposes and to describe forest structure and biodiversity. In this way it is possible to have a much more detailed forest inventories, that can optimize and improve the exploita-

tion of forests but also that can help in its conservation. Indeed the information extracted from an individual tree crown level inventory can be very useful also for ecological studies.

## The computational revolution in environmental research

Computational biology applies bioinformatics, mathematical modeling, and genomics for the study and resolution of the complexity of biological processes and the interactions between organisms and their environment. The enormous quantity of data provided by the technologies of modern biology (the so-called “omics”) makes it necessary an increasing integration with in silico approaches to reduce the complexity and extract meaningful information. The goal is the development of Systems Biology, a discipline that investigates biological systems integrating mathematics, physics, chemistry and computer science with the aim to devise complex biological models able to interpret the reality of living organisms. In 2014 DBC, together with DQAN and DBEM has completed the two-year project METAFODLABS, the first phase of the consortium Metafoodbook dedicated to the study of the interactions between the immune system, micro-organisms and diet. Aim of the project is to enlight the flux of micro-organisms from the alpine environment to traditional fermented foods and their role in delivering probiotic microorganisms in maintaining a proper state of health of the immune system and exploring the possibility of characterizing microorganisms present in the typical products of

Trentino-Alto Adige. The DBC developed a pipeline for data analysis of metagenomics, allowing the choice of the regions of genes universally recognized as taxonomic markers best suited to identify bacteria and yeast in the intestinal community, food, and environmental Trentino.

This pipeline allows the analysis of the flow of microorganisms from the environment to food typical Trentino to the human microbiota and the effects of different diets on the composition of the intestinal microbiota in children with chronic inflammatory diseases. In parallel we have developed facilities and procedures for the study of short and long range transport of environmental microorganisms and their accumulation in the snow. The results of this study show that the definition of pathogenic species should depends on the variability of the characteristics of each strain of yeast (genera *Saccharomyces* and *Candida*) and cannot be established at the species level. Practically our studies set the stage to the development of integrated analyses of microbial biodiversity in alpine ecosystems, showing how environmental biodiversity is linked to self-sustainability of health through healthier typical products.

DUCCIO CAVALIERI  
ALESSANDRO CESTARO  
CLAUDIO DONATI

# HIGHLIGHTS



## Ecosystem services of mountain forests: ozone removal by Norway spruce in Trentino

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ELENA GOTTARDINI, ANTONELLA CRISTOFORI, FABIANA CRISTOFOLINI

Regulating air pollution is a key ecosystem service provided by plants. Ozone removal by Norway spruce - both through stomatal and non-stomatal deposition - has been proved to be of 56% by a fully randomized study carried out along an altitudinal gradient (900-1.500 m a.s.l.) in Trentino.



## Stable isotope ratios of wood

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FEDERICA CAMIN, YURI GORI, RON WEHRENS, NICOLA LA PORTA

The stable isotope ratios of H, C, N and O in the tree rings of *Picea abies* have allowed to investigate the short- and long-term effects on wood of fungi and insect attacks. Moreover they show geographical variability usable to verify the geographical origin of wood.



## Anthropogenic impacts and climate change: Evolutionary trends of lakes in the Province of Trento

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NICO SALMASO, MONICA TOLOTTI, GIOVANNA FLAIM,  
ULRIKE OBERTEGGER, LEONARDO CERASINO

The evolution of water bodies is analyzed with multidisciplinary methods and at different levels of biocomplexity and integration - from molecules to ecosystems. This approach allows us to clarify the impact of human activities and climate change on the functionality of aquatic ecosystems.

## Conservation of freshwater fish fauna in Trentino

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ANDREA GANDOLFI

A genetic database of representative - and threatened - fish of Trentino (marble trout, Garda's carpione, Adriatic grayling, Southern pike, Italian barbel) is now available to guide management and conservation of these taxa, including the evaluation and selection of native breeding stocks.



## Gut flora biodiversity for wildlife conservation

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CARLOTTA DE FILIPPO, HEIDI HAUFFE, CLAUDIA BARELLI

We study gut microbiota diversity of an endangered primate (*Procolobus gordonorum*) living in the Udzungwa Mountains (Tanzania), discovering that it is affected by habitat fragmentation with a significant  $\alpha$ -diversity decrease in disturbed forest, opening implications for wildlife conservation.



## Hydropeaking

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MARIA CRISTINA BRUNO, BRUNO MAIOLINI

Hydropower generation causes strong increases in discharge of irregular and unpredictable length, i.e., hydropeaking. Simulations conducted in seminatural flumes allowed evaluating the impacts of repeated hydropeaking waves on the benthic communities.





