eez

Report 2020

eez
estación experimental del zaidín

ESTACIÓN EXPERIMENTAL del **ZAIDÍN**

Estación Experimental del Zaidín

eez
Estación Experimental del Zaidín

Report 2020

INDEX

INDEX

FOREWORD

The President of the Spanish National Research Council (CSIC), Mrs. Rosa Menéndez, spoke in the Spanish Senate this past June to remind politicians that the moment had come to grant the same level of importance to science as to national security and defence. She warned that the lack of resources and their blockage could have irreversible consequences and that the pandemic had evidenced that it is not only important to react and take immediate actions, but also to prevent and be fully ready for future threats. She also stressed the fact that with the hundreds of research projects on COVID, society has felt and wanted to see in science an efficient instrument with which to combat suffering and despair. Year 2020 with the international pandemic has put the focus on such issues and us scientists hope that both society and the political class will not put them into oblivion.

In EEZ we have very vivid memories of all those difficult months when the state of alarm was declared and we compiled all the material we could donate to local hospitals and our scientists and technicians volunteered to carry out PCR tests. We were forced to limit the access to our institute, put a stop to many experiments that were under way and leave things halfway. Our return to work was not easy either with labs and offices half occupied or taking turns. However, thanks to our joint efforts we managed to come through and improve our e-working tools. We resumed our projects, our contracts, we participated in new national and international research calls and our institute's administrative machinery, that was well greased, worked smoothly.

Despite the situation, we also wanted society to feel we were present and communicating our results. Our dissemination projects such as CAOS and research activities such as "The Researchers' Night" or our events devoted to women scientists present and past were still held with either reduced audience or via internet. Through these dramatic challenging times, EEZ has shown resilience and hard-working capacity in extremely tough conditions as evidenced by its success in the number of projects obtained for financing both in national and regional calls, as well as in EU projects within the areas of biodiversity, sustainable farming, soil preservation and climate change.

It is our hope that the CSIC's active involvement in the Recovery Plan for Europe and its associated future reforms and investments will benefit our institute in many ways. We are already off to a head start preparing the new Strategic Plan 2022-2025 that will put great emphasis of national and international collaborations.

Our President of the CSIC pointed out to the Senate the loss of infrastructure, the need for laboratory renovations and equipment updating, particularly after the latest financial crisis, but stressed most specially the loss of human resources. "Spain cannot afford to make the same mistake again if it really desires a sustainable reactivation of its economy and society in general because societal advances of the XXI century depend greatly on science and technology".

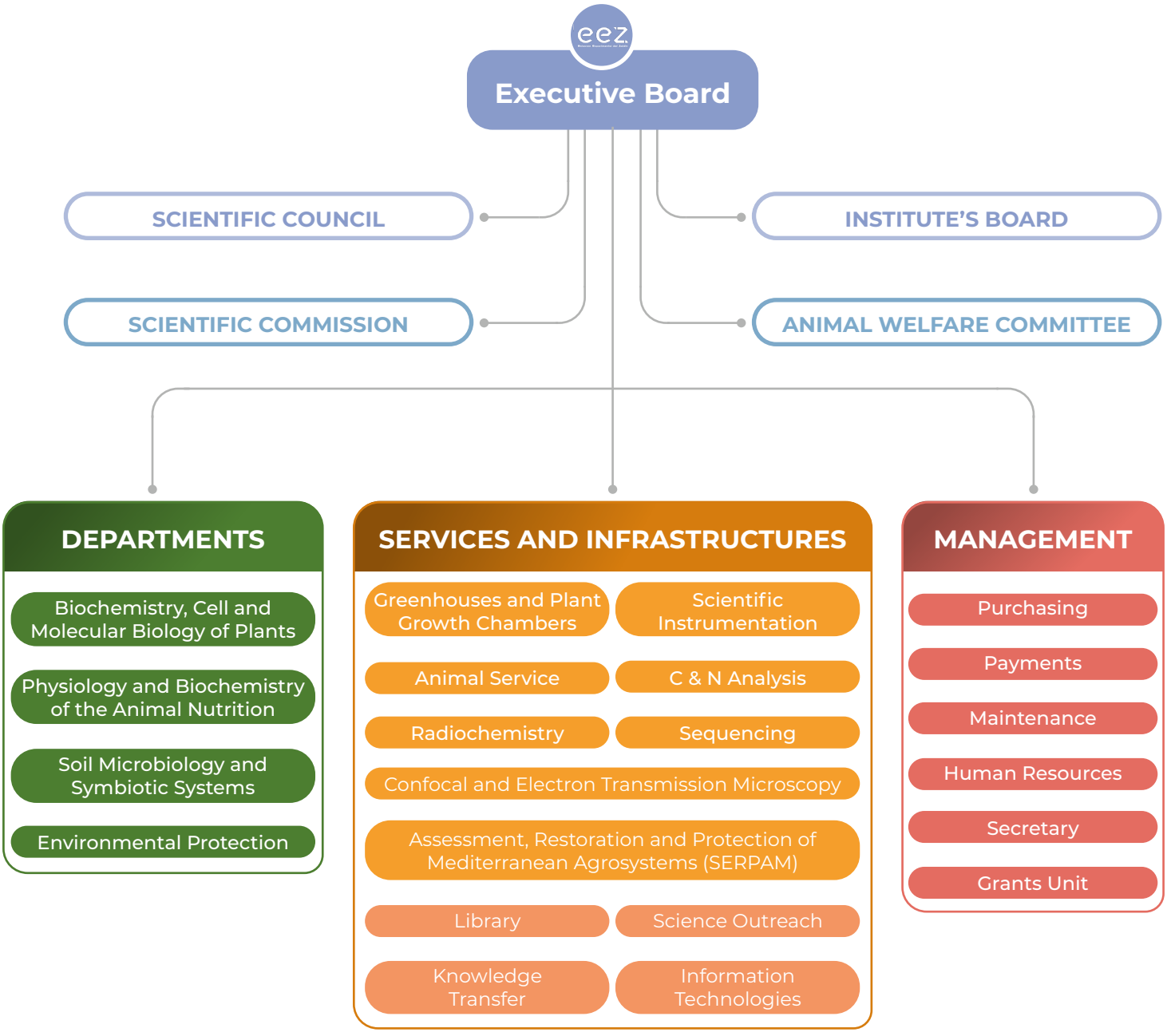
For all these reasons we must not forget that if we want to face new health, food, environmental and agricultural challenges and associated threats, we must build solid scientific grounds with sufficient funding and strong long-term commitment with the infrastructure to favour not only innovation, but most particularly, permanent staff and well-defined scientific, technical and management careers.

MATILDE BARÓN AYALA

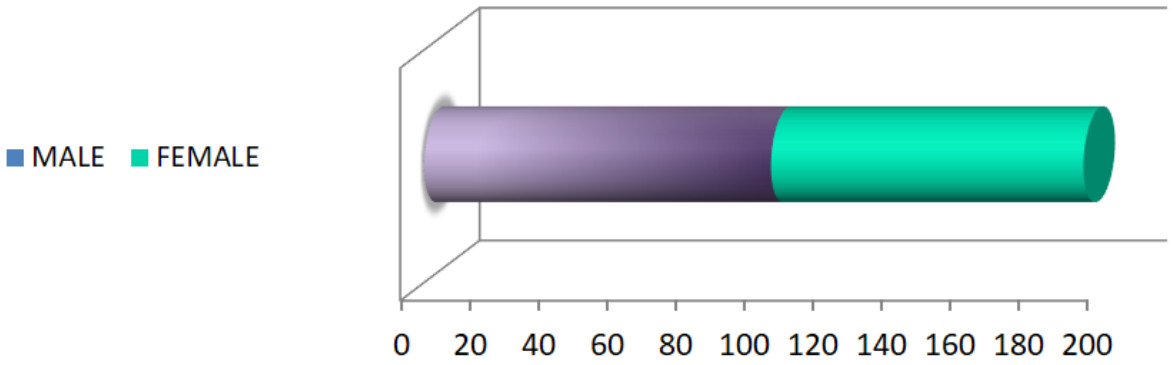
Director of the EEZ

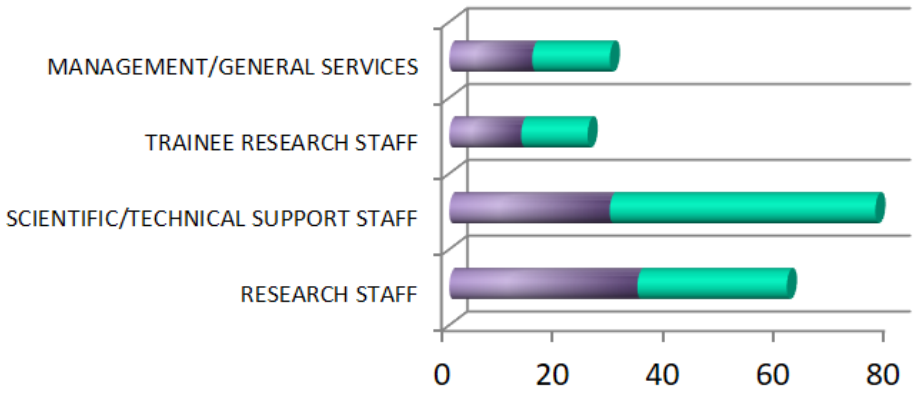
THE INSTITUTE

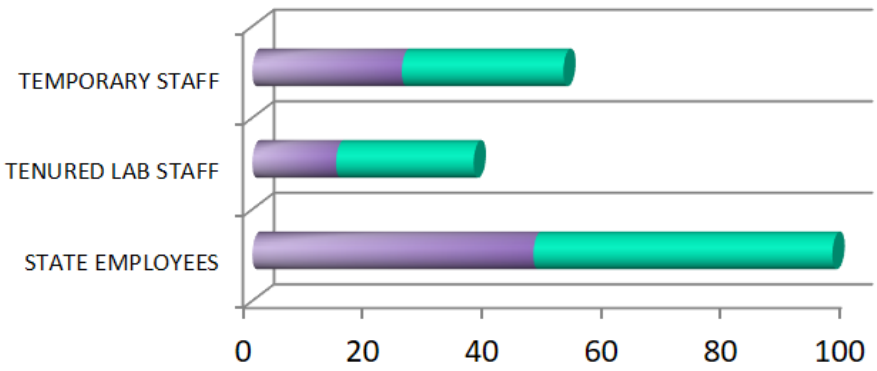
ORGANIZATION CHART

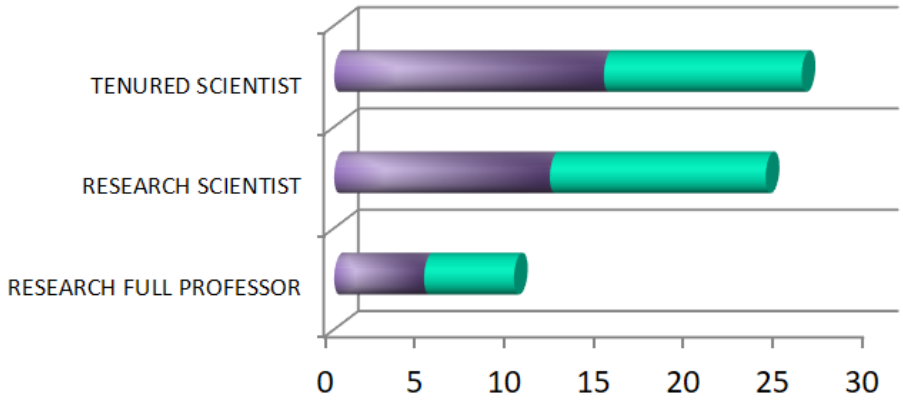


STAFF









(GEP Database on personnel assigned to the EEZ, December 2020)

DIRECTION AND MANAGEMENT

- **Dr. Matilde Barón Ayala**
  Director
- **Dr. Nuria Ferrol González**
  Deputy Director
- **Dr. Alfonso Clemente Gimeno**
  Deputy Director
- **José Luis Sánchez Justicia**
  General Manager

ADMINISTRATION AND GENERAL SERVICES

SECRETARY

Inés Abril Martí
Ana Mª Esteban Muñoz
Salomé García Jiménez
Carmen Lorente Vázquez

PAYMENTS

Isabel Abril Álvarez
Jorge García Salazar

HUMAN RESOURCES

Mª del Mar Fandila Enrique
Mª Paz Montesinos Parra

GRANT UNIT

Rosario Molina Quesada
Carmen Lorente Navarro
Eva Mª Sánchez Abolafia
Juan Carlos Vílchez Rojas

PURCHASING

Álvaro Mérida González
Carmen Camacho Guzmán
Luis Miguel García Rodríguez
Jaime Cecilio Ramírez Melguizo
Rafael Miguel Ruiz García

MAINTENANCE

Samuel Martínez Marruecos
Fernando Caro Fernández
Fernando Flores García
Pedro Palomares Martínez
Juan Pablo Vera Padial *(Armilla)*

ANIMAL SERVICE

Isaac Abdel Rahman Gálvez
Francisco Funes Madrid
Mª Jesús Molina Luzón

INSTITUTE'S BOARD

PRESIDENCY	**Dr. Matilde Barón Ayala**	*Director*
	Dr. Nuria Ferrol González	*Deputy Director*
	Dr. Alfonso Clemente Gimeno	*Deputy Director*
SECRETARY	**José Luis Sánchez Justicia**	*General Manager*
HEADS OF DEPARTMENTS	**Dr. María C. Romero Puertas** *Dept. of Biochemistry and Molecular and Cellular Biology of Plants*	
	Dr. Ignacio Martín García *Dept. of Physiology and Biochemistry of the Animal Nutrition*	
	Dr. Mª Jesús Delgado Igeño *Dept. of Soil Microbiology and Symbiotic Systems*	
	Dr. Rogelio Nogales Vargas-Machuca *Dept. of Environmental Protection*	
STAFF REPRESENTATIVES	**Dr. Cristina Delgado Andrade**	
	Dr. José Luis Garrido Sánchez	
	Jaime C. Ramírez Melguizo	
	Dr. Mª Eugenia Ramos Font	

SCIENTIFIC-TECHNICAL SERVICES

The **EEZ** has several services available both to the Centre's groups and to the scientific community and companies that require them. All information and fees are available on the Centre's website. These services belong to the Scientific and Technical Services Network of **CSIC.**

ANIMAL SERVICE

Head
Isaac Abdel Gálvez

Technicians
Francisco Funes Madrid
Mª Jesús Molina Luzón

Facilities and equipment

This animal facility makes available it's installations to researchers from the Department of Physiology and Biochemistry of Animal Nutrition, as well as the conditions and requirements necessary for carrying out research projects with pigs, small ruminants, birds and rodents. The facilities consist of exercise yards, and animal housing for pigs and small ruminants, rodent and bird testing rooms, quarantine area, operating theatre, hayloft and feed warehouse. These facilities offer opportunities of collaboration with private companies.

Analyses / Services offered

General services:

- Supply of own-produced animals
- Reception of external animals, identification, weighing
- Maintenance of small ruminants, pigs, birds and rodents: Housing, feeding, cleaning of enclosures and sanitary control
- Collaboration in experimental procedures

Technical services:

- Waste management: SANDACH (carcasses/manure/slurry/milk)
- Management of animals transport.
- Participation in the Animal Welfare Authority (OEBA)
- Organize workshops and seminars for training in handling and experimental techniques
- Manage access to facilities
- Maintenance of the census of animals, records. of discharges and casualties

Laboratory services:

- Carrying out necessary health checks to ensure the proper health status of the animals
- Assistance and prescription of medication
- Euthanasia following the legal criteria. Necropsies
- Surgeries
- Technical assistance in experimental procedures

Activities in 2020

• Assembly of bird cages: Adaptation to the law, according to Real Decreto 53/2013, of the 1st February, which establishes the basic rules applicable for the protection of animals used in experimentation and for other scientific purposes, including teaching

• Collaboration in search for external farms

• Upgrading of facilities ES18021000016 after the quarantine period

• Completion of the Operating Regulations of the Service of Animal Facilities. Documentation management (Treatment book, Animal transport, Procedures, SANDACH...)

Animal Facility ES180210000016. Department of Physiology and Biochemistry of Animal Nutrition

CARBON AND NITROGEN ANALYSIS SERVICE

Personnel
Rafael Hueso Ibáñez

Facilities and equipment
- Elemental analyzer (Leco TruSpec CN)
- Analytical balance and drying oven

Analyses / Services offered
- Quantitative determination of total Nitrogen (by Dumas method) and Carbon (by infrared detector) in a wide range of matrices (water, biological fluids like milk or urine, animal feed, forage, animal or plant tissues, faeces, soils, etc.)
- Quantification is performed with certified standards from Leco

Elemental Analyzer: Leco TruSpec CN

GREENHOUSES AND PLANT GROWTH CHAMBERS SERVICE

Head
Andrés Belver Cano

Technician
Francisco Sires Navarrete

Facilities and equipment
- 14 walk-in growth chambers provided with LED illumination and ventilation, with a total cultivation area of approximately 130 m^2. One chamber is dedicated to the cultivation of plants under short-day conditions, other to *in vitro* cultivation, another is conditioned for studies at high ambient CO_2 concentrations and 2 are exclusively devoted to the cultivation of plants infected with pathogenic bacteria and fungi
- 10 greenhouses, providing a total area for plant cultivation of 154 m^2, with additional lamps to provide artificial light, three of them also equipped to set up hydroponic cultures
- Phenotyping platform, with the possibility of incorporating different sensors (CCD, thermal or multispectral cameras)
- Latest generation imaging fluorimeter

Activities in 2020
- Implementation of a web-based GLPI system for requesting the technician assistance to users in their experiments in the Greenhouses and Growth Chambers Service
- Implementation of a web-based calendar to book the entrance and working times in the Service facilities in order to follow the EEZ´s anti-Covid protocol

CONFOCAL AND TRANSMISSION ELECTRON MICROSCOPY SERVICE

Head
Adela Olmedilla Arnal

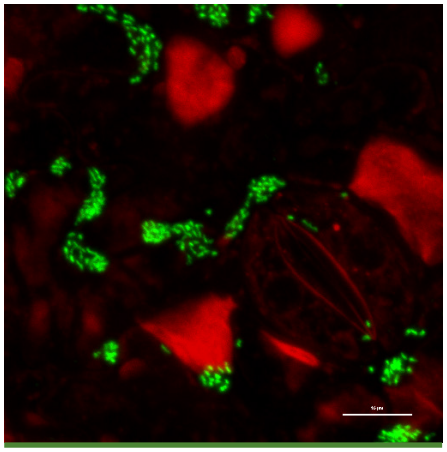
Technician
Alicia Rodríguez Sánchez

Facilities and equipment

- Confocal Laser Scanning Microscope (Nikon C-1)
- Transmission Electron Microscope (JEOL JEM-1011)
- Inverted Epifluorescence Microscope (Leica DMI600B)
- Epifluorescence Stereomicroscope (Leica M165FC)
- Different tissue processors for electron and laser microscopy: Automatic tissue processor for electron microscopy samples (Leica TP1020), processor for paraffin inclusion (Leica EG1150), vibratome (Leica VT1200s), microtome (Leica RM 2165) and ultramicrotome (Reichert-Jung ULTRACUT)