**FACTS AND FIGURES**

# RESEARCH EXPLOITATION

## Research projects

Approved in 2013 and 2014

29 with an overall amount of 3.353.000 €

## Patents

N. 1

Mechanical device for the characterization of an internal structure of a block of cheese.

7 proposal of patents

## Contracts 2013-2014

In 2013-14, 62 contract were signed, for a total amount of around € 2,400,000. Contracts were signed with major food companies, wineries, national and international fruit and other private and public entities, which were signed subcontractor agreements of research activities. Other 45 agreements signed did not involve economic commitment.

## National Research Qualifications

In 2006 it has been established the National Agency for Evaluation of the Universities and Research Institutes (ANVUR). In 2013 the first exercise of evaluation of the Italian Research System has been completed with reference to year 2004-2010.

### FEM ranking among Italian Research Institutions (not Academic)

#1 Chemistry

#1 Agriculture

#4 Biology

### ANVUR 2012 professorship qualifications (ASN)

7 full professor qualification

27 associate professor qualification

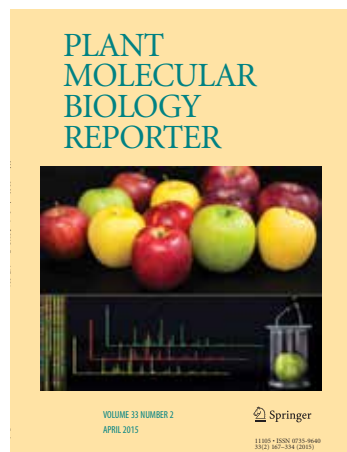


# JOURNALS WITH IMPACT FACTOR

Articles published in scientific journals

2013-2014 **370**

Covers of scientific journals



## Nature Biotechnology

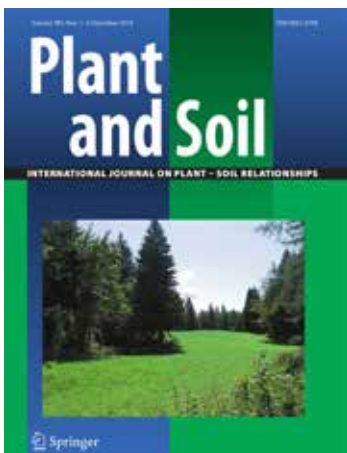
Volume 32 (2014)

Riccardo Velasco was Invited Reviewer by Editor in chief about the genealogy of Citrus.

## Plant Molecular Biology Reporter

Volume 33 (2014)

The cover of this issue refers to the changes in soil organic carbon following forest expansion on grassland in the Southern Alps, a research conducted by Claudia Guidi and Mirco Rodeghiero.



## Plant and Soil

Volume 385 (2014)

Evidences from the analysis of apple flavor profile, carried out with a non-invasive method, by the working group coordinated by Fabrizio Costra and Luca Cappellin has been included as main article for this volume.

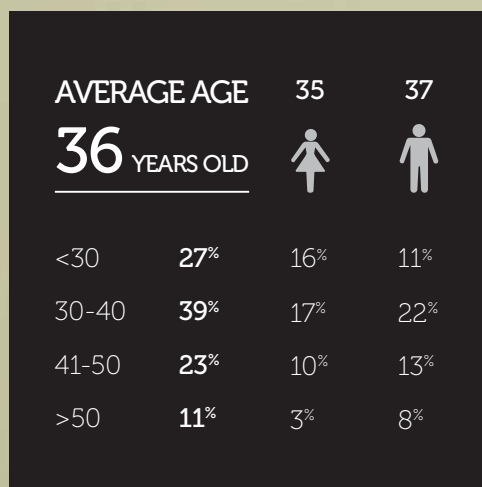
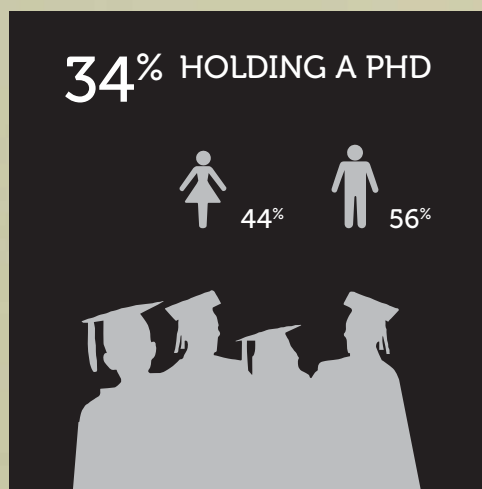
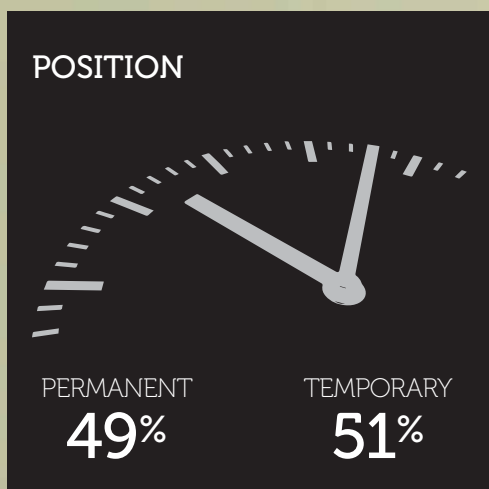
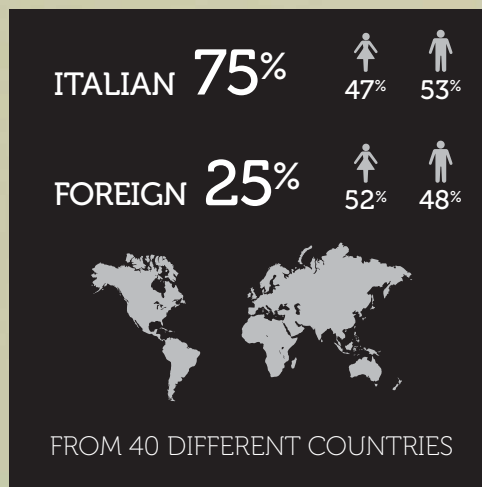
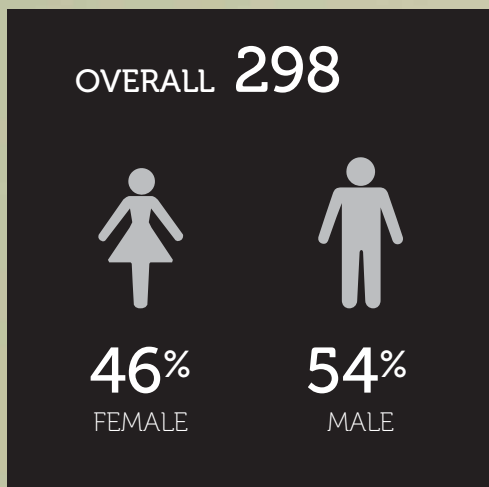
## Genome Biology and Evolution

Volume 6 (2014)

For the first time are presented the results of the genome sequencing of olive, a National project, conducted by the University of Perugia and Tuscia in which FEM is a member of the consortium.

# STAFF DATA

AT 31/12/2014



# ORGANIZATION CHART

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STAFF 2013-2014

## A .....

Agostini Romina, Ahrar Mastaneh, Albanese Davide, Alcazar Martinez Alberto, Algarra Alarcon Alberto, Anfora Gianfranco, Angeli Andrea, Angeli Dario, Antonielli Livio, Aprea Eugenio, Arapitsas Panagiotis, Arnoldi Daniele, Asquini Elisa.

## B .....

Bagnara Maurizio, Baldacchino Frederic Alexandre, Baldi Paolo, Banchi Elisa, Baráková Ivana, Barbaro Enrico, Barelli Claudia, Bastien Geraldine Liliane, Battilana Juri, Battistel Gian Antonio, Battocletti Ivana, Bengtsson Martin Jonas, Bergamaschi Matteo, Bertolini Emanuele, Betta Emanuela, Bianco Luca, Biasioli Franco, Bolzoni Luca, Bonosi Lorenzo, Bontempo Luana, Boscaini Adriano, Bottini Silvia, Bozzi Emiliano, Brazzale Daniele, Bresadola Luisa, Brillì Matteo, Bruno Maria Cristina, Bussola Francesca, Buti Matteo.

## C .....

Cagnacci Francesca, Calliari Valentina, Camin Federica, Campa Manuela, Campbell-Sills Hugo, Campisano Andrea, Capelli Camilla, Capossela Luigi, Cappelletti Valentina, Cappelli Anna, Cappellin Luca, Carafa Ilaria, Carli Josè, Carlin Silvia, Carotenuto Federico, Carvalho Elisabete, Caset Marisa, Castellani Cristina, Catalano Valentina, Cattaneo Alberto Maria, Cattani Andrea, Cavagna Mauro, Cavalieri Duccio, Cavazza Agostino, Ceppa Florencia Andrea, Cerasino Leonardo, Cervantes Gonzalo Ricardo, Cestaro Alessandro, Chadwick Elizabeth Anne, Chan Cheung Wai, Charles Mathilde Clemence, Chincarini Roberto, Chini Isaac, Chitarrini Giulia, Cieplinski Adam, Clementi Silvano, Collini Margherita, Colombini Andrea, Colombo Monica, Conforti Francesco, Conter Luigi, Conterno Lorenza, Cordano Emanuele, Corneo Paola Elisa, Cornetti Luca, Corollaro Maria Laura, Costa Fabrizio, Costantini Laura, Covelli Laura Tiziana, Crestanello Barbara, Crisculi Irene, Cristofolini Fabiana, Cristofori Antonella, Csikasz Nagy Attila.