Activities in 2020

- Course on Occupational hazards followed by the technician and the supervisor of the Service



Bacterial distribution in tomato leaves infected with Pto after Syto 13 staining. Confocal microscopy image

RADIOCHEMISTRY LABORATORY

Heads
Narciso Algaba García
(until 2nd May 2020)

Francisco Martínez-Abarca Pastor

The EEZ has authorization to operate the 2nd category radioactive facility IR/GR-06/73 (IRA 159, according to the CSN nomenclature). The authorized activities are the use of non-encapsulated radioactive material

Authorized isotopes:
- ^{3}H (50mCi); ^{14}C (30mCi); ^{33}P (20mCi); ^{35}S (10mCi); ^{125}I (5mCi); ^{32}P (10mCi)
- Encapsulated radioactive source of ^{137}Cs of 32.25 µCi (1.19 MBq) of maximum activity used in the scintillation counter

Facilities and equipment

- Two units, one located on the ground floor of the Microbiology Building, that consists of two areas (monitored area and controlled area), and a second laboratory located at the Armilla headquarters
- Geiger-Müller contamination detectors
- Liquid scintillation counter (Beckman Coulter, model LS 6500)
- Fume hood, thermal cycler, hybridization oven, freezer, refrigerator and microcentrifuges
- Adequate radioprotection and decontamination equipment

Performed techniques

- Microbiology Building: DNA and RNA labeling and probes-hybridization, autoradiography, incorporation of radioisotopes into cells, protein phosphorylation, *in vitro* transcription, etc.
- Armilla headquarters: Radioimmunoassays for determination/quantification of animal hormones

SCIENTIFIC INSTRUMENTATION SERVICE

Head
Tino Krell

Technicians
Virginia Cuéllar Maldonado
Rafael Núñez Gómez
Lourdes Sánchez Moreno
Miryam Rojas Gómez

Facilities and equipment

Equipment for Liquid Chromatography and mass spectrometry:

- HPLC Waters Allience 2695
- UPLC Waters Acquity H-Class
- UV, fluorescence and refractive index detectors
- Electrospray ionization mass spectrometer with triple cuadrupole detector (Quattro micro)
- Electrospray ionization mass spectrometer with qTOF detector (Vion IMS-QTof)
- Equipment for Gas Chromatography (GC):
- Gas Chromatograph coupled to mass spectrometer Varian 450-GC-240MS
- Gas Chromatograph 490 Micro GC
- Equipment for elemental analysis:
- Inductively coupled plasma optical emission spectrometry (ICP-OES) Varian ICP 720-ES
- Isothermal Titration Calorimeter (ITC)
- Nano Isothermal Titration Calorimeter (T.A. Instruments)
- Electron Paramagnetic Resonance (EPR) Spectrometry:
- EPR spectrometer EMXnano (Bruker)

Analyses / Services offered

• Detection and quantification of a wide range of low molecular weight compounds by liquid chromatography or gas chromatography separation followed by infusion into mass spectrometers

• Quantification of permanent gases by GC (methane, CO, CO_2, N_2O, etc.)

• Determination of elemental composition of liquid and solid samples using ICP-OES

• Custom-tailored development of extraction protocols of analyte compounds from different biological samples

Activities in 2020

• Installation of three new instruments and reception of training courses by the Service members, namely the Vion IMS-QTof mass spectrometer, the ITC microcalorimeter from T.A. Instruments and the EPR spectrometer

• Organization of a training course on chromatographic separation techniques by facility members

The recently installed high-resolution mass spectrometry facility in the Scientific Instrumentation Service: Shown is the UPLC (ultra-performance liquid chromatography) instrument (on the left) linked to the high-resolution electrospray ionization mass spectrometer Vion IMS-QTof (on the right)

DNA SEQUENCING SERVICE

Head
Ricardo Aroca Álvarez

Technicians
Miryam Rojas Gómez

Facilities and equipment

- ABI PRISM 3130xl Genetic Analyzer with sixteen 80 cm long capillaries

Analyses / Services offered

- Plasmid DNA sequencing
- PCR products sequencing
- Low copy number DNA sequencing (Cosmic, Genomic, BAC)

ASSESSMENT, RESTORATION AND PROTECTION OF MEDITERRANEAN AGROSYSTEMS (SERPAM)

Head
Matilde Barón Ayala
Ana Belén Robles Cruz

Technicians
Mª Eugenia Ramos Font
Mauro Tognetti Barbieri

SERPAM is an environmental research and advisory service (natural and agricultural environments), whose pillars are:

- Knowledge of Mediterranean pasture systems and resources: flora, wild forage crops, vegetation, pastures, plant covers, and agrosilvopastoral systems
- Management of the natural environment: evaluation and management of natural pastures, livestock carrying capacity, restoration of degraded lands, enhancement of mountain areas and preventive silviculture alternatives with livestock

Analyses / Services offered

- Herborization, identification and determination of flora
- Evaluation and analysis of plant resources (floristic composition, structure, production)
- Evaluation of the carrying capacity of natural pastures
- Management of plant covers
- Management of vegetation cover with livestock
- Germplasm bank of native plant and forage species
- Collection of native seeds
- Characterization and seed germination tests
- Restoration and improvement of natural pastures
- Evaluation of the livestock impact on the vegetation cover
- Pastoral planning in fire prevention systems
- Training and participatory activities in the management of the natural and agricultural environment
- Outreach activities

Activities in 2020

- Project Interreg-SUDOE: Open2preserve. Sustainable management model for the preservation of open mountain areas. European project, INTERREG V-SUDOE 2017 (SOE2/P5/E0804). General coordinator: Rosa Mª Canals (UPNA). EEZ-CSIC coordinator: Ana Belén Robles Cruz. 2018-2021. (www.open2preserve.eu)

TECHNICAL RESEARCH SUPPORT UNITS

INFORMATION TECHNOLOGIES SERVICE (ITS)

Head
Francisco Javier Mengual Maldonado

Other members
César Azorín Márquez

Lourdes Salmerón García
(Armilla headquarters)

Víctor Baena Vílchez *(Integra S.A.)*

The IT Service maintains and supports the entire communications infrastructure (voice and data) at the two headquarters of the EEZ. It also manages different services, such as the Centre's website and intranet and offers support to the users' incidences.

Activities in 2020

- Set-up of a platform for teleworking and access to all EEZ staff
- Update and expansion of the Centre's private cloud services
- Implementation of the users' backup systems at the two headquarters and of all the installed servers
- Centralization and unification of the systems of both EEZ headquarters
- Conditioning of two meeting rooms at the EEZ Central headquarters, including the assembly hall for online seminars
- Implementation of a server to host the Centre's departments web. The IT Service offers support for web maintenance, development and update
- Purchase of an uninterruptible power supply system (UPS) to provide uninterruptible access while enhancing and improving the electrical system at the communications room of the newly refurbished "Casa Roja"
- Users access to telework has considerably increased the number of incidences. The IT Service's actions have largely focused on solving these user problems

KNOWLEDGE TRANSFER UNIT

Head
Alfonso Clemente Gimeno

In collaboration with:
Juan Carlos Vílchez Rojas

This Unit provides support to the Centre's research groups, managing the transfer of the knowledge generated through its technological offer and promoting collaboration with companies and institutions. Its activities include consultancy and management of research contracts, support in the application for public aid in collaboration with companies, the development of an updated portfolio of technology-based companies, as well as the protection, promotion and commercialization of research results.

Services offered

- Advice to research groups for the management of contracts, patents and collaborations with companies and institutions

• Management of contracts for Technological Support, R&D (Research and Development), Confidentiality Agreements (NDA), Material Transfer Agreements (MTA), Patents and Services

Activities in 2020

• Advice on the signing of contracts with 26 companies (15 Spanish and 11 foreign), including 21 Technology Support contracts, 1 R&D contract, 3 NDA and 3 MTA

• The EEZ has joined the platform Granada Salud (www.granadaessalud.es)

• Meetings and attendance at trade fairs and congresses:

— Meeting Koppert Biological Systems (Granada, 21st January)

— Transfiere, European Meeting on Science, Technology and Innovation (Málaga, 12-13 February)

— Meeting EEZ-Lime Europe (Granada, 20th February)

Transfiere, European Meeting on Science, Technology and Innovation

LIBRARY

Head
Felícitas Ramírez Malo

Librarian
Francisca González Iglesias

The Library is oriented towards scientific researchers, doctoral, master and bachelor's degree students, as well as teachers. It is integrated within the CSIC Network of Libraries.

Its main mission is to attend the scientific and specialized information needs of the scientific staff of the EEZ.

The Library provides different ways of accessing electronic books and digital journals. The paper archives, specialized in Agricultural Sciences and similar, includes around 6.000 book volumes and over 330 specialized journals.

Services offered

- Reading room with internet access
- Access to digital journals
- Book loans
- Interlibrary loans
- Bibliographic information and assistance
- Access to documents for staff personnel
- Reproduction of documents
- Access to scientific databases
- Archive integrated in the Institutional repository

SCIENCE OUTREACH UNIT

Head
Manuel Espinosa Urgel

Other members
Mágina Cruz Caballero

In February 2020, the Unit obtained the two-years renewal of its recognition as part of the National Network of Outreach and Innovation Units by FECYT.

Public outreach and Science education

• *International Year of Plant Health.* Several activities were organized for the general public: Science Talks at the Lemon Rock (29th January); Fascination for Plants Day, on-line round table on plant health (18th May); Plantathon, a plant photography contest that was part of the "Granada, City of Science" project.

• *European Researchers' Night*. Funded by the EU, the activity was moved to November and held exclusively on-line due to the restrictions generated by COVID-19. EEZ scientists took part with two on-line encounters with students, eight video-talks and a live program.

• *Ciencia BaSe + PIIISA*. Research projects carried out by high school students, supervised by a scientist. Although activities had to be interrupted in March, the projects could be finished on-line, and results published in *High School Students for Agricultural Science Research,* Vol. 9, ISSN 2340-9746.

• *Exhibits.* Three exhibits have remained open during 2020: *"Mushrooms"* (Casa de la Ciencia, Sevilla), *"What is Science for you?"* (Granada and Seville), and *"Mnemosyne"* (EEZ), the last two arranged by the EEZ Library.

Exhibit "Mushrooms", Casa de la Ciencia, Seville

Exhibit "What is Science for you?", Casa de la Ciencia, Seville

Press releases and social media

• During 2020, the Unit has issued 32 web news and press releases. The highest coverage by the media corresponded to two projects in which scientists of the EEZ take part, on *Verticillium* wilt of olive, and on the antihypertensive effect of unfiltered virgin olive oil.

In June 2020, the Instagram profile of the EEZ was created. Data for our social media of December 2020 show a significant increase in impact:

- Twitter: 2.339 followers (+24% with respect to 2019)
- Facebook: 1.847 likes, 1.995 followers (+11%)
- Instagram: 270 followers
- Youtube: 198 suscriptors (+51%)

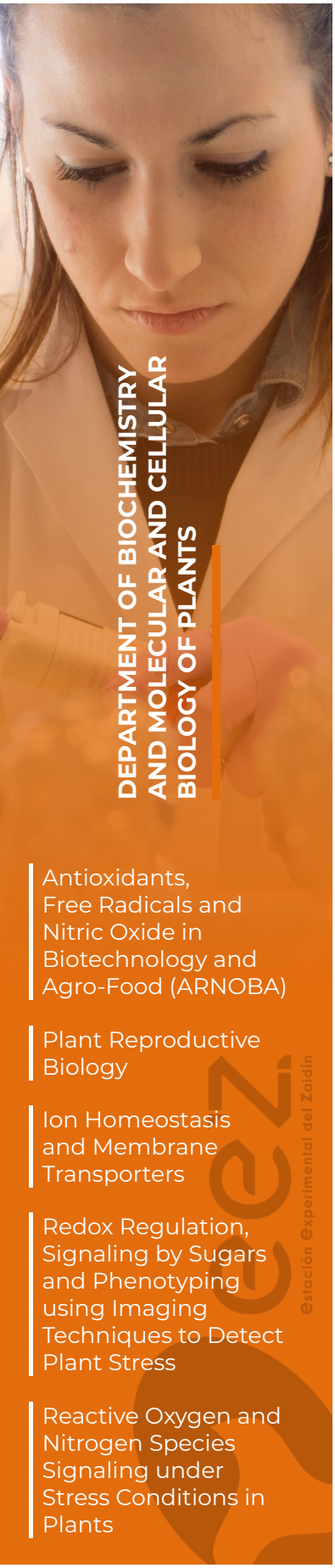
Women in Science

• *International Day of Women and Girls in Science (11th February)*: During that week, EEZ female scientists gave talks at 4 elementary and high schools to stimulate girls towards scientific careers.

• *Women's Day (8th March)*: "Coffee with Science", an activity organized with Fundación Descubre, where several Andalusian female scientists explain their work to groups of students while sharing breakfast. In 2020, 100 high school students and 10 researchers from the University and the CSIC institutes in Granada participated.

• *Other activities:* Several talks on the role of female scientists throughout history were presented in different locations (Artistic, Literary and Scientific Centre of Granada, Government Delegation, University).

DEPARTMENTS AND RESEARCH GROUPS



DEPARTMENT OF BIOCHEMISTRY AND MOLECULAR AND CELLULAR BIOLOGY OF PLANTS

- Antioxidants, Free Radicals and Nitric Oxide in Biotechnology and Agro-Food (ARNOBA)
- Plant Reproductive Biology
- Ion Homeostasis and Membrane Transporters
- Redox Regulation, Signaling by Sugars and Phenotyping using Imaging Techniques to Detect Plant Stress
- Reactive Oxygen and Nitrogen Species Signaling under Stress Conditions in Plants

DEPARTMENT OF PHYSIOLOGY AND BIOCHEMISTRY OF THE ANIMAL NUTRITION

- Animal Nutrition
- Small Ruminants Production
- Gastrointestinal Health

DEPARTMENT OF SOIL MICROBIOLOGY AND SYMBIOTIC SYSTEMS

- Biofertilization and Biodegradation by Rhizospheric Fungi
- Structure, Dynamics and Function of Rhizobacterial Genomes
- Genetics of Phytobacterial Infections
- Plant-Bacteria Interactions
- Nitrogen Metabolism
- Mycorrhiza

DEPARTMENT OF ENVIRONMENTAL PROTECTION

- Environmental Microbiology and Biodegradation
- Plant-Soil Relationships

DEPARTMENT OF BIOCHEMISTRY AND MOLECULAR AND CELLULAR BIOLOGY OF PLANTS

ANTIOXIDANTS, FREE RADICALS AND NITRIC OXIDE IN BIOTECHNOLOGY, FOOD AND AGRICULTURE (ARNOBA)

MEMBERS

Group Leader
José Manuel Palma Martínez

Researchers
Francisco Javier Corpas Aguirre
Eduardo López-Huertas León

Technicians
Mª Jesús Campos Ramos
Carmelo Ruiz Torres

PhD Students
Salvador González Gordo

OVERVIEW

The Group investigates, at the cell and molecular levels, the role of antioxidants, free radicals and nitric oxide in the physiology of horticultural species (pepper, tomato, olive, pea, etc.) for the development of biotechnological tools/strategies, which allow a better exploitation of the nutritional features of these crops. To address these objectives, our Group applies high throughput approaches (transcriptomics, proteomics, and metabolomics), and collaborates with leading companies and foundations in the food and biotechnology sector, such as Syngenta Seeds Ltd., Lactalis Puleva, S.L.U., Deoleo Inc., Agrosol, and Foundation MEDINA. In addition, we carry out research in Arabidopsis and pea, as model plants, to generate basic science knowledge to be further used in the applied objectives of the Group's activity.

This Group started in 1983 and, from the beginning, it focused its objectives on the study of antioxidants and cell signaling by Reactive Oxygen and Nitrogen Species (ROS and RNS) in plants of agronomic interest. Without refusing to basic research, the Group's activity is also aimed at applied research to ease the knowledge transfer to the productive sector. After greatly contributing to the advance of the knowledge, the Group has gained the expertise to potentially exploit it in the Biotechnology and Agro-food fields.

LINES OF RESEARCH

1. Study of the fruit physiology from crop species. Ripening and post-harvest are basically investigated in pepper, tomato and olive, through the analysis of enzymatic and non-enzymatic antioxidants. The involvement of nitric oxide (NO), ROS and RNS in those physiological processes is also accomplished. The influence of these molecules in the quality parameters of the selected products is analyzed as well. To address this objective, whole fruits and subcellular fractions, mainly peroxisomes, are used, and transcriptomic, proteomic and metabolomic approaches are developed.

2. Role of NO and RNS in germination, development and abiotic stress in higher plants. The biochemical and molecular characterization of the endogenous cell targets (proteins, lipids and nucleic acids) involved in post-translational modifications promoted by ROS, RNS and reactive sulfur species is investigated, as well as the analysis of their participation in cell signaling processes during germination and development, and in abiotic stresses (salinity, wounding, high and low temperature, heavy metals and metalloids). *Arabidopsis* and pea are used as model plants, but also pepper, tomato, wheat, rice and olive, and the use of bio-markers induced in those plants in response to the above stress conditions are investigated. These approaches will contribute to the development of strategies and tools for biotechnological applications, which allow modifying the regulation of the germination and developmental processes, as well as the selection of plants more tolerant to several environmental stresses.

3. Search for natural bioactive compounds coming from vegetables with nutritional and biotechnological applications. Due to the Group's evolution, this objective is addressed to the nutritional and biotechnological sectors. New bioactive compounds (capsaicin, proteins and/or peptides, flavonoids, etc.) and antioxidants from tomato, olive and pepper with beneficial health effects, applied

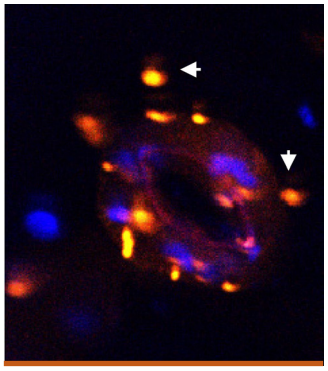
either through biomedical therapies or as dermatological products, are investigated. In connection with the productive sector, our Group carries out the characterization and selection of vegetable varieties especially rich in antioxidants, focused at improving their competitiveness in the markets.

HIGHLIGHTS

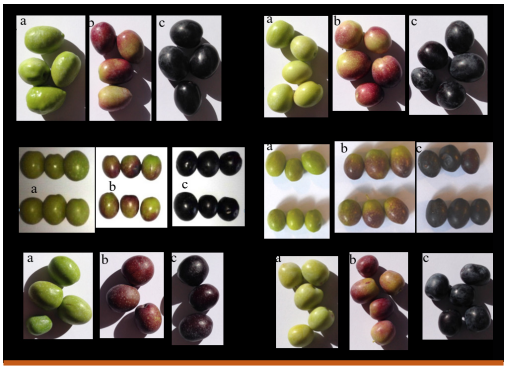
• The research of the Group was top-ranked to be financed by two agencies: the Spanish Ministry of Science and Innovation (Ref. PID2019-103924GB-I00) and the Junta de Andalucía (Spain, P18-FR-1359). These projects will allow the use of high throughput technologies (transcriptomics, proteomics and -metabolomics) and the interaction with leading companies in those fields.

• Our patent on Antihypertensive peptides from olive oil EP15380049/EP1641.1160 has been licenced by the Alodia Farmacéutica, S.L. company.

• Aghdam et al. 2020. Trends in Food Science and Technology, 103: 152-161 is ranked in position 1 in the Food Science and Techonology category. Besides, 8 more articles were published in journals included within the decile 1 (D1), and 11 in quartile 1 (Q1).



Localization (blue) by confocal laser microscopy scanning of hydrogen sulfide in peroxisomes (arrowheads) of guard cells from Arabidopsis.



Varieties and ripening stages of olive fruits investigated in the Group ARNOBA

PLANT REPRODUCTIVE BIOLOGY

MEMBERS

Group Leader
Juan de Dios Alché Ramírez

Researchers
Antonio Jesús Castro López
José Carlos Jiménez López

Technicians
Mª Elena Lima Cabello
Diana Fuensanta Nicolás Llorach
Rafael Nisa Martínez
Alicia Rodríguez Sánchez
Adoración Zafra Álvarez

OVERVIEW

The main goal of the research Group is to advance into the knowledge of the reproductive developmental biology of plants, including model plants (e.g. *Arabidopsis, Lilium*…) and particularly in species of agronomic interest like the olive tree, lupine and argan, in order to further manipulate the plant reproductive cycle improving crop productivity and quality. In addition, we aim to understand the impact of different components from reproductive tissues (pollen, fruit, seed) and other industrial derived products (e.g. oils, flours, isolates, etc.) in allergy, their nutritional and nutraceutical properties, and in the development of molecular tools of agro-food interest. To achieve these objectives, we use multidisciplinary approaches, encompassing integrative omics, and biochemical, molecular and cellular methods, with special emphasis in advanced microscopy techniques. Current research lines include the study of the functional role of reactive oxygen and nitrogen species in developmental physiology, storage lipids and oxylipins in signaling and metabolism during plant reproduction, and the characterization of the potential health benefits of

seed constituents as anti-inflammatory and anti-diabetic molecules. These research lines have also broad practical applications, which are explored through the development of patentable and transferable industrial collaborations.

LINES OF RESEARCH

1. Identification, characterization and functional analysis of gene products involved in the development of flower, pollen, pistil, seed, and the germination and growth of the pollen tube. Analysis of the cellular and molecular basis of self- and cross- pollination. Signaling mechanisms involved in orientation and focused growing of the pollen tube.

2. Characterization of seed storage proteins and other proteins of interest in the olive seed, and in new by-products resulting from the alternative processing of the olive fruits and other species of agronomical interest. Identification of proteins in olive oils. Description of protein-derived components (protein isolates, digests, peptides…) and applications to alimentary or pharmaceutical use.

3. Allergy to olive pollen, pollen grains from other species and allergens from seeds involved in food allergy and pollen-food syndromes. Molecular allergology: isolation and characterization of allergenic proteins, including panallergens like profilin, lipid transfer proteins, polcalcins, glucanases… Characterization of genetic and functional variability of allergens, and its physiological and clinical implications. Development of advanced molecular techniques for allergy diagnosis and therapy and allergens detection and quantitation.

4. Proximal characterization of new foods derived from plant reproductive tissues and assessment of their nutritional value and potential toxicity in animal models, including mouse and zebrafish.

5. Assessment of the immunological, antioxidant, antiinflammatory, antidiabetic and other nutraceutical effects of new agri-food components of high biological value derived from the alternative processing of olive, lupinus, argan, and other plant reproductive tissues on healthy and pathological human adults through in vivo nutritional interventions and *ex* vivo assays.

HIGHLIGHTS

• Identification and characterization of olive seeds components of interest for the agri-food industry and with healthy properties (Ref. Junta de Andalucía, P18-RT-1577).

• Overview of glutathione-dependent redox state of reproductive tissues in Arabidopsis thaliana using multidisciplinary approaches (García-Quirós et al. 2020. Journal of Experimental Botany, 71: 730-741).

• A detailed analysis of the unique lipid composition of olive pollen and a transcriptomic analysis of lipid metabolism through pollen maturation and germination (Hernández et al. 2020. Plant and Cell Physiology, 61: 1348-1364).

• Edition of a Special Issue of "Frontiers in Plant Science" (Lausanne: Frontiers Media SA. Journal): "Legumes for Global Food Security" A collection of 37 original contributions.

Bagging olive inflorescences for mature pollen collection, at the EEZ

Transmitted light photomicrograph of Lilium longiflorum pollen grains (bar: 20 μm)

ION HOMEOSTASIS AND MEMBRANE TRANSPORTERS

MEMBERS

Group Leader
Andrés Belver Cano

Researchers
Mª Pilar Rodríguez Rosales
Cornelis Venema

Technicians
Jesús Espinosa Rodríguez
Paloma González Fernández
Mª Elena Sánchez Romero

OVERVIEW

We use an integrated approach to study the biochemical and molecular mechanisms of ion homeostasis in plants in order to develop biotechnological applications to improve salt tolerance, mineral nutrition and water use efficiency in crop plants. The ongoing research makes special emphasis on the functional characterization of ion transporters in economically important crops, as tomato and citrus, and model organisms, such as *Arabidopsis* and yeasts. In our Group we develop two separate research lines. One of the lines uses a genetic and molecular approach focusing on quantitative traits (QTL) of agronomical interest functionally supported by ion transporters. Thus, we study the function of ion transporter encoding genes (HKT, NPR, etc.) that control the exclusion of Na^+ and C^-, as functional determinants of QTLs or loci, which control salt tolerance in tomato and citrus rootstock-mediated fruit production. The identification of genes that functionally underly QTLs by combining QTL mapping, candidate gene analysis and reverse genetics (RNAi, CRISPR/Cas, OEX), facilitates their monitoring in genetic improvement programs (genomic selection or their manipulation through genetic engineering) in order to obtain tolerant plants to abiotic stress or their use as rootstocks of commercial varieties. Another approach deals with the functional characterization of ion transporters at the biochemical and molecular level. We study ion transporters involved in regulating proton, potassium and chloride gradients that play primordial roles in photosynthesis. Currently we study the role of chloroplast KEA K^+/H^+ antiporters in photosynthesis efficiency in *Arabidopsis* and characterize the function of the tomato KEA1,2 homologue using transgenic plants in which these genes are disrupted by CRISPR/Cas. Inhibition of photosynthesis contributes substantially to the negative effects of abiotic stresses like salinity, drought or K^+ deficiency on crop productivity. In this context we are performing a characterization of K^+/H^+ and Na^+/H^+ antiport in chloroplasts of halophytic and salt tolerant species.

LINES OF RESEARCH

1. Analysis of genetic factors related to ion homeostasis by identifying genes that encode Na^+ and Cl^- transporters involved in salt tolerance in terms of fruit yield in tomato and citrus.

2. Study of the molecular basis of ion transport (Na^+, K^+, Cl^-, Ca^{2+}) across chloroplast membranes of glycophytic and halophytic species and their relevance for chloroplast function and photosynthesis under normal and stress condition.

HIGHLIGHTS

- KEA1 and KEA2 mediate specific K^+/H^+ antiport at the chloroplast envelope membrane and are critical for the rapid down-regulation of stromal pH especially during light–dark transitions (Aranda-Sicilia *et al.* 2020. New Phytologist 229: 2080-2090).

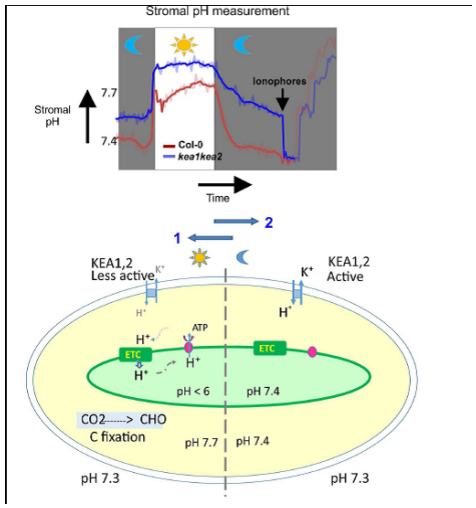
- Removal of the autoinhibitory N-terminal domain of yeast vacuolar cation/H^+ exchanger Vnx1p has a pronounced effect on yeast salt tolerance and vacuolar pH. Expression of this truncated *VNX1* gene also improves *Arabidopsis* salt tolerance thus suggesting a biotechnological potential of activated Vnx1p to improve salt tolerance of crop plants (Cagnac *et al.* 2020. *Yeast*, 37: 173-185).

- Overexpression of LeNHX4 in tomato increases size, sugar (glucose and fructose) and ion (Na^+ and K^+) contents of fruits and enhanced fruit yield under both non-stress and salinity stress conditions (Maach *et al.* 2020. *Molecular Biology Reports,* 47: 4145-4153).

- Na^+ transporter HKT1;2 protects the flower against Na^+ toxicity and mitigates the reduction in tomato fruit yield under saline conditions (Romero-Aranda *et al.* 2020. *Plant Physiology and Biochemistry,* 154: 341-352).

• Participation in the Project Thylakoid ion flux-linking photosynthetic efficiency with osmotic stress response (ERA-CAPS Flux4LIVES). Project Leader: Dr. Ute Armbruster, Max Planck Institute Potsdam, Germany. Participants of the Group: Dr. Kees Venema. 2019-2021. (http://www.eracaps.org/joint-calls/era-caps-funded-projects/era-caps-third-call-–-2017/thylakoid-ion-flux-linking).

Tomato lines silenced in the Na^+ transporter-encoding gene HKT1;2, which controls Na^+/K^+ homeostasis in the aerial part, showed a salt-hipersensitive phenotype as grown under saline conditions in a commercial greenhouse



A working model for Arabidopsis KEA1 and KEA2 function in stroma pH regulation. Upon transition from dark to light, light-driven electron transport chain (ETC) acidifies the thylakoid lumen and causes alkalinization of the stroma. Upon transition from light to dark, the electron transport stops, and pH gradients are dissipated. Our results show that the stroma is predominantly neutralized by KEA1 and KEA2 via rapid influx of protons from the cytosol in exchange for K^+

REDOX REGULATION, SIGNALING BY SUGARS AND PHENOTYPING USING IMAGING TECHNIQUES TO DETECT PLANT STRESS

MEMBERS

Group Leader
Antonio Jesús Serrato Recio

Researchers
Matilde Barón Ayala
Mariam Sahrawy Barragán

Technicians
Eduardo Flores Ruiz
Tamara Molina Márquez
Mª Luisa Pérez Bueno
Mónica Pineda Dorado
Paola Andrea Vargas Gallego

OVERVIEW

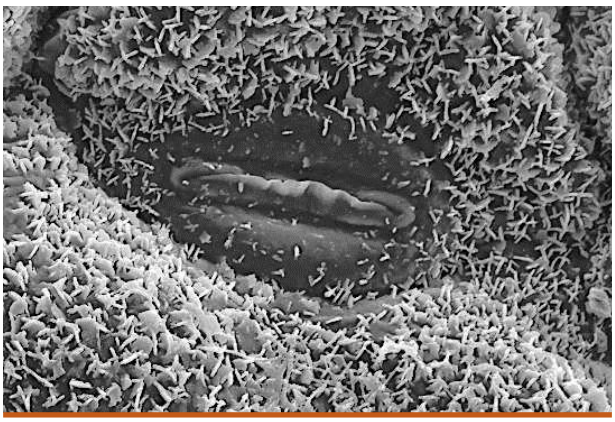
Plants are vital for sustaining a continuously growing global population. Additionally, global warming is threatening crop production and, in the last years, it has become a main concern for governments and the scientific community. Understanding regulatory mechanisms, by which plants adapt to environmental changes, together with the development of big-data based tools, to monitor crops productivity with non-invasive techniques, are crucial to mitigate climate changes consequences. These complementary approaches are well represented in the two sub-lines of our research: Redox Regulation and Plant Phenotyping.

LINES OF RESEARCH

1. We investigate the redox regulation carried out by plastid thioredoxins (TRXs) and the photosynthetic processes involved in maintaining redox homeostasis. We also study carbon metabolism and sugar biosynthesis and signaling. Our aim is to gain more insight into the regulation and biochemical features of the enzymes controlling sucrose and starch accumulation in plants. The functions of the key plastid redox proteins TRXs *f* and *m* are investigated. Our research interest is focused on plastid processes and how they are redox controlled. In addition to the study of classic redox signaling pathways, we also explore novel redox players including both individual proteins as big photosynthetic complexes.

2. Plant phenotyping is mostly based on imaging techniques: thermography, chlorophyll fluorescence (Chl-F), multicolour fluorescence (MCFI) and hyperspectral reflectance. We investigate plant biotic and abiotic stress provoked by pathogen infections (viruses, bacteria and fungi), parasitic

plants or by challenging environmental cues (high temperatures and CO_2, drought, etc.). We carry out a time-spatial analysis of leaves or fruits for stress detection, identification of developmental stage and mutant characterization. For data handling and analysis, we use machine learning classifiers such as artificial neural networks (ANN), support vector machines (SVM), linear discriminant analysis (LDA) or binary linear regression analyses (LRA), among others. These algorithms learn from known data and make predictions on new data, classifying new samples in given categories, according to the experimental design.



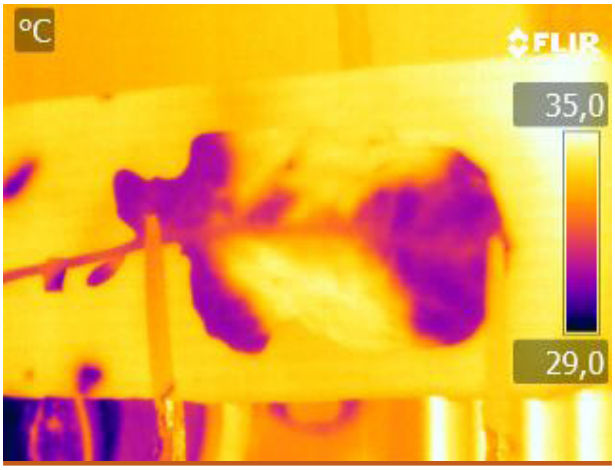
SEM image of soybean (Glycine max) stoma surrounded by epicuticular wax crystals

HIGHLIGHTS

• We have signed a contract with SERVALESA, a Spanish enterprise dedicated to develop plant biostimulants (SERVALESA, 20203213). We have proven the efficacy of a product against thermal stress in three species of fruit trees. SERVALESA belongs to the international player DE SANGOSSE, with more than 23 operating companies.

• Members of our Group have been also involved in an international project to study the redox mechanisms controlling seed aging of European tree seeds (National Science Centre of Poland, OPUS 16 project nº 2018/31/B/NZ9/01548).

• Our Group collaborates with Dr. Eduardo A. Pagano, from The School of Agriculture of the University of Buenos Aires (Argentina). We have investigated the redox mechanisms behind the drought tolerance/sensitivity of soybean varieties obtained in DONMARIO, a leading enterprise in five of the six largest soybean producing countries.



Thermal image of a broccoli leaf infected with the race 4 of Xanthomonas campestris pv. campestris at 9 days post inoculation. The infected areas display a higher temperature than the healthy

REACTIVE OXYGEN AND NITROGEN SPECIES SIGNALING UNDER STRESS CONDITIONS IN PLANTS

MEMBERS

Group Leader
Luisa Mª Sandalio González

Researchers
Adela Olmedilla Arnal
María C. Romero Puertas

Technicians
Aurelio Manuel Collado Arenal
Felipe Luis Pérez Gordillo

PhD Students
Eliana Molina Moya
Mª Ángeles Peláez Vico
Alejandro Rodríguez González

OVERVIEW

In our Group we are interested in unravelling the signaling pathways involved in plant responses to different types of abiotic (heavy metal and xenobiotics) and biotic (*Pseudomonas* and *Fusarium*)

stress with the aim of applying the knowledge obtained to early stress monitoring and design of improved plant breeding strategies. For that purpose, we use multidisciplinary approaches integrating techniques in biochemistry, cellular and molecular biology and bioinformatics.

LINES OF RESEARCH

1. The study of the function of reactive oxygen and nitrogen species as signaling molecules in the regulation of gene expression and plant metabolism, throughout protein post-translational modifications and autophagy processes in response to stress.

2. The study of the role of peroxisomal dynamics (peroxules formation, peroxisomes proliferation and pexophagy) and peroxisomal dependent signaling in both the perception and regulation of cell response to its environment.

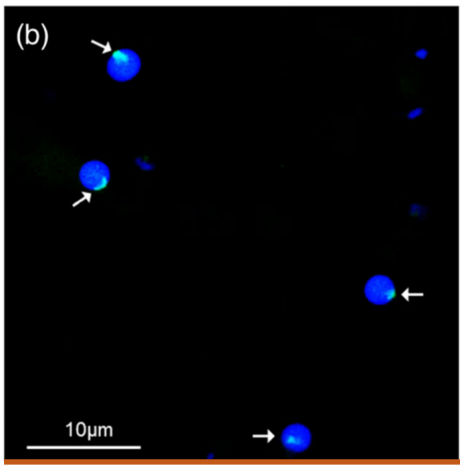
HIGHLIGHTS

• The increase in oxygen and reactive nitrogen (ROS/RNS) species in *Arabidopsis* seedling roots growing under cadmium contamination (Cd) conditions is responsible for oxidative stress and weight loss of plants. An excess of nitric oxide (NO) in seedlings under Cd stress induces oxidative stress, therefore, the levels of NO need to be strictly regulated, and the antioxidant system is essential to prevent damage to the plant (Terrón-Camero *et al.* 2020. *Environmental Pollution*, 256: 113411).

• NO levels regulation is also required for an optimal function of peroxisome and the regulation of signaling derived from these organelles. Thus, NO is essential to regulate not only the proliferation of peroxisomes in response to Cd but also peroxules formation, which are peroxisomal dynamic structures. Therefore, the number and the distribution of peroxisomes in addition to their oxidative metabolism are disturbed in *Arabidopsis* mutants altered in NO production (Terrón-Camero *et al.* 2020. *Plant, Cell and Environment*, 43:2492-2507).

• Peroxisomes can perceive changes in their environment, are involved in signaling and crosstalk between other organelles, and influence cellular decision-making, involving nuclei, mitochondria and chloroplasts, through small molecules, such as H_2O_2, NO, and acetyl-CoA. Sequential changes in the morphology, number and velocity of these organelles contribute to these processes in a complex ROS- and probably NO-regulated manner (Sandalio *et al.* 2020. *Frontiers in Cell and Developmental Biology,* 8: 505.)