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Pancher Michael, Paolini Mauro, Pareeth Sajid, Parisi Veronica, Pascoe Emily Louise, Pasini Luca, Paternoster Genny, Pavlovcic Petra, Pellegrini Alberto, Perazzolli Michele, Perenzoni Daniele, Peressotti Elisa, Perini Elisabetta, Perkins Sarah, Pertot Ilaria, Pessina Stefano, Peters Wibke Erika Brigitta, Piazza Stefano, Pighini Sylvie Florence Anne Laure, Pilati Stefania, Pindo Massimo, Pironti Arturo, Pojer Elisa, Polajnar Jernej, Poles Lara, Poletti Valentino, Poli Michele, Poncetta Paula, Potenza Emilio, Pozzi Carlo Massimo, Prada Germano, Prasad Mridula, Prazzoli Maria Lucia, Pullens Johannes Wilhelmus Maria, Puopolo Gerardo.

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Sablok Gaurav, Sakowska Karolina, Salmaso Nico, Salvagnin Umberto, Samad Samia, Sanchez Cova Carla, Sanchez del Pulgar Rico Jose, Sargent Daniel James, Savoia Stefania, Scholz Matthias Uwe, Scolozzi Rocco, Segarra Braunstein Guillem, Semenzato Paola, Sgaramella Vittorio, Shahaf Nir, Shams Shiva, Si Ammour Azeddine, Sicher Carmela, Simoni Marco, Siozios Stefanos, Soini Evelyn, Sonogo Paolo, Sordo Maddalena, Sottocornola Matteo, Stefani Erika, Stefanini Irene, Stefanini Marco, Strati Francesco, Surbanovski Nada.

## T .....

Tadiello Alice, Tagliapietra Valentina, Tait Laura, Tarter Milva, Ting Valentina, Tocci Noemi, Toccoli Silvia, Tolotti Monica, Tomasi Jacopo, Tomasi Tiziano, Tonazzolli Giorgio, Tonon Agostino, Torfs Sanne, Toubiana David, Trapin Eleonora, Troggio Michela, Trost Kajetan, Tudoroiu Marin, Tuohy Kieran Michael, Turco Elena.

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Wehrens Herman Ronald Maria Johan, Wehrens-Kunne Odilia, Weil Tobias Franz Anton Ludwig, Weingart Georg, Whitener Margaret Elizabeth Beckner, Wolters Pieter Jacobus.

## Y .....

Yener Sine, Yu Xiaoguang.

## Z .....

Zagari Nicola, Zambanini Jessica, Zambelli Pietro, Zampedri Andrea, Zampedri Roberto, Zannoni Michele, Zanon Flavia, Zatelli Alessandra, Zecchini Romina, Ziller Luca, Zimmermann Anja, Zorer Roberto, Zulini Luca.





## CRI EVENTS

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2013-2014

.....

### 6 big events

2.000 people involved

### Abstracts submitted

1.100

### 65 seminars

2,5 per month

### 23 educationals

### 23 dissemination events

27.000 people involved

In 2013 and 2014, 130 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.

Six big events with an overall participation of 2.000 people. An average of 65 seminars and 23 educational initiatives dedicated to PhD students and re-searchers careers' and expertise: specialist courses, workshops and summer/winter schools. Finally, 23 dissemination events that engaged the non-expert public and citizens and saw the participation of about 27.000 people. Kudos to all our supporters, staff and volunteers who helped us last two years!





# CREDITS



Gianni Zotta: cover image

Comunicazione Office FEM: p. 5

Massimo Brega, "Kepach Production" ([www.kepachproduction.com](http://www.kepachproduction.com)): pp. 7, 8, 12-13, 18 (top), 18 (bottom), 19 (bottom), 22, 24, 26 (bottom), 27 (top), 28-29, 30, 32

Elisa Colla: p. 11

Ilaria Pertot: p. 14

Roberto Zorer: p. 16

Juan Sebastian Lopez Fernandez: p. 18 (center)

Canstockphoto: pp. 19 (center), 20-21.

Centre for Technological Transfer FEM: pp. 19 (top), 27 (center)

Paola Morini: p. 26 (top)

Nicola Busatto: p. 26 (center)

Stefan Martens: p. 27 (bottom)

Elena Gottardini: p. 34 (top)

Andrea Mancini: p. 34 (center)

Adriano Boscaini: p. 34 (bottom)

Andrea Gandolfi: p. 35 (top)

Christina Gupfinger: p. 35 (center)

Cristina Bruno: p. 35 (bottom)

Umberto Salvagnin: p. 45