• A new plant species tolerant to heavy metals have been characterized in our Group, *Biscutela auriculata* which is capable of growing in mining soils polluted by heavy metals and shows a differential resistance to the metals analyzed, Pb and Cd. Thus, excess Pb produces an increase in seedling vigour, while Cd reduced the growth without affecting the plant biological cycle. The tolerance of this species to heavy metals lies in its ability to regulate the translocation of metals to the aerial part, the development of differential mechanisms of accumulation of metals at the tissue level, the induction of phytochelatines and glutathione and an efficient antioxidant defence. These results indicate that *Biscutella auriculata* could be an interesting plant for the development of phytostabilization for Pb and for phytoextraction techniques in the case of Cd (Peco *et al*. 2020. *Ecotoxicology and Environmental Safety,* 201: 110784; Peco *et al.* 2020. *Chemosphere,* 261: 127721).



Imaging of pexophagy in Arabidopsis leaves after treatment with 100µM $CdCl_2$. Confocal image of leaves from Arabidopsis seedlings simultaneously expressing GFP-ATG8a (green), as a marker of autophagy, and CFP-SKL (blue) to image peroxisomes

Phenotype of the heavy metal tolerant plant Biscutela auriculata in response to Pb 125 µM

DEPARTMENT OF PHYSIOLOGY AND BIOCHEMISTRY OF THE ANIMAL NUTRITION

ANIMAL NUTRITION

MEMBERS

Group Leader
Rosa Mª Nieto Liñán

Researchers
Ignacio Fernández-Fígares Ibáñez
Manuel Lachica López
Isabel Seiquer Gómez-Pavón

Technicians
Alfonso Bartolomé García Écija
Gloria González Cañas
Ana Mª Haro García
Luis Lara Escribano
Miguel Ángel Liñán Fernández

PhD Students
Zaira Pardo Domínguez

OVERVIEW

The activity of the Group is focused on the study of energy and nutrient utilization in non-ruminant, and on the identification of processes and specific compounds involved in the metabolic response to feed intake, including bioaccesibility and bioavailability of nutrients (amino acids, minerals, antioxidant compounds, etc.) using *in vitro*, *ex vivo* and *in vivo* techniques.

The research activity is nowadays focused on pigs and it is carried out mainly on native breeds (Iberian pig), known to have a wide genetic variation and high adaptability to local production systems. These breeds give rise to high-quality products with regional identity and highly appreciated by consumers. However, autochthonous breeds show comparatively lower productivity than the modern, high yielding, commercial breeds. In this way, a contribution to the preservation and development of the diversity of local breeds will also be achieved. On the other hand, the efficiency of livestock production systems will be optimized by accurately defining the nutritional requirements of these local breeds and by increasing the quality and nutritional value of their products, while decreasing the environmental footprint associated. Whenever possible, local feeding resources and by-products will be involved in practical feeding and production systems. The effects of climate change, particularly, heat stress effects on productive and physiological traits of growing Iberian pigs is currently under investigation.

LINES OF RESEARCH

1. Data base on nutritional requirements of native porcine breeds with additional information on new native strains, mainly linked to the Iberian trunk.

2. Effects and mechanism of action of substances with biological activity naturally present in feedstuffs or incorporated. Focus on additives which may alter the efficiency of nutrient utilization and the quality and healthy properties of animal products.

3. Use of local feeding resources and agroindustrial by-products as ingredients in practical balanced diets for swine.

4. Effects of innovative management practices on productivity, animal welfare and product quality of local porcine breeds.

5. Impact of heat stress on physiology and productivity of growing Iberian pigs, as well as the use of nutritional strategies to mitigate its detrimental effects.

HIGHLIGHTS

• Heat stress is a major concern in pig production in summer. Above 25°C pigs are out of their comfort zone and mechanisms such as decreasing feed intake are triggered. Intestinal microbiota is also affected but the consequences on fermentation capacity are poorly known. Short-chain fatty acids are the end-products of bacterial metabolism of carbohydrates and protein and, in addition to being an energy source, they have beneficial effects on immune status and health. By using an *in vitro* model, we proved that chronic heat stress increased short-chain fatty acid production, which

favors gastrointestinal health (Pardo *et al.* 2020. *Animals,* 10: 2173).

• Editorial contribution that reviews the concept of antioxidants in foods and highlights the different antioxidant pathways on animal tissues and plants. Molecular mechanisms of dietary antioxidants and the role of food antioxidants in the prevention of health are summarized (Palma *et al.* 2020. *Antioxidants*, 9: 1234).

• In the case of carnivorous predators, it is thought that nutritional composition does not influence foraging strategies. In this collaborative paper the influence of abundance, size, difficulty of capture, gross energy and nutritional composition of prey species on the foraging behaviour of a predator species, the common kestrel *Falco tinnunculus*, was investigated. The results show that preferred prey take longer to be provisioned and it is also shown that specific nutritional components, such as protein and amino acid contents, are likely to explain food preference in this carnivorous-insectivorous species (Fargallo *et al.* 2020. *Scientific Reports,* 10: 7583).

• Cowpea (*Vigna unguiculata*) is among the most cultivated legumes, with interesting agronomic and environmental properties, and great potential as a nutritious food. The nutritional value of cowpea may be improved by technological processing. In this study, we showed that natural fermentation improved bioavailability of protein, amino acids, and dietary essential minerals from cowpea in growing rats, thus strengthening its potential value as functional food or food supplement. (Kapravelou *et al.* 2020. *Nutrients,* 12: 2186).

• Composition of macrominerals and trace elements of eighteen edible wild-growing mushrooms from the Spanish southeast was analyzed for the first time, showing the different abilities of species grown in the same area to uptake minerals from soil. Estimation of contribution of mushrooms consumption to the daily recommended mineral intake was provided (Haro *et al.* 2020. *Journal of Food Composition and Analysis,* 91: 103504).

Iberian growing pigs in outdoor facilities at the Dept.of Physiology and Biochemistry of Animal Nutrition

SMALL RUMINANTS PRODUCTION

MEMBERS

Group Leader
Eduarda Molina Alcaide

Researchers
Alejandro Belanche Gracia
A. Ignacio Martín García
David R. Yáñez Ruiz

Technicians
Pablo Ignacio Fernández Hernández
Julia Eugenia Fernández Yepes
Alfonso Bartolomé García Écija
Elisabeth Jiménez Jiménez
Isabel Mª Jiménez Romero

PhD Students
Juan Manuel Palma Hidalgo
Pedro Jesús Romero Márquez

OVERVIEW

The activities focus on the nutrition of the ruminant and work on develop feeding strategies to lower the cost of the diet and paying special attention on the optimization of the ruminal fermentation. Identifying the main mechanisms of action of those rumen microorganisms involved in methane production and fatty acids biohydrogenation are key areas of work in the Group. The activity of the Group fits within some pillars of the

priority areas of H2020: Food Security, Sustainable Agriculture and Forestry, Maritime Research and Bioeconomy, Climate change and energy sustainability, and Blue Growth.

The Group has four major objectives: 1) Nutritional evaluation of conventional and non-conventional foods (by-products, wastes, algae) as a strategy to reduce the cost of feeding ruminants, to improve animal health and to optimize ruminal fermentation. The cost of the diet represents 70-80% of the total cost of production. The use of non-conventional ingredients could help to achieve this goal. The supply of diets that include by-products, wastes or algae can have added value by improving animal health and welfare and the quality of meat, milk and dairy products and by reducing the production of methane, a greenhouse gas; 2) Study of the effects and mechanisms of action of additives (plant extracts, essential oils, synthetic compounds, secondary compounds) and probiotics on the utilization of nutrients, fermentation and ruminal microbiota. According to a recent EFSA report, the use of antimicrobials in animals far exceeds European recommendations, especially in Italy and Spain. Developing alternatives to maintain healthy and profitable animal production is critical in the coming years; 3) Study of the potential of *in vitro* technologies to simulate ruminal fermentation and reduce the use of experimental animals; 4) Evaluation of the factors involved in the microbial colonization of the rumen in early stages of ruminant life and the microbiome specificity of the host to develop nutritional interventions that allow programming the microbial ecosystem and the efficiency of the animal in adulthood.

LINES OF RESEARCH

1. Metabolism of nutrients and energy: productive and health beneficial aspects.

HIGHLIGHTS

• The Spanish Excellence Network NUEVA: Network for Updating Emissions Values in Spanish Agriculture (Plan Estatal, Red de Excelencia, AGL2017-90924-REDT), led by the Group organized a webinar on the 21st May 2020 to present the newly published 'Zootechnical Documents' by the Spanish Ministry of Agriculture. During the webinar the main characteristics of the Spanish GHG National Inventory was presented, together with the Documents for sheep, dairy and beef cattle. 180 people attended the event (https://www.rednueva.es/webinar-mayo-2020/)

• We have published a meta-analysis describing for the first time the effects of an additive based on a blend of essential oils (Agolin Ruminant) on a range of parameters in dairy production systems. The study used data from 23 trials and concluded that, despite not having a mode of action fully described, its use represents an interesting strategy to improve farm efficiency and reduce GHG emissions (Belanche *et al.* 2020. *Animals*, 10: 620).

• A mixture of corn dried distillers grains with solubles, dried citrus pulp and extracted olive cake replaced 44% of cereal grains and protein feeds in the concentrate for dairy goats without compromising nutrient utilization or ruminal fermentation and resulted in greater milk fat and protein production as well as a more unsaturated milk FA profile. This dietary strategy contributes to provide nutrients sources for livestock and has environmental benefits (Marcos *et al.* 2020. *Journal of Dairy Science,* 103: 1472-1483).

• The use of diets including seaweeds in ruminant feeding could be an alternative to conventional diets. The potential of as source of protein *Porphyra sp* was studied *in vitro* and *in vivo* in comparison with soybean meal and low impact on ruminal fermentation and methane production as well as similar growth rates of lambs were observed confirming the high-quality protein of the seaweed *Porphyra sp* in ruminant feed (Lind *et al.* 2020. *Animals,* 10: 79).

• We also highlight the continuity of two large-scale European projects: MASTER: Microbiome Applications for Sustainable food systems through Technologies and EnteRprise (H2020 LC-SFS-03-2018/EU189746_31), and iSAGE: Innovation for sustainable sheep and goats Production in Europe (RESEARCH & INNOV H2020-FOOD/0157-EU154338_01). In addition, two new projects have been granted in 2020 in European calls, that will start in 2021.

Goat kids

GASTROINTESTINAL HEALTH

MEMBERS

Group Leader
Luis Ángel Rubio San Millán

Researchers
Alfonso Clemente Gimeno
Cristina Delgado Andrade
Raquel Olías Sánchez

Technicians
Lesly Arbesu Fernández
Antonia Felipe Reyes
Mª Carmen Marín Manzano

OVERVIEW

The research activity of the Group of Gastrointestinal Health focuses on the study of aspects such as the digestive and metabolic use of nutrients, and the physiological effects at the local (intestine) or systemic level of food chemical fractions (proteins, carbohydrates, fibre, etc.). Through a multidisciplinary approach, special attention is paid to the study of the mechanisms of action and biological effects, both nutritional and/or non-nutritional, of active substances either present in food or added to the diet.

LINES OF RESEARCH

1. Study the nutritional use, biological effects and digestive behaviour of legume food proteins (peas, chickpeas, lentils, among others) and compounds with putative biological effects (e.g., protease inhibitors, oligosaccharides) involved in the prevention of inflammatory and carcinogenic processes within the gastrointestinal tract by using *ex vivo*, *in vivo* (rodents) and *in vitro* (cell models, faecal homogenates) approaches.

2. Study the correlation between variations in the composition of the digestive microbiota and specific physiological, health and productive parameters in productive birds (broilers).

3. Develop *in vitro* digestion and colonic fermentation models designed to investigate the relationships between structure, protein digestibility and antigenicity, as well as carbohydrate fermentability, nutrient availability, bioaccesibility of processing contaminant and survival of probiotic strains.

4. Evaluate the prebiotic potential of oligosaccharides of different origin, both natural and from enzymatic synthesis, and their biological activities.

5. Develop mathematical models (R programming) capable of simulating intestinal bacterial growth.

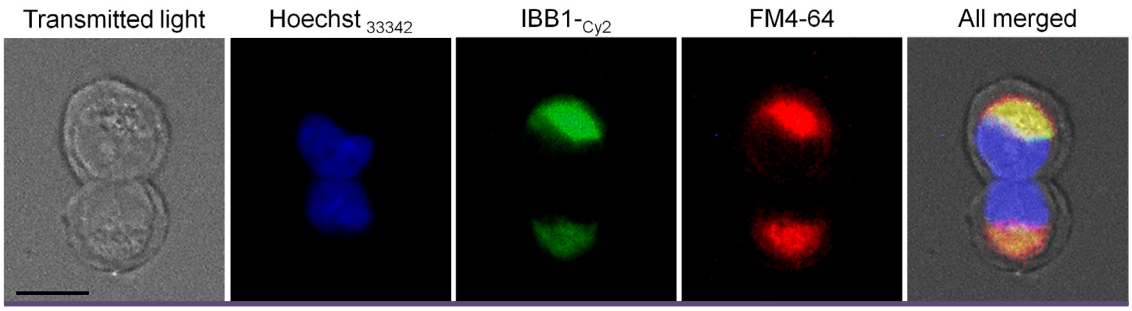
Legume seeds and their derived products as source of nutrients and bioactive compounds. (The picture is published under permission of José Ramón Fernández)

HIGHLIGHTS

• Alfonso Clemente and collaborators have revealed the interest for naturally-occurring oligosaccharides from plant origin having prebiotic properties, with special focus being paid to supplemented products for infants. In this study, results suggest that non-fructosylated beta-galactooligosaccharides from peas could be used as potential ingredient in infant formula supplemented with prebiotic oligosaccharides (Marín-Manzano *et al.* 2020. *Foods,* 9: 921).

• Luis A. Rubio was joint first author of this work which was carried out at The Rowett Research Institute (Aberdeen, UK) thanks to a Salvador de Madariaga scholarship from the Spanish Ministry of Education. New experimental and theoretical evidence was presented to establish the combined major impact of pH, lactate concentration and the presence of lactate utilizing bacteria on the stability of human gut-derived microbial communities (Wang *et al.* 2020. *mSystems,* 5: e00645-20).

• Alfonso Clemente was the Chairman of the XI Workshop of the Spanish Society of Microbiota, Probiotics and Prebiotics (SEMIPyP; www.semipyp.es) that took place from 12th to 14th February 2020 at the Conference Hall in Granada. This meeting was attended by more than 350 participants and 30 pharmaceutical companies, as well as the presence of national and international speakers who addressed many current topics of great interest such as the gut-brain axis, fecal transplantation, the role of microbiota in health and disease, etc.



Mechanism of IBB1 (green) internalization into human colorectal cancer HT29 cells. Nuclei were stained with Hoechst 33342 (blue). The endocytic tracer FM 4-64 (red) was added to the culture medium at the onset of theexperiment. HT29 cells were imaged after 120 min of culture. Bar = 10 µm. (Castro et al., 2020)

DEPARTMENT OF SOIL MICROBIOLOGY AND SYMBIOTIC SYSTEMS

BIOFERTILIZATION AND BIODEGRADATION BY RHIZOSPHERIC FUNGI

MEMBERS

Group Leader
José Manuel García Garrido

Researchers
Alberto Bago Pastor
Inmaculada García Romera

Technicians
Custodia Cano Romero
Tania Ho Plágaro
Nuria Molinero Rosales
Mario Paniagua López
Gloria Andrea Silva Castro
Mª Isabel Tamayo Navarrete

PhD Students
Jonathan David Avilés Cárdenas
Martín Ramos-Alvelo Cancellieri

OVERVIEW

Arbuscular mycorrhiza (AM), established between the endosymbiotic AM fungi and higher plants, is the most widespread symbiosis in the plant kingdom. In the cortical cells of the roots, the AM fungi develop specialized intraradical and highly branched structures, called arbuscules, where bidirectional exchange of nutrients between plant and fungi partners occurs. During the establishment of the symbiosis, the interaction is highly regulated by both partners at the cellular, molecular and genetic levels. Research in this Group is particularly focused on the improvement of the Arbuscular Mycorrhizal symbiotic association in order to optimize plant nutrition.

We use a broad range of approaches, technologies and experimental systems to investigate the phenomenon of compatibility between plants roots and AM fungi that implies the elucidation of the recognition mechanisms and molecular signaling and regulatory events involved in AM formation, especially in the development and turnover of arbuscules.

AM fungi establish relationships with other soil microorganisms, particularly saprobic fungi, and research in the Group addresses questions related to how this relationship can alleviate abiotic stresses such as heavy metals, and examines a range of biological activities of saprobic fungi related to degradation of phytotoxic compounds in order to valorize agricultural waste, particularly from the olive oil industry, as bio-stimulatory fertilizer and contaminant adsorbent.

Other research in the Group focus on the design, formulation and production of mycorrhizal ultra-pure inoculants and biostimulants, such as the unique, patented gel-type products, nowadays commercialized in over 70 countries. The members of the *in vitro* laboratory are co-promoters of two biotechnological companies, and involved on innovative research and technology transfer to SMEs. A particular attention is given to alleviation of heavy metal and other recalcitrant contaminant stresses in plants and soils via autochthonous arbuscular mycorrhizal fungi through tailor-made inoculants.

LINES OF RESEARCH

1. Regulation of the formation and function of arbuscules in Arbuscular Mycorrhiza.

2. Role of the transcription factors of the GRAS family in arbuscule homeostasis and Mycorrhizal autoregulation (AOM).

3. Use of AM and saprobic fungi in the bioremediation of soils contaminated with heavy metals and aromatic hydrocarbons and in the conservation of soil biodiversity.

4. Optimization of the valorisation of agricultural waste from the olive oil industry by saprobic fungi to use as bio-stimulatory fertilizer and adsorbent for soil decontamination.

5. Formulation and production of mycorrhizal ultra-pure inoculants.

6. Alleviation of heavy metals and other recal-

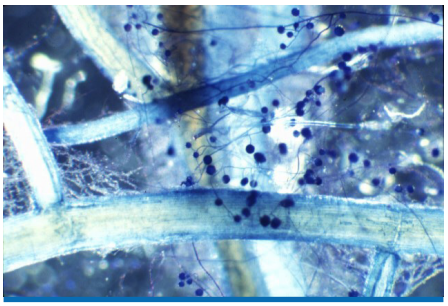
citrant contaminant stresses in plants and soils combining saprobic fungi and autochthonous arbuscular mycorrhizal fungi through tailor-made inoculants.

HIGHLIGHTS

• Important contribution on the use and improvement of *Agrobacterium rhizogenes*-mediated root transformation and hairy root production for functional analysis of plant genes related to arbuscular mycorrhiza symbiosis and straightforward genetic analysis of bacterial wilt disease (Ho-Plágaro *et al.* 2020.

• The application of dry olive residue (DOR) biochar to smelter contaminated soils significantly changed the nutrient and trace element availability to wheat plants (Vejvodová *et al.* 2020. *Journal of Soil Science and Plant Nutrition,* 20: 1067-1079).

• Members of the research Group are involved in the development of two research projects related to the implementation of a bioremediation strategy for soils contaminated by heavy metals based on the use of symbiotic and saprobic microorganisms (REMYCOSOL) (Plan Estatal, RTI2018-094327-B-I00), and in the characterization of plant molecular elements as key regulatory factors to improve Arbuscular Mycorrhizal symbiosis functionality (APOGRASAM) (Plan Estatal, AGL2017-83871-P).



Monoxenic Culture of Arbuscular Mycorrhizal Fungi. Fungal mycelium and mature spores are observed after trypan blue staining

STRUCTURE, DYNAMICS AND FUNCTION OF RHIZOBACTERIAL GENOMES

MEMBERS

Group Leader
Nicolás Toro García

Researchers
Manuel Fernández López
José Ignacio Jiménez Zurdo
Francisco Martínez-Abarca Pastor

Technicians
José Mª del Arco Martín
Antonio José Fernández González
Fernando Manuel García Rodríguez
Ascensión Martos Tejera
Mª Dolores Molina Sánchez
Pablo José Villadas Latorre

PhD Students
Natalia Isabel García Tomsig
Alejandro González Delgado
Nuria Martín Wentzien

OVERVIEW

The Group focuses its research lines on the ecology of rhizospheric microorganisms and their use in the recovery of degraded soils; in the application of genomic approaches for the study of woody plant microbiomes; the characterization of novel regulatory RNAs in symbiotic microorganisms and finally, in the basic knowledge and biotechnological development of reverse transcriptases in prokaryotes, those associated with CRISPR-Cas systems and others related to novel anti-phage systems.

LINES OF RESEARCH

1. Microbiology of agroforestry ecosystems.

2. Group II introns and bacterial reverse transcriptases.

3. Regulation by RNA in nitrogen-fixing symbiotic bacteria.

HIGHLIGHTS

• A correlation between modifications in the microbial networks of the olive root endosphere and

susceptibility/tolerance to the soilborne pathogen *Verticillium dahliae* was found. Moreover, the pathogen irruption in the microbial networks of sensitive olive suggests a stronger impact on the belowground microbial communities of this cultivar upon inoculation. That is to say, changes in the microbial co-occurrence interactions may explain the differential olive susceptibility to verticilosis (Fernández-González *et al.* 2020. *Microbiome,* 8: 11).

• We found that the retroelements known as retrons generally comprise a tripartite system composed of the ncRNA, the RT and an additional protein or RT-fused domain with diverse enzymatic functions. These retron systems are highly modular, and their components have coevolved to different extents. Based on the additional module, we classified retrons into 13 types, some of which include additional variants. Our findings provide a basis for future studies on the biological function of retrons and for expanding their biotechnological applications (Mestre *et al.* 2020. *Nucleic Acids Research*, 48: 12632–12647).

Olive orchards as agroforestry ecosystems. (Picture by M. Fernández-López)

GENETICS OF PHYTOBACTERIAL INFECTIONS

MEMBERS

Group Leader
Mª José Soto Misffut

Technicians
Lidia Mª Bernabéu Roda
Silvia Moreno Morillas
Virginia Cuéllar Maldonado

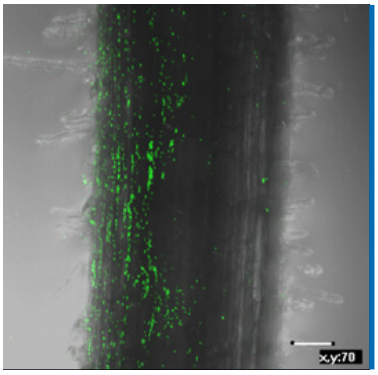
OVERVIEW

The general objective of the Group is to decipher the molecular mechanisms that explain how bacteria are capable of colonizing and infecting plants using the *Rhizobium*-legume symbiosis as a model. We are especially interested in identifying chemical signals and bacterial components involved in the early stages of the interaction and that can affect the colonization of plant tissues, an essential step required for the establishment of both pathogenic and mutualistic plant-bacteria associations. To achieve our goal, we focus our studies on the regulatory mechanisms that control rhizobial life on surfaces and on the role played by bacterial airborne metabolites. The knowledge acquired during these investigations can provide the basis for the development of agrobiotechnological solutions aimed at the control of phytopathogens and/or the production of biofertilizers/biostimulants in the context of sustainable agriculture.

LINES OF RESEARCH

1. Studies of the volatilome of *Rhizobium* and its role in interkingdom communication with plants: Identification of the regulatory mechanisms that affect the volatile profile in rhizobia, the bioactivities associated to the different volatile compounds produced by these bacteria, their mechanism of action and biosynthetic pathways.

2. Identification of the molecular bases responsible for the different types of surface motility exhibited by *Sinorhizobium meliloti* as a strategy to unveil mechanisms with a role in plant colonization.



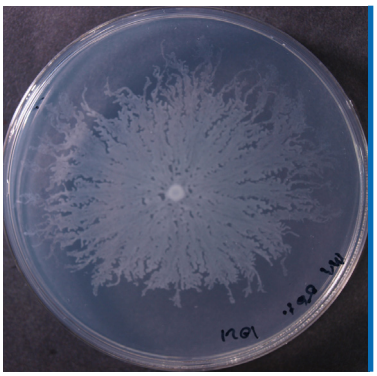
Alfalfa root colonization by GFP-tagged Sinorhizobium meliloti

HIGHLIGHTS

• In collaboration with researchers from the Centro de Ciencias Genómicas (CCG, UNAM, Mexico), an article has been published in the open access journal *Microorganisms*. This work presents evidence indicating that the *fadD* genes of *Escherichia coli* and *Sinorhizobium meliloti* are functionally equivalent and demonstrates that, in both species, FadD activity and therefore fatty acid degradation plays a crucial role in long-term bacterial survival (Pech-Canul *et al.* 2020. *Microorganisms,* 8, 470).

• Lipidic volatiles produced by *Sinorhizobium* (*Ensifer*) *meliloti*: functional analyses, mechanism of action and biosynthetic pathways (PGC2018-096477-B-I00): During the second year of this project, different tasks have been performed to gain insights into the biological role of volatile methylketones produced by *S. meliloti* in the establishment of plant-bacteria interactions, as well as to move forward the understanding of the mechanism of action and synthesis of these compounds.

• 2-tridecanone evaporation system to improve the productivity of crops of agricultural interest under greenhouse conditions: protective effect against phytopathogenic bacteria and evaluation of its potential as a phytostimulant (Invicta Ambientación, S.L., 20196964): The activities contemplated in this R+D+i contract have been accomplished with the aim of evaluating the capacity of a 2-tridecanone evaporation system to improve the health and productivity of plants under greenhouse conditions.



Surface motility exhibited by Sinorhizobium meliloti

PLANT-BACTERIA INTERACTIONS

MEMBERS

Group Leader
Juan Sanjuán Pinilla

Researchers
Mª Trinidad Gallegos Fernández

Technicians
Sebastián Acosta Jurado
Mª José Lorite Ortega
Socorro Muñoz Rodríguez

PhD Students
Ariana Casas Román
Mª Dolores Ferreiro García

OVERVIEW

The general objective of the Group is understanding molecular mechanisms governing bacteria-plant interactions and their biotechnological applications.

LINES OF RESEARCH

1. Identification of bacterial components and plant responses during the establishment of beneficial and pathogenic bacteria-plant associations.

2. Molecular signaling through cyclic di-GMP in mutualistic and pathogenic bacteria-plant interactions.

3. Bacterial pathways involved in signal exchange and infection of the host.

4. Discovery and biotechnological exploitation of bacterial extracelular polymers.

5. Genetic and functional diversity of plant beneficial bacteria.

6. Probiotics for plants.

NITROGEN METABOLISM

MEMBERS

Group Leader
Eulogio J. Bedmar Gómez

Researchers
Mª Jesús Delgado Igeño
Mª Socorro Mesa Banqueri

Technicians
Alba Hidalgo García
Andrea Jiménez Leiva
Germán Tortosa Muñoz

PhD Students
Pedro José Pacheco Márquez
Sergio Parejo Treviño

OVERVIEW

To gain knowledge about denitrification usingthe endosymbiotic bacterium *Bradyrhizobium diazoefficiens* as a model to study the process both in free living-conditions and in symbiosis with legumes. For this purpose, the integrated study of the environmental factors, genes and enzymes, and oxidation-reduction processes involved in denitrification is contemplated, paying special interest to the identification of the transcriptional regulators that control their expression and activity, and to the characterization of the molecular mechanism of these regulators. On the other hand, the aim is to analyze the metagenome, including the relative abundance, functional diversity and activity of denitrifying bacteria populations in environmental samples, mainly nitrate-contaminated water and sediments. In the plant-bacteria-environment interaction, the Group seeks to establish the N_2 fixation-denitrification interrelationship and to understand the processes, environmental factors and regulatory mechanisms involved in the production of highly reactive nitric oxide (NO) and the potent greenhouse gas nitrous oxide (N_2O) by endosymbiotic bacteria of leguminous plants. These latter serve as a basis for the development of solutions to reduce their emissions in agricultural soils.

LINES OF RESEARCH

1. Study the environmental factors, genes, enzymes and redox processes involved in the denitrification of legume endosymbiotic bacteria.

2. Unravel the molecular mechanisms that control the expression, activity and regulation of denitrification and nitrogen fixation-related processes during symbiosis.

3. Analyse the molecular ecology of nitrifying and denitrifying bacteria in soils, waters and sediments contaminated with nitrates. Effect of nitrogen fertilization.

4. Determine the environmental and regulatory factors involved in reducing the emission of the greenhouse gas nitrous oxide by endosymbiotic bacteria associated witht legumne crops.

HIGHLIGHTS

• Copper in the nitrate-containing mineral solution of soybeans inoculated with *Bradyrhizobium diazoefficiens* produced a significant reduction of nitrous oxide emissions from soybean nodules. This reduction was correlated with Cu accumulation in nodules, which produced a simultaneous decrease of nitrate and nitrite reductase activities, but an increase of nitrous oxide reductase activity in the bacteroids. We propose that the denitrifying nitrate reductase and nitrous oxide reductase enzymes of the bacteroids are effective targets for mitigation of nitrous oxide emissions from soybean nodules (Tortosa *et al.* 2020. *Environmental and Experimental Botany*, 180: 104262).

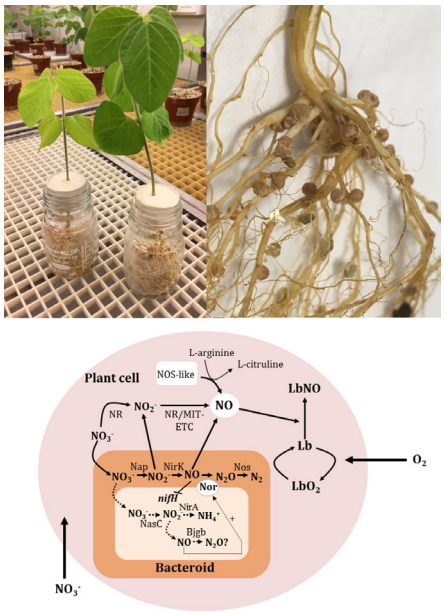
• In a 3-year microcosm study the nitrous oxide emissions from an agricultural soil amended with urea, ammonium sulphate or potassium nitrate were examined. In general, N-fertilisation increased the abundance of bacteria and decreased that of archaea. Soils treated with ammonium or urea emitted more nitrous oxide than that amended with potassium nitrate and produced yearly increases in the abundance of nitrification genes. Also, the abundance of the denitrification genes gradually increased during the experimental period. This work also shows that N-fertilisation decreases soil biodiversity and that its response depends on the type of the N-fertiliser (Castellano-Hinojosa *et al.* 2020. *Applied Soil Ecology,* 145: 103380).

• Reduction of nitrogenase activity and *nifH* expression in nodules of soybeans subjected to

flooding was lower in plants inoculated with *Bradyrhizobium diazoefficiens* lacking the single domain haemoglobin Bjgb than in nodules formed by the wild type strain. We show that these effects are probably due to a higher activity of the denitrifying nitric oxide reductase enzyme in the mutant strain. This avoids NO accumulation, so that the negative effect of NO on nitrogenase is partially prevented (Salas *et al.* 2020. *Frontiers in Microbiology*, 10: 2915).

• Using multilocus sequence analysis we show for the first time that *Retama* species can be nodulated by members of the genus *Microvirga*. A *nodC*-based phylogeny confirmed that *Microvirga* representative strains are affiliated with symbiovar mediterranense (Lamrabet *et al.* 2020. *Symbiosis*, 82: 249-258).

• In a 3-year ammonium sulphate-treated soil, 49.0-58.0% of the nitrous oxide emitted originated from nitrification and 42.0–51.0% from denitrification. Conversely, in the soil treated with potassium nitrate, the ^{15}N isotopic analyses showed that denitrification contributed 84.0–99.0% of the total nitrous oxide produced. The results also showed that values of $^{15}N_2$ enrichment were significantly higher in the nitrate-treated soil. Calculation of the N transformation rates indicated that autotrophic nitrification and denitrification were responsible for nitrous oxide production in the ammonium -treated soil and that denitrification was the most important nitrous oxide source in the soil treated with nitrate (Castellano-Hinojosa *et al.* 2020. *Soil Biology and Biochemistry*, 143: 107757).



Nitric oxide (NO) and nitrous oxide (N_2O) metabolism in soybean nodules

MYCORRHIZA

MEMBERS

Group Leader
Concepción Azcón González de Aguilar

Researchers
Mª del Mar Alguacil García
Ricardo Aroca Álvarez
Nuria Ferrol González
José Luis Garrido Sánchez
Juan Antonio López Ráez
Mª José Pozo Jiménez
Juan Manuel Ruiz Lozano

Technicians
Estefanía Berrio Pozo
Juan Manuel García Ramírez
Olga Mª López Castillo
Sonia Mª Molina Arias
Ana Isabel Molina Santiago
Eulogio Javier Palenzuela Jiménez
Mª Carmen Perálvarez Gutiérrez
Beatriz Sánchez Romera
Ascensión Valderas Jiménez

PhD Students
Laura Dejana
Javier Lidoy Logroño
Víctor Manuel López Lorca
Jorge Prieto Rubio
Alejandro Rodríguez González

OVERVIEW

The Group of Mycorrhiza is interested in aspects of the ecology, physiology, biochemistry, molecular biology and biotechnology of arbuscular mycorrhizal (AM) symbiosis and AM fungi in relation to plant nutrition and health. Special attention is given to the signaling processes in AM symbioses, as well as to their role in plant protection against

biotic (pathogens, pests and parasitic weeds) and abiotic (nutrient deficiency, metal toxicity, salinity and drought) stresses, and to the mechanisms involved in these processes. The diversity of mycorrhizal fungi in natural communities and the plant-fungus interaction networks they establish are also investigated. The final goal is to promote the rational use of mycorrhizas, in association with other soil microorganisms, with the aim of achieving sustained productivity with the minimal disturbance of the environment and in the current context of accelerated climate change.

LINES OF RESEARCH

1. Plant-AM fungi communication: Understanding the molecular signaling in the rhizosphere during the early stages of mycorrhizal colonization. The final goal is the promotion of symbiosis establishment.

2. Mycorrhiza and nutrient transport: Understanding the molecular mechanisms involved in nutrient transport processes in AM symbioses and in the tolerance of AM plants to heavy metals.

3. Mycorrhiza and protection against osmotic stresses: Understanding the physiological and molecular mechanisms underlying the tolerance of AM plants to drought and salinity. Aquaporins regulation by AM fungi in combination or not with other soil beneficial microorganisms.

4. Mycorrhiza and protection against biotic stresses: Understanding the molecular mechanisms by which AM fungi are able to boost plant defence responses making them more resistant/tolerant to diseases and pests.

5. Ecology of mycorrhizas and AM fungi: Studies of the diversity of AM fungi in Mediterranean environments. Factors driving AM fungal communities' assemblages. Life- history of AM fungi. Plant-fungus interaction networks and their implication in the recruitment dynamics in natural plant communities.

6. Interactions of AM fungi with other beneficial microorganisms. Multitrophic interactions. Mechanisms underlying the beneficial effects of PGPR.

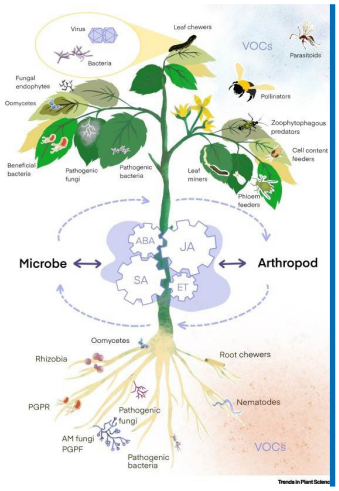


Illustration of multiway interactions between plants, microbes, and arthropods (PMA) and the main signaling pathways orchestrating the corresponding plant responses

HIGHLIGHTS

• Publication of Teaching Tools in Plant Biology featured by the prestigious journal The Plant Cell, entitled "Three-way interactions between plants, microbes, and arthropods (PMA): Impacts, mechanisms, and prospects for sustainable plant protection". It consists in a collection of slides, teaching guide, lecture notes and a section with further reading and questions as a tool for teachers, professors and students interested in understanding the potential applications of plant microbe-insect interactions and the mechanisms regulating them (Pozo *et al.* 2020. *The Plant Cell*, 7: 8699118).

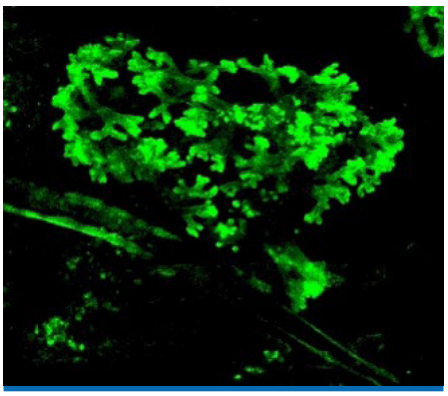
• In collaboration with the University of Turin we have edited a book of the series Methods in Molecular Biology, published by Springer Nature, entitled "Arbuscular Mycorrhizal Fungi: Methods and Protocols", that compiles the most comprehensive and up-to-date collection of cutting-edge protocols used in arbuscular mycorrhizal fungal research. This book will be an ideal tool for biologists specialized in arbuscular mycorrhizal symbiosis, from beginners to experienced researchers in the field (Ferrol and Lanfranco. 2020).

• In the frame of the Innovative Training Network MIRA (H2020-MSCA-ITN-ETN/0359), two early stage researchers (ESRs) from our institute, and 3 ESRs from other European institutions (Koppert Biological Systems, the Netherlands Institute of Ecology NIOO, and the CNRS in France) have been collaborating in our Group this year. All together they carried out a very interesting field experiment to test the benefits of inoculating tomato plants with mycorrhizal fungi and other beneficial microbes under production conditions in the installations of Cajamar, a non profit organization focusing in applied research to improve sustainability in agriculture.

• A new PRIMA project entitled Valorization of Mediterranean small-scale farms by cropping wild unexploited species (Valuefarm-PRIMA) (PCI2020-112091) was initiated. The aim is to valorize Mediterranean small-scale farms by introducing wild edible plants of the Mediterranean as complementary crops within a competitive farming sector and in a context of climate change. The idea is to crop them using sustainable techniques through the implementation of biostimulants, biofertilizers, biopesticides and the use of tailored composts.

• Publication of a study showing for the first time the role of the phytohormones strigolactones as early modulators of plant responses to phosphate starvation. This knowledge will help to develop new agricultural strategies focused on the optimization of phosphorous uptake and use, as well as to reduce the use of chemical fertilizers (Gamir *et al.* 2020. *Plant, Cell and Environment,* 43: 1655-1668).

• A study was published suggesting for the first time the possible role of AM-regulated plant aquaporins in the boron transport and homeostasis. A down-regulation of aquaporins and other B transporters in AM plants was found, which suggest that, when the mycorrhizal fungus is present, other mechanisms contribute to B homeostasis. These are probably more related to the enhancement of water transport, which would concomitantly increase the passive transport of this micronutrient (Quiroga *et al.* 2020. *Plants,* 9: 148).



Arbuscule of Rhizophagus irregularis developed in a rice cortical root cell

DEPARTMENT OF ENVIRONMENTAL PROTECTION

ENVIRONMENTAL MICROBIOLOGY AND BIODEGRADATION

MEMBERS

Group Leader
Silvia Marqués Martín *(until Aug.)*
Miguel Ángel Matilla Vázquez *(since Sept.)*

Researchers
Estrella Duque Martín de Oliva
Manuel Espinosa Urgel
Tino Krell
Marian Llamas Lorente
Mª Isabel Ramos González
Juan Luis Ramos Martín
Ana Segura Carnicero
Pieter van Dillewijn
Regina Michaela Wittich

Technicians
Inés Mª Aguilar Romero
Mª Cristina Civantos Jiménez
Jesús de la Torre Zúñiga
Alicia Inmaculada García Puente
Patricia Godoy Alba
Theodoros Goulas
Patricia Marín Quero
David Martín Mora
Sophie Marie Martirani von Abercron
Lázaro Molina Delgado
Mª Antonia Molina Henares
Daniel Pacheco Sánchez
Mª Luisa Travieso Huertas
Sarah Wettstadt

PhD Students
Ana Ángeles García Franco
Félix Velando Soriano

OVERVIEW

Our research focuses on the interactions between bacteria and their environment, and especially those interactions that are beneficial for the ecosystem, with the final goal of exploiting microbial activities and capacities in a number of biotechnological applications. Using multidisciplinary approaches, we aim to understand the molecular basis for these microbial activities through two main research lines: 1. Understanding the processes that are crucial in the interaction of the bacteria with their environment, such as chemotaxis, motility, antibiotic production, biofilm formation, and cell signaling; 2. Improving bacterial biodegradation capacities to implement efficient bioremediation strategies or recycling to produce added-value chemicals.

Within the first line of research, we use bacteria of the genus *Pseudomonas* as model systems. The root-colonizing strain *Pseudomonas putida* is our model to analyse relevant mechanisms involved in plant-microbe interactions in the rhizosphere, such as the development of biofilms during root colonization, the chemotactic response towards root exudates components and signaling pathways between bacterial cells or with the plant. We analyse the role of surface determinants (exopolysaccharides, adhesins and other extracellular proteins) in planktonic and sessile bacterial populations, and how the levels and transduction of the second messenger cyclic diguanylate modulates the switch between lifestyles. The human opportunistic pathogen *Pseudomonas aeruginosa* is our model to study host-pathogen interactions, in particular those required for the infection process, with the ultimate goal of finding new antimicrobial compounds that block such interactions and therefore bacterial virulence. Using these bacteria, we study different mechanisms by which bacteria sense environmental and host signals, including chemosensory pathways, one- and two-component systems, and cell-surface signaling systems. Sensory mechanisms currently studied modulate a number of important bacterial functions like chemotaxis, biofilm formation, stress responses, iron uptake, virulence and synthesis and degradation of antibiotics. The identification of environmental signals which define different features of bacterial physiology, and of the specific signal molecules that interact with the sensor proteins, is a necessary requisite for diverse biotechnological applications.

Our research on biodegradation especially targets mono- and polycyclic aromatic hydrocarbons, nitroaromatics, and polychlorinated aromatic compounds, as well as pesticides, among others.

We are looking for novel aerobic and anaerobic pathways, their genetic determinants, and the molecular mechanisms controlling their expression. The objectives include the construction of improved strains through metabolic engineering and the molecular analysis of pathway enzymes and regulatory proteins. We are using synthetic biology approaches to export the metabolic diversity to produce from wastes aromatic compounds of industrial interest. We are also interested in the bacterial diversity of polluted and pristine sites to investigate the response of microbial communities towards environmental changes and explore them as a source for new activities of biotechnological relevance using metagenomic approaches.

The biological control of pathogens, pollutant elimination and phytoremediation are potential applications of our research.

LINES OF RESEARCH

1. Biofilm and plant-Pseudomonas interactions.

2. Bacterial sensing and signal transduction, in particular chemotaxis.

3. Signal transduction by cell-surface signaling systems and virulence.

4. Anaerobic biodegradation, pathways and regulation.

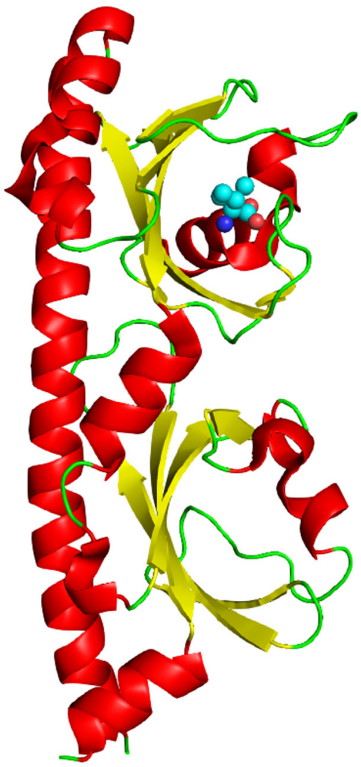
5. Aromatics and pesticide biodegradation, metabolic engineering.

6. Biodegradation and biodiversity.

7. Rhizoremediation and synthesis of biofuels.

8. Biosynthesis of added value compounds and polymers, and circular economy.

9. Bacterial signaling, antibiotic production and regulation in phytobacteria.



Three dimensional structure of the ligand binding domain of the PctA chemoreceptor from Pseudomonas aeruginosa PAO1 in complex with isoleucine. The structure has been published in Gavira et al. (2020) mBio 11: e03066-19

HIGHLIGHTS

• The evolutionary history of the *Pseudomonas aeruginosa* PctA, PctB and PctC paralogous chemoreceptors that respond to different amino acids was determined. We solved the three-dimensional structures of the sensor domains of these 3 receptors in complex with their ligands, which revealed the detailed changes in molecular recognition during their evolution. This article represented a multidisciplinary study carried out in collaboration with national and international world leader researchers (Gavira *et al.* 2020. *mBio,* 11: e03066-19).

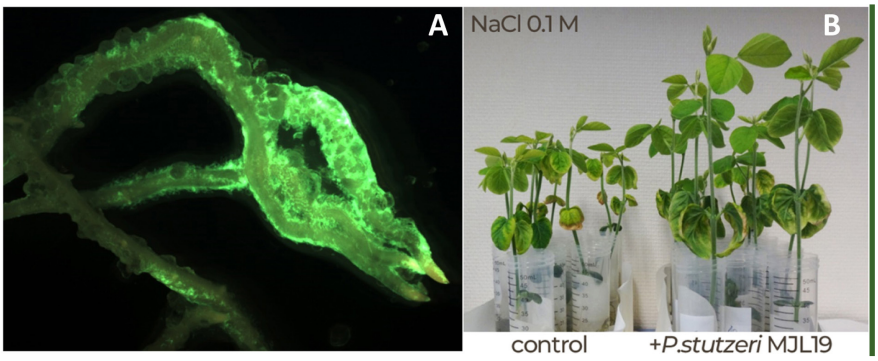
• The effect of three emerging contaminants related to Pharmaceutical and Personal Care Products were studied in biopurification systems. It was found that triclosan took longer to dissipate and had a stronger effect on bacterial communities and ecotoxicity when compared to ibuprofen or diclofenac but these effects were altered when the contaminants were applied as mixtures (Aguilar-Romero *et al.* 2020. *Science of the Total Environment,* 741: 140461).

• Udaondo *et al.* 2020. *Environmental Microbiology,* 22: 3561-3571: This work uses metadata analysis of acid phosphatases (APs) in soil and aquatic

environments. Based on the "PROFILES_SIB" programme, three large families of APs were detected; one associated with pathogens and two families of ubiquitous proteins. Functional analysis revealed that within the APs, enzymes can be distinguished that function in narrow (i.e. 3.5 to 6) or wide (i.e. 3 to 10) pH ranges. The study highlights the importance of APs as phosphorus mobilisation agents and their environmental relevance.

• Biofilms and plants colonization by beneficial and pathogenic bacteria: environmental and metabolic signals, regulation by c-di-GMP and relevance in plant protection (Plan Estatal, PID2019-109372GB-I00): The objective of the project is to analyse the molecular mechanisms that determine the lifestyle of plant-associated bacteria in three microorganisms of agricultural interest, including phytopathogenic, biocontrol and plant-growth promotion bacteria. The project includes in the team prestigious international researchers from the USA and Argentina, and is part of the activities of the CSIC *Xylella* Platform.

• TRACE-Soils: Mechanisms underlying TRAde-offs between Carbon sequestration, greenhouse gas Emissions and nutrient losses in Soils under conservation agriculture in Europe (European Project, H2020-FOOD/0648): The overall project aims to perform a correlation analysis between soil physico-chemical properties and soil health, focusing on the factors involved in the C, N and P cycles. The project covers a cross-sectional series of long-term trials on a transverse axis from Spain to the Scandinavian countries. The EEZ studies focus on P mobilization by plant growth promoting bacteria.



Root colonization (A) and plant growth promotion (B) by the rhizospheric bacterium Pseudomonas stutzeri MJL19 under saline stress

PLANT-SOIL RELATIONSHIPS

MEMBERS

Group Leader
Rogelio Nogales Vargas-Machuca

Researchers
Emilio Benítez León
Esperanza Romero Taboada

Technicians
Rafael Alcalá Herrera
Celia Cifuentes Urién
Laura Delgado Moreno
Mª Luisa Fernández Sierra
Beatriz Moreno Sánchez

PhD Students
Lisanne Smulders

OVERVIEW

The Group of Plant Soil Relationships (PSR) was created in 1989. The main research goals of this research Group is generate basic and applied knowledge, within the framework of a circular and a green economy, contributing to the protection of soil, water and crops through the use of low-cost agro-environmental technologies and the promotion of agrosystems by sustainable alternatives. This is approached from a triple perspective: 1) the development of biotechnological processes for recycling and reusing of organic and inorganic wastes, 2) the development of low-cost biotechnologies for the prevention and protection of soils and waters against diffuse and punctual pollution induced by organic pollutants (pesticides,

emerging pollutants), and 3) the development of methods for the sustainable management of agrosystems and their implication in the maintenance of multiple ecosystem services. For these approaches, innovative field, chemical, enzymatic and molecular biology tools are used at different spatial scales.

LINES OF RESEARCH

1. Aerobic bioconversion of organic wastes into value-added products.

2. Low-cost remediation technologies for minimizing environmental pollution.

3. Identification of agricultural practices for the maintenance of multiple ecosystem services.

HIGHLIGHTS

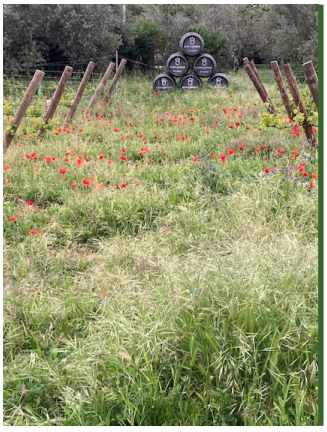
• We have shown for the first time the effects of emerging contaminants such as pharmaceutical and personal care products (PPCPs) on bacterial ecotoxicity and diversity in biopurification system microcosms and also facilitates the design of further applications of biomixtures to eliminate PPCPs. Our study showed that diclofenac dissipation rate was reduced in the presence of the other PPCPs. Ibuprofen and diclofenac increased while triclosan lowers bacterial diversity. Triclosan had the largest negative effect on bacterial viability and dominant bacterial taxa (Aguilar-Romero *et al. Science of the Total Environment,* 741:140461).

• Scenarios for providing multiple ecosystem services and biodiversity in viticultural landscapes (Plan Estatal, Acciones de Programación Conjunta Internacional, PCI2018-092938): The aim of this international project is to model the effects on biodiversity and ecosystem services to determine optimal land use strategies in viticultural landscapes in living labs from Spain, France, Germany, Austria and Romania.

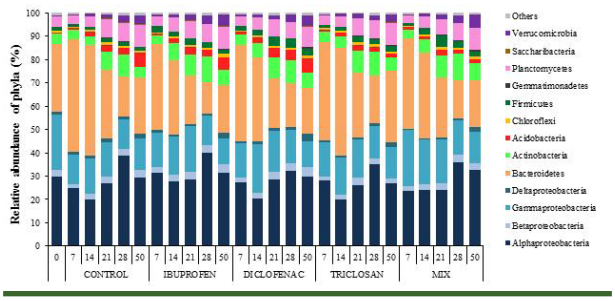
• We have developed, on an industrial scale, a new viable and economically sustainable composting system that allows the recycling of sludge and waters of the mill effluent ponds, and the olive leaves generated during the olive oil production chain. The obtained compost complies with the Spanish legislation on organic amendments, and therefore is usable as marketable agricultural input. The composting system created, which received the Best Business Model Award 2018 of EU-Project AGRIFORVALOR, is currently being implemented by the olive-oil extraction facilities in Spain.

• We have used for the first time a vermicomposting process to remove pesticides in residual contaminated biomixtures from two biopurification systems. Although the presence of high loads of pesticides and the composition of the biomixtures limited the vermiremediation, satisfactory results were obtained for some pesticides as diuron and oxyfluorfen. Complementing vermiremediation with other remediation practices could improve the efficiency of this low-cost technology (Delgado-Moreno *et al. Applied Sciences (Switzerland),* 10:3173:.

• We have shown for the first time that *Chrysoperla lucasina* captured feed mainly on pollen from sown native species. Therefore, our recommendation at the conclusion of this study is to include *Capsella bursa-pastoris* and *Biscutella auriculata* in the list of the most attractive plant species for *C. lucasina*. These native plant species are able to attract and maintain *C. lucasina populations* and also promote a more heterogeneous landscape in Mediterranean agroecosystems (Alcalá Herrera *et al. PLoS ONE*, 15: e0239847).



Spontaneous vegetation in organic viticulture



Relative abundance of the most dominant phyla (>1%) and classes of Proteobacteria at different incubation times (days) in non-contaminated (control) and contaminated biopurification systems with ibuprofen, diclofenac and triclosan, applied separately or in mixture

R&D&I ASSOCIATED UNITS

Plant Phenotyping by Imaging Techniques and Studies of Stomata Development for Stress Analysis. 2018-2021. Group of Biotechnology and Plant Molecular Biology, University of Castilla-La Mancha, PI: Carmen Fenoll Comes. Group of Redox Regulation, Sugar Signaling and Plant Phenotyping by Imaging Techniques for Stress Detection, EEZ-CSIC, PI: Matilde Barón Ayala.

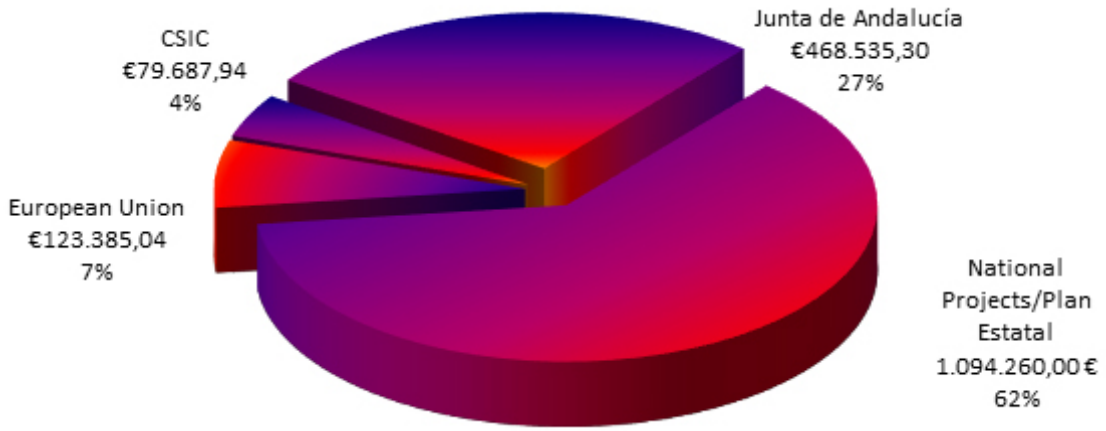
Cell Signaling and Metabolic Integration. 2014-2023. Group of Metabolic Integration and Cell Signaling, Department of Agricultural Sciences from the Jaume I University in Castellón, PI: Víctor Flors Herrero. Group of Mycorrhiza, EEZ-CSIC, PI: Mª José Pozo Jiménez.

Soil Bioremediation. 2020-2023. Department Soil Science and Agricultural Chemistry, University of Granada, PI: Fco. José Martín Peinado. Group of Biofertilization and Biodegradation by Rhizospheric Fungi, EEZ-CSIC, PI: Inmaculada García Romera.

FUNDING 2020

TOTAL INCOME 2020	4.440.588,85€
Administrative Budget	1.171.566,16 €
Services Revenues	12.746,67 €
Investments & Special Actions (Buildings, constructions, etc.)	1.164.227,38 €
Competitive Calls Incomes	1.765.868,28 €
Contracts & Agreements Incomes	326.180,36 €

FUNDING AGENCIES OF COMPETITIVE CALLS



(Sources: PCO2020, SAICI and PAI)

ONGOING RESEARCH PROJECTS DURING 2020

NATIONAL CALLS
SPANISH R&D PLAN (PLAN ESTATAL MICINN)

Arbuscular mycorrhizal fungi as biotechnological tools to increase plant resilience to climate change. Retos de la Sociedad (RTI2018-098756-B-I00). PI: Nuria Ferrol González, Concepción Azcón González de Aguilar. 2019-2021.

Biofilms and colonization of plants by beneficial and pathogenic bacteria: Environmental and metabolic signals, regulation by c-di-GMP and relevance to plant protection. Generación de Conocimiento (PID2019-109372GB-I00). PI: Manuel Espinosa Urgel, Mª Isabel Ramos González. 2020-2023.

Bioremediation of aromatic compounds under oxygen-limiting conditions, with emphasis on the production of value-added polymers from polycyclic aromatic hydrocarbons. Retos de la Sociedad (BIO2017-82242-R). PI: Silvia Marqués Martín. 2018-2020.

Deciphering *Sphigomonadaceae*-plant interactions: analysis for advanced rhizoremediation. Generación del Conocimiento (BIO2017-85994-P). PI: Ana Segura Carnicero. 2018-2020.

Effects of heat stress on physiological and productive traits in Iberian pigs: nutritional strategies. Retos de la Sociedad (AGL2016-80231-R). PI: Ignacio Fernández-Fígares Ibáñez, Isabel Seiquer Gómez-Pavón. 2016-2020.

Emission of nitric oxide and nitrous oxide by legume crops: Processes involved, their control and mitigation strategies. Retos de la Sociedad (AGL2017-85676-R). PI: Mª Jesús Delgado Igeño. 2018-2021.

Evaluation of the use of probiotic after hatching to promote optimal microbial colonisation, ruminal function and efficiency after weaning. Retos de la Sociedad (AGL2017-86938-R). PI: David R. Yáñez Ruiz. 2018-2020.

Exposure and bioaccesibility of acrylamide in collective catering and household. Retos de la Sociedad (RTI2018-094402-B-100). PI: Marta Mesías García, ICTAN-CSIC, Cristina Delgado Andrade. 2019-2021.

Functional analysis of the oxylipins derived from the peroxygenase activity of pollen caleosins, and their impact on fertilization in oleaginous crops. Generación del Conocimiento (AGL2017-84298-P). PI: Antonio Jesús Castro López. 2018-2020.

Functional characterization of regulatory elements in the arbuscular mycorrhizal symbiosis: GRAS transcription factors, apocarotenoids and alpha/beta-hydrolase receptors. Generación del Conocimiento (AGL2017-83871-P). PI: José Manuel García Garrido. 2018-2021.

Functional involvement of nitric oxide, hydrogen sulfide and antioxidants in pepper fruit ripening and quality. Generación del Conocimiento (PID2019-103924GB-I00). PI: F. Javier Corpas Aguirre, José Manuel Palma Martínez. 2020-2024.

Innovation of biobed bioremediation systems by bioaugmentation and novel adsorbent materials for the removal of emerging pollutants and pesticides from waters Retos de la Sociedad (CTM2017-86504-R). PI: Esperanza Romero Taboada, Pieter van Dillewijn. 2018-2020.

Integration of regulatory signals and response to oxidative stress in *Pseudomonas putida* biofilms associated with abiotic and plant surfaces. Generación del Conocimiento (BFU2016-80122-P). PI: Manuel Espinosa Urgel, Mª Isabel Ramos González. 2016-2020.

Ion transporters likely involved in major QTLs controlling citrus and tomato salt tolerance in terms of fruit yield. Retos de la Sociedad (AGL2017-82452-C2-1-R). PI: Andrés Belver Cano, Mª Remedios Romero Aranda, Instituto de Hortofruticultura Subtropical y Mediterránea "La Mayora" (EELM-CSIC). 2018-2021.

Lipidic volatiles produced by *Sinorhizobium (Ensifer) meliloti:* Functional analyses, mechanism of action and biosynthetic pathways. Generación del Conocimiento (PGC2018-096477-B-I00). PI: Mª José Soto Misffut. 2019-2021.

Marine microbiome against cancer. Retos Colaboración (RTC-2017-6405-1). PI: Silvia Marqués Martín. 2018-2021.

Mechanisms of auxin recognition by plant-associated beneficial bacteria. Generación del Conocimiento (PID2019-103972GA-I00). PI: Miguel A. Matilla Vázquez. 2020-2023.

Mechanisms underlying riboregulation of metabolism and symbiotic nitrogen fixation in rhizobia. Generación del Conocimiento (BFU2017-82645-P). PI: José Ignacio Jiménez Zurdo. 2018-2021.

Microbial conversion of lignocellulosic wastes into value-added products. Retos de la Sociedad (RTI2018-09370-B-I00). PI: Juan Luis Ramos Martín, Estrella Duque Martín de Oliva. 2019-2021.

Molecular biotechnology of Group II intron and related reverse transcriptases. Generación del Conocimiento (BIO2017-82244-P). PI: Nicolás Toro García. 2018-2020.

Mycorrhiza induced resistance: Bridging the gap between basic knowledge and application. Retos de la Sociedad (RTI2018-054350-B-C-31). PI: Mª José Pozo Jiménez, Juan Antonio López Ráez. 2019-2021.

Nutritional and functional properties of Bowman-Birk inhibitors from pea (*Pisum sativum* L.). Retos de la Sociedad (AGL2017-83772-R). PI: Alfonso Clemente Gimeno, Luis Rubio San Millán. 2018-2021.

Olive seed germinates as alimentary, agronomical and ornamental source. Retos Colaboración (RTC-2017-6654-2). PI: Juan de Dios Alché Ramírez. 2018-2021.

Organic fertilization in soils under olive cultivation: evaluation of the sustained flow of ecosystem services. Retos de la Sociedad (AGL2017-84745-R). PI: Emilio Benítez León, Engracia Madejón Rodríguez (IRNAS-CSIC). 2018-2020.

Peroxisome-dependent signalling under stress: role of peroxules and peroxisomal homeostasis: Generación del Conocimiento (PGC2018-098372-B-I00). PI: Luisa Mª Sandalio González, María C. Romero Puertas. 2019-2021.

Phenotyping plant-pathogen interactions under different scenarios of climate change. Retos de la Sociedad (RTI2018-094652-B-I00). PI: Matilde Barón Ayala. 2019-2021.

Regulation by cyclic diguanylate and role of extracellular proteins and polysaccharides in bacteria-plant interactions. Generación del Conocimiento (BIO2017-83533-P). PI: Juan Sanjuán Pinilla, Mª Trinidad Gallegos Fernández. 2018-2021.

Regulation of root hydraulic properties by aquaporins, plant hormones and soil beneficial microorganisms. Retos de la Sociedad (AGL2017-88341-R). PI: Ricardo Aroca Álvarez, Juan Manuel Ruiz Lozano. 2018-2021.

Replacement networks in forests: Ecogeographic variation and influence of phyllosphere fungal communities and plant-soil interactions. Generación del Conocimiento (PGC2018-100966-B-I00). PI: José Luis Garrido Sánchez, Julio M. Álcántara Gámez (UJA). 2019-2021.

Restoration of soils contaminated by heavy metals: A strategy based on waste recycling and bioremediation by symbiotic and saprobic microorganisms. Retos de la Sociedad (RTI2018-094327-B-I00). PI: Inmaculada García Romera. 2019-2021.

Sensing and response to the environment: Bacterial cell signaling mediated by sigma factors of extracytoplasmic function (ECF). Generación del Conocimiento (BIO2017-83763-P). PI: Marian Llamas Lorente. 2018-2020.

Signalling mechanisms and regulation of photosynthesis and carbon metabolism in chloroplasts. Generación del Conocimiento (PGC2018-096851-B-C21). PI: Mariam Sahrawy Barragán, Antonio Jesús Serrato Recio. 2019-2021.

Study of proton linked ion transport at the chloroplast envelope. Generación del Conocimiento (PID2019-105260GB-I00). PI: Kees Venema, Mª Pilar Rodríguez Rosales. 2020-2024.

Systematic, high-throughput identification of signal molecules recognized by bacterial sensor proteins. Generación del Conocimiento (BIO2016-76779-P). PI: Tino Krell. 2016-2020.

The olive holobiont: linking plant microbiome and host tolerance to biotic and abiotic stresses. Retos de la Sociedad (PID2019-106283RB-I00). PI: Manuel Fernández López, Jesús Mercado Blanco, Instituto de Agricultura Sostenible (IAS-CSIC). 2020-2024.

Universal biosensors. Explora (BIO2017-91210-EXP). PI: Tino Krell. 2018-2020.

JUNTA DE ANDALUCÍA

Contribution of the non-coding transcriptome to symbiotic diversity of rhizobia nodulating agronomically relevant legumes. Proyecto FEDER-University of Seville (US-1250546). PI: José Mª Vinardell González (US), José I. Jiménez Zurdo. 2020-2022.

Identification and characterization of compounds from pepper fruits with anti-tumoral activity. Proyectos de Generación de Conocimiento Frontera (P18-FR-1359). PI: José Manuel Palma Martínez, F. Javier Corpas Aguirre. 2020-2022.

Identification and characterization of olive seeds components of interest for the agri-food industry and with healthy properties. Proyectos de Investigación orientados a los Retos de la Sociedad Andaluza (P18-RT-1577). PI: Juan de Dios Alché Ramírez, Antonio Jesús Castro López. 2020-2022.-

Integrated study of mechanisms affecting greenhouse gas production by legume endosymbiotic bacteria. Proyectos de Investigación orientados a los Retos de la Sociedad Andaluza (P18-RT-1401). PI: Mª Jesús Delgado Igeño, Mª Socorro Mesa Banqueri. 2020-2023.

Signaling mechanisms in *Pseudomonas aeruginosa*: New strategies to combat this human pathogen. Proyectos de Generación de Conocimiento Frontera (P18-FR-1621). PI: Tino Krell, Mª Antonia Llamas Lorente. 2020-2022.

CSIC

Dissection of the regulatory network that controls the FixK$_2$ protein of *Bradyrhizobium diazoefficiens*, a key transcriptional factor for symbiosis. Ayudas Extraordinarias para Preparación de Proyectos en el Marco del PE 2019 (2019AEP193, Project AGL2015-63651-P). PI: Mª Socorro Mesa Banqueri. 2020-2021.

Effect of arbuscular mycorrhizal fungi with different life strategies and functional characteristics on their colonization dynamics and effects on plant development and stress tolerance. Proyecto Intramural (201940E025). PI: Concepción Azcón González de Aguilar. 2019-2021.

Impact of dietary protein intake on mineral metabolism in a porcine model. Proyecto Intramural (202040E006). PI: Rosa Mª Nieto Liñán. 2020-2022.

Impact of oligogalacturonides on tomato defense responses and the study of their role in mycorrhiza induced resistance. Proyecto Intramural CSIC (201840E130). PI: Mª José Pozo Jiménez. 2018-2021.

Integration of regulatory signals and response to oxidative stress in *Pseudomonas putida* biofilms associated with abiotic and plant surfaces. Ayudas Extraordinarias para Preparación de Proyectos en el Marco del PE 2019 (2019AEP196, Project BFU2016-80122-P). PI: Manuel Espinosa Urgel, Mª Isabel Ramos González. 2020.

Interaction among nitric oxide and antioxidants in pepper fruit ripening. Ayudas Extraordinarias para Preparación de Proyectos en el Marco del PE 2019 (2019AEP194, Project AGL2015-65104-P). PI: F. Javier Corpas Aguirre, José Manuel Palma Martínez. 2020.

Molecular mechanisms of signaling mediated by the phytohormone indole acetic acid in phytobacteria beneficial to plant crops. Proyecto Intramural Especial-Incorporación Personal Científico (202040I003). PI: Miguel A. Matilla Vázquez. 2020-2021.

Omics-assisted strategies for *Verticillium* wilt of olive management (OVerMan). Ayudas Extraordinarias para Preparación de Proyectos en el Marco del PE 2019 (2019AEP195, Project AGL2016-75729-C2-1-R). PI: Manuel Fernández López, Jesús Mercado Blanco, Instituto de Agricultura Sostenible (IAS-CSIC). 2020.

Physiological response of plants of agronomic interest to *Piriformospora indica*. Proyecto Intramural (201640E057). PI: Nuria Ferrol González. 2016-2022.

NATIONAL EXTERNAL PROJECTS

Comprehensive study of plant-induced defenses through exogenous application of fluorescent derivatives of MSB, Vitamin K3 and sodium bisulfite. Ref: Agencia Canaria de Investigación, Innovación y Sociedad de la Información (ProID2020010082). PI: Antonio Jesús Herrera González. Participants of the EEZ: Luisa Mª Sandalio González. 2020-2022.

Novel sustainable protein sources meeting human health. CSIC, ILINKA (ILINKA 20292). PI: Isidra Recio Sánchez, CIAT-CSIC. Participants of the EEZ: Alfonso Clemente Gimeno, Raquel Olías Sánchez. 2020-2021.

Recovery of the high mountains vegetation after wildfire of year 2019 at Teide National Park. Proyectos de I+D por organismos de investigación y empresas en las áreas prioritarias de la Estrategia de Especialización Inteligente de Canarias RIS-3 (ProID2020010103). PI: Milagros Alicia León Barrios, University of La Laguna, Tenerife. Participants of the EEZ: Manuel Fernández López, Pablo J. Villadas Latorre. 2020-2022.

EUROPEAN & INTERNATIONAL PROJECTS

Biostimulant Academy. ERASMUS+ 2019 (2020-1-FR01-KA202-080329). PI: Ricardo Aroca Álvarez. 2020-2022.

Improvement of symbiotic nitrogen fixation by modulating NO formation in soybean nodules. Japan Society for the Promotion of Science (JSPS, Japan). PI: Toshiki Uchiumi**,** University of Kakoshima, Japan**.** Participants of the EEZ: Mª Jesús Delgado Igeño. 2020-2023.

Innovation for sustainable sheep and goats production in Europe. European Project (RESEARCH & INNOV H2020-FOOD/0157-EU154338_01). PI: David R. Yáñez Ruiz. 2016-2020.

Microbe induced resistance to agricultural pests (MIRA). European Project (H2020-MSCA-ITN-ETN/0359). PI: Mª José Pozo Jiménez. 2017-2021.

Microbiome Applications for Sustainable food systems through Technologies and EnteRprise. European Project (H2020 LC-SFS-03-2018/ EU189746_31). PI: David R. Yáñez Ruiz. 2019-2023.

Scenarios for providing multiple ecosystem services and biodiversity in viticultural landscapes. European Project H2020/Acciones de Programación Conjunta Internacional (PCI2018-092938). PI: Emilio Benítez León. 2019-2021.

The effect of thiol redox regulators on seed quality and the aging process. Ref: National Science Centre of Poland (OPUS 16 project nº 2018/31/B/NZ9/01548). PI: Ewelina Ratajczak, Institute of Dendrology, Polish Academy of Sciences. Participants of the EEZ: Mariam Sahrawy, Antonio Jesús Serrato.

TRACE-Soils: Mechanisms underlying TRAdeoffs between Carbon sequestration, greenhouse gas Emissions and nutrient losses in Soils under conservation agriculture in Europe (Towards climate-smart sustainable management of agricultural soils). European Project (H2020-FOOD/0648). PI: Juan Luis Ramos Martín, European Project Coordinator: Marta Goberna, INIA. 2020-2025.

Valorization of Mediterranean small-scale FARMs by cropping wild unexploited species. European Project PRIMA/Acciones de Programación Conjunta Internacional (PCI2020-112091). PI: Mª del Mar Alguacil García. 2020-2022.

NATIONAL AND INTERNATIONAL NETWORKS

Ammonia and Greenhouse Gas Emission from Animal Production Housing. COST Action LivAGE CA16106, H2020 Programme. Action Chair: Thomas Bartzanas, Centre for Research and Technology Hellas, Institute of Bio-Economy and Agritechnology, Greece. Participant of the EEZ: David R. Yáñez Ruiz. Participation of 29 countries. 2017-2021.

European Network of Multidisciplinary Research and Translation of Autophagy knowledge. COST Action Transautophagy CA15138, H2020 Programme. Action Chair: Cécile Vindis, French Institute of Health and Medical Research. Participants of the EEZ: Luisa Mª Sandalio González, Adela Olmedilla Arnal, María C. Romero Puertas. Participation of 31 countries. 2016-2020.

Network for updating emission values in Spanish agriculture. Redes de Excelencia, (AGL2017-90924-REDT). PI: David R. Yáñez Ruiz. 2018-2021.

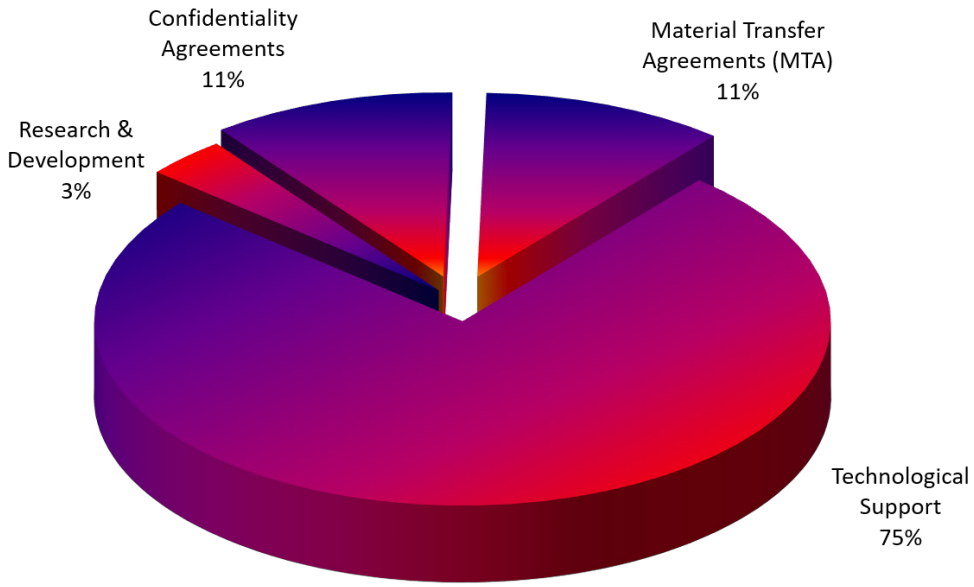
Redox signaling and post-translational regulation in plant development and stress response. Acciones de Dinamización-Redes de Investigación (RED2018-102397-T). PI: Luisa Mª Sandalio González. 2020-2021.

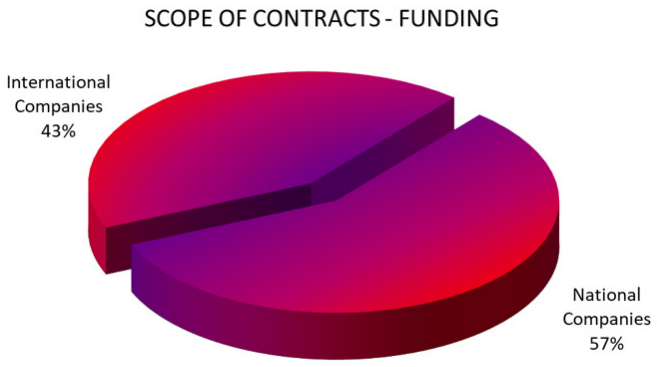
Research Network "Learning from nature: multitrophic interactions for crop and forest protection". Acciones de Dinamización-Redes de Investigación (RED2018-102407-T). PI: Isabel Díaz Rodríguez, Centro de Biotecnología y Genómica de Plantas. Participants of the EEZ: Mª José Pozo Jiménez, Juan Antonio Lopez Ráez. 2020-2021.

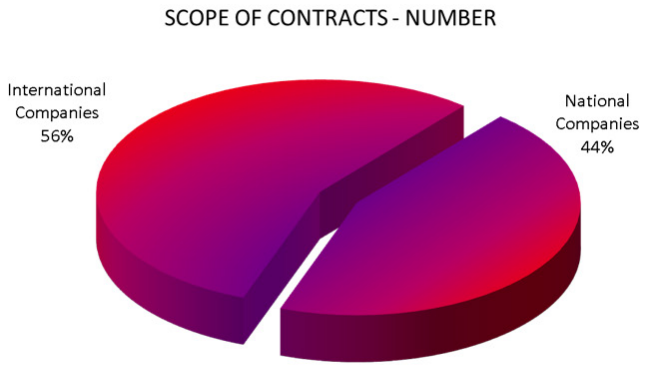
Soil network. Acciones de Dinamización-Redes de Investigación (RED2018-102624-T). PI: Ana Segura Carnicero. 2020-2021.

RESEARCH, DEVELOPMENT & INNOVATION CONTRACTS AND COLLABORATION AGREEMENTS WITH COMPANIES

During 2020, 28 new contracts and 11 addenda were signed, for a total amount of 358.726,79 €. This is the distribution according to the type of contract and the national/international scope.







ONGOING CONTRACTS / COLLABORATION AGREEMENTS DURING 2020

During 2020, 28 new contracts and 11 addenda were signed, for a total amount of 358.726,79 €. This is the distribution according to the type of contract and the national/international scope.

2-tridecanone evaporation system to improve the productivity of crops of agricultural interest under greenhouse conditions: protective effect against phytopathogenic bacteria and evaluation of its potential as a phytostimulant. Invicta Ambientación, S.L. (20196964), PI: Mª José Soto Misffut. 2019-2020.

Altitud 1.080. Altiplanum Oleum, University of Granada (20192738), PI: Isabel Seiquer Gómez-Pavón. 2019-2020.

Biological effects of pea proteins and instalation in the EEZ-CSIC of two isomodule attached modules (Isodule®) and other attached modules. Abbott Laboratories, S.A. (20201507), PI: A. Ignacio Martín García. 2020.

Chemical and *in vitro* evaluation of different byproducts of avocado as ingredients of high nutritive value. Cereales MACOB, S.L. (20196358), PI: A. Ignacio Martín García. 2019-2020.

Effect of cobalt supplements on rumen function and vit B12 synthesis. Pancosma, S.A. Switzerland (20202114), PI: David R. Yáñez. 2020.

Effect of the inclusion of a feed additive (SILVATEAM) on ruminal fermentation parameters. INDUNOR, S.L., Argentina (20210234), PI: A. Ignacio Martín-García. 2020-2021.

ES 631289: Ensiled cultivated macroalgae as a sustainable ruminant feedstuff (En Mac). Nord University, Norway (20192480), PI: Eduarda Molina Alcaide. 2019-2021.

Evaluation of mycorrhizal inoculants. Agrogenia Biotech, S.L. (20202563), PI: Juan Antonio López Ráez. 2020-2021.

Evaluation of plant extracts as rumen fermentation modifiers. Pancosma, S.A., Switzerland (201629/20197014), PI: David R. Yáñez Ruiz. 2019-2020.

Evaluation of the effect of a biostimulant (Betaser) on young fruit tree plants under heat stress. SERVALESA (20203213). PI: Mariam Sahrawy Barragán. 2020-2021.

Improvement of mycorrhizal inoculants. Agrogenia Biotech, S.L. (20191331), PI: Juan Antonio López Ráez. 2019-2020.

***In vivo* evaluation of diets for livestock including avocado by-products.** La Caña, S.L. (20194638), PI: A. Ignacio Martín García. 2019-2020.

***In-vitro* cultivation of AMF isolates from the EEZ collection and efficacy tests.** Koopert Biological Systems, R.V. (20180727), PI: Mª José Pozo Jiménez. 2017-2022.

Involvement of auxin hormone in the mode of action of PGPR. Agrotecnologías Vegetales, S.L. (20193368), PI: Ricardo Aroca Álvarez. 2019-2020.

Nutrition of Iberian sows. Sánchez Romero Carvajal Jabugo, S.A. (20191276), PI: Rosa Mª Nieto Liñán. 2019-2020.

Preparation of meals and focused feeding of animal models with components isolated from the olive tree. Elayotecnia, S.L. (20201357), PI: Juan de Dios Alché Ramírez, José Carlos Jiménez López. 2020-2022.

Reduction of the use of antibiotics in the organic animal production. Asociación Valor Ecológico, CAAE (20186638), PI: David R. Yáñez Ruiz. 2018-2022.

Study of the agronomic efficiency of plant growth promoting bacteria (PGPR). Establecimiento HEFE, S.L. (20192496), PI: Eulogio Bedmar Gómez. 2019-2020.

Study of the effect of CCPA additive on goat kids' performance, digestive tract development, diet digestibility and milk production on composition during the adulthood. Deltavit, France (20182343), PI: A. Ignacio Martín García. 2018-2020.

Study of the immune-modulator effect of INNOFARM on the health and immune system and on productive parameters of lactating goats. INNOFARM, S.L. (20203851), PI: A. Ignacio Martín-García. 2020-2021.

Study of the *in situ* degradability and *in vitro* digestibility of avocado by-products as ingredients of high added value feeds for animals. Frumaco, S.L. (20196344), PI: A. Ignacio Martín García. 2019-2020.

Sustainable Usage of trace MINerals in Animal Production Programs (SUMMINAPP) PigCHAMP Pro Europa, S.L. (090201180027), PI: Isabel Seiquer Gómez-Pavón.-2018-2020.

The effect of the development of bacteria populations in the chicken gut having received diets containing all tested products. Agro Innovation International, Francia (201302), PI: Luis Rubio San Millán. 2019-2020.

PATENTS

Antihypertensive peptides from olive oil.

Licensed patent.

Authors: Eduardo López-Huertas León, Juan Mª Alcaide Hidalgo, EEZ-CSIC.

Entity: CSIC

Application number:

EP15380049/EP1641.1160.

Company: Alodia Farmacéutica, S.L.

First presentation date: 20th November 2015.

New licence date: 25th February 2020.

Bacterial nanocellulose production.

Priority patent application.

Authors: Silvia Marqués Martín, Sophie Marie Martirani von Abercron, Patricia Marín Quero, Daniel Pacheco Sánchez.

Entity: CSIC.

Application number: 202030505.

Date: 1st June 2020.

PUBLICATIONS

SCI PUBLICATIONS

Aghdam, M.S.; Palma, J.M.; Corpas, F.J. 2020. NADPH as a quality footprinting in horticultural crops marketability. *Trends in Food Science and Technology,* 103: 152-161.

Aguilar-Romero, I.; Romero, E.; Wittich, R.M.; van Dillewijn, P. 2020. Bacterial ecotoxicity and shifts in bacterial communities associated with the removal of ibuprofen, diclofenac and triclosan in biopurification systems. *Science of the Total Environment,* 741: 140461.

Aguirre-Garrido, J.F.; Martínez-Abarca, F.; Montiel-Lugo, D.; Hernández-Soto, L.M.; Ramírez-Saad, H. 2020. Metagenomic analyses uncover the differential effect of azide treatment on bacterial community structure by enriching a specific cyanobacteria present in a saline-alkaline environmental sample. *International Microbiology,* 23: 467-474.

Alcaide-Hidalgo, J.M.; Margalef, M.; Bravo, F.I.; Muguerza, B.; López-Huertas, E. 2020. Virgin olive oil (unfiltered) extract contains peptides and possesses ACE inhibitory and antihypertensive activity. *Clinical Nutrition,* 39: 1242-1249.

Alcaide-Hidalgo, J.M.; Romero, M.; Duarte, J.; López-Huertas, E. 2020. Antihypertensive effects of virgin olive oil (Unfiltered) low molecular weight peptides with ace inhibitory activity in spontaneously hypertensive rats. *Nutrients,* 12: 271.

Alcalá Herrera, R.; Fernández Sierra, M.L.; Ruano, F. 2020. The suitability of native flowers as pollen sources for *Chrysoperla lucasina* (Neuroptera: Chrysopidae). *PLoS ONE,* 15: e0239847.

Aranda-Olmedo, I.; Rubio, L.A. 2020. Dietary legumes, intestinal microbiota, inflammation and colorectal cancer. *Journal of Functional Foods,* 64: 103707.

Barra Caracciolo, A.; Grenni, P.; Garbini, G.L.; Rolando, L.; Campanale, C.; Aimola, G.; Fernández-López, M.; Fernández-Gonzalez, A.J.; Villadas, P.J.; Ancona, V. 2020. Characterization of the belowground microbial community in a poplar-phytoremediation strategy of a multi-contaminated soil. *Frontiers in Microbiology,* 11: 2073.

Barrientos-Moreno, L.; Molina-Henares, M.A.; Ramos-González, M.I.; Espinosa-Urgel, M. 2020. Arginine as an environmental and metabolic cue for cyclic diguanylate signalling and biofilm formation in *Pseudomonas putida*. *Scientific Reports,* 10: 13623.

Belanche, A.; Newbold, C.J.; Morgavi, D.P.; Bach, A.; Zweifel, B.; Yáñez-Ruiz, D.R. 2020. A meta-analysis describing the effects of the essential oils blend Agolin ruminant on performance, rumen fermentation and methane emissions in dairy cows. *Animals,* 10: 620.

Belanche, A.; Palma-Hidalgo, J.M.; Nejjam, I.; Jiménez, E.; Martín-García, A.I.; Yáñez-Ruiz, D.R. 2020. Inoculation with rumen fluid in early life as a strategy to optimize the weaning process in intensive dairy goat systems. *Journal of Dairy Science,* 103: 5047-5060.

Belanche, A.; Patra, A.K.; Morgavi, D.P.; Suen, G.; Newbold, C.J.; Yáñez-Ruiz, D.R. 2020. Gut microbiome modulation in ruminants: Enhancing advantages and minimizing drawbacks. *Frontiers in Microbiology*, 11: 622002.

Cagnac, O.; Baghour, M.; Jaime-Pérez, N.; Aranda-Sicilia, M.N.; Sánchez-Romero, M.E.; Rodríguez-Rosales, M.P.; Venema, K. 2020. Deletion of the N-terminal domain of the yeast vacuolar $(Na^+,K^+)/H^+$ antiporter Vnx1p improves salt tolerance in yeast and transgenic *Arabidopsis*. *Yeast,* 37: 173-185.

Castellano-Hinojosa, A.; Correa-Galeote, D.; González-López, J.; Bedmar, E.J. 2020. Effect of nitrogen fertilisers on nitrous oxide emission, nitrifier and denitrifier abundance and bacterial diversity in closed ecological systems. *Applied Soil Ecology,* 145: 103380.

Castellano-Hinojosa, A.; Charteris, A.F.; Müller, C.; Jansen-Willems, A.; González-López, J.; Bedmar, E.J.; Carrillo, P.; Cárdenas, L.M. 2020. Occurrence and ^{15}N-quantification of simultaneous nitrification and denitrification in N-fertilised soils incubated under oxygen-limiting conditions. *Soil Biology and Biochemistry,* 143: 107757.

Castellano-Hinojosa, A.; González-López, J.; Vallejo, A.; Bedmar, E.J. 2020. Effect of urease and nitrification inhibitors on ammonia volatilization and abundance of N-cycling genes in an agricultural soil. *Journal of Plant Nutrition and Soil Science,* 183: 99-109.

Castro, A.J.; Lima-Cabello, E.; Alché, J.D. 2020. Identification of seed storage proteins as the major constituents of the extra virgin olive oil proteome. *Food Chemistry,* 7: 100099.

Clemente, A.; Jiménez-López, J.C. 2020. Introduction to the special issue: Legumes as food ingredient: Characterization, processing, and applications. *Foods*, 9: 1525.

Clemente, A.; Olías, R.; Castro, A.J.; Jiménez-López, J.C.; Rodríguez, A.; Alché, J.D.; Domoney, C. 2020. Exploiting molecular diversity in legume Bowman Birk inhibitors to investigate their potential role as colorectal chemopreventive agents. *Legume Perspectives*, 18: 29.

Contreras-Moreno, F.J.; Muñoz-Dorado, J.; García-Tomsig, N.I.; Martínez-Navajas, G.; Pérez, J.; Moraleda-Muñoz, A. 2020. Copper and melanin play a role in *Myxococcus xanthus* predation on *Sinorhizobium meliloti*. *Frontiers in Microbiology,* 11: 94.

Corpas, F.J.; González-Gordo, S.; Palma, J.M. 2020. Nitric oxide: A radical molecule with potential biotechnological applications in fruit ripening. *Journal of Biotechnology,* 324: 211-219.

Corpas, F.J.; González-Gordo, S.; Palma, J.M. 2020. Plant peroxisomes: a factory of reactive species. *Frontiers in Plant Science,* 11: 853.

Corpas, F.J.; Palma, J.M. 2020. H_2S signaling in plants and applications in agriculture. *Journal of Advanced Research,* 24: 131-137.

Costa-Gutiérrez, S.B.; Lami, M.J.; Santo, M.C.C.D.; Zenoff, A.M.; Vincent, P.A.; Molina-Henares, M.A.; Espinosa-Urgel, M.; de Cristóbal, R.E. 2020. Plant growth promotion by *Pseudomonas putida* KT2440 under saline stress: role of *eptA*. *Applied Microbiology and Biotechnology,* 104: 4577-4592.

Costa-Gutiérrez, S.B.; Raimondo, E.E.; Lami, M.J.; Vincent, P.A.; Espinosa-Urgel, M.; de Cristóbal, R.E. 2020. Inoculation of *Pseudomonas* mutant strains can improve growth of soybean and corn plants in soils under salt stress. *Rhizosphere,* 16: 100255.

Dastkar, E.; Soleimani, A.; Jafary, H.; Alché, J.; Bahari, A.; Zeinalabedini, M.; Salami, S.A. 2020. Differential expression of genes in olive leaves and buds of ON- versus OFF-crop trees. *Scientific Reports,* 10: 100099.

de Evan, T.; Carro, M.D.; Yepes, J.E.F.; Haro, A.; Arbesú, L.; Romero-Huelva, M.; Molina-Alcaide, E. 2020. Effects of feeding multinutrient blocks including avocado pulp and peels to dairy goats on feed intake and milk yield and composition. *Animals,* 10: 194.

de Evan, T.; Vintimilla, A.; Molina-Alcaide, E.; Ranilla, M.J.; Carro Travieso, M.D. 2020. Potential of recycling cauliflower and romanesco wastes in ruminant feeding: *in vitro* studies. *Animals,* 10: 1247.

de la Torre-Hernández, M.E.; Salinas-Virgen, L.I.; Aguirre-Garrido, J.F.; Fernández-González, A.J.; Martínez-Abarca, F.; Montiel-Lugo, D.; Ramírez-Saad, H.C. 2020. Composition, structure, and PGPR traits of the rhizospheric bacterial communities associated with wild and cultivated *Echinocactus platyacanthus* and *Neobuxbaumia polylopha*. *Frontiers in Microbiology,* 11: 1424.

Delgado-Moreno, L.; Nogales, R.; Romero, E. 2020. Vermiremediation of biomixtures from biobed systems contaminated with pesticides. *Applied Sciences (Switzerland),* 10: 3173.

Domoney, C.; Rayner, T.; Isaac, P.G.; Warren, F.; Moreau, C.; Clemente, A.; Ellis, N.; Frost, G.; Petropoulou, K.; Cheema, J. 2020. Improving nutritional and health associated traits in *Pisum sativum* (pea). *Legumes perspectives*, 18: 25-28.

El-Batanony, N.H.; Castellano-Hinojosa, A.; Correa-Galeote, D.; Bedmar, E.J. 2020. Phylogenetic diversity of bacterial strains from root nodules of legumes grown wild in Egypt. *Biocatalysis and Agricultural Biotechnology*, 27: 101692.

El-Batanony, N.H.E.; Castellano-Hinojosa, A.; Mamdouh, A.; Ashraf, N.; Bedmar, E.J. 2020. Ag-

ronomical parameters of host and non-host legumes inoculated with *Melilotus indicus*-isolated rhizobial strains in desert unreclaimed soil. *Archives of Microbiology,* 202: 1929-1938.

Fargallo, J.A.; Navarro-López, J.; Palma-Granados, P.; Nieto, R.M. 2020. Foraging strategy of a carnivorous-insectivorous raptor species based on prey size, capturability and nutritional components. *Scientific Reports,* 10: 7583.

Fernández, M.C.; Godino, A.; Príncipe, A.; López Ramírez, V.; Quesada, J.M.; Rigo, V.; Espinosa-Urgel, M.; Morales, G.M.; Fischer, S. 2020. Characterization of the bacteriocins and the PrtR regulator in a plant-associated *Pseudomonas* strain. *Journal of Biotechnology,* 307: 182-192.

Fernández-González, A.J.; Cardoni, M.; Gómez-Lama Cabanás, C.; Valverde-Corredor, A.; Villadas, P.J.; Fernández-López, M.; Mercado-Blanco, J. 2020. Linking belowground microbial network changes to different tolerance level towards Verticillium wilt of olive. *Microbiome,* 8: 11.

Fernández-González, A.J.; Wentzien, N.M.; Villadas, P.J.; Valverde-Corredor, A.; Lasa, A.V.; Gómez-Lama Cabanás, C.; Mercado-Blanco, J.; Fernández-López, M. 2020. Comparative study of neighboring Holm oak and olive trees-belowground microbial communities subjected to different soil management. *PLoS ONE,* 15: e0236796.

Franco-Luesma, S.; Cavero, J.; Plaza-Bonilla, D.; Cantero-Martínez, C.; Tortosa, G.; Bedmar, E.J.; Álvaro-Fuentes, J. 2020. Irrigation and tillage effects on soil nitrous oxide emissions in maize monoculture. *Agronomy Journal,* 112: 56-71.

Gamir, J.; Torres-Vera, R.; Rial, C.; Berrio, E.; de Souza Campos, P.M.; Varela, R.M.; Macías, F.A.; Pozo, M.J.; Flors, V.; López-Ráez, J.A. 2020. Exogenous strigolactones impact metabolic profiles and phosphate starvation signalling in roots. *Plant, Cell and Environment,* 43: 1655-1668.

García-Angulo, D.; Heres, A.M.; Fernández-López, M.; Flores, O.; Sanz, M.J.; Rey, A.; Valladares, F.; Curiel Yuste, J. 2020. Holm oak decline and mortality exacerbates drought effects on soil biogeochemical cycling and soil microbial communities across a climatic gradient. *Soil Biology and Biochemistry,* 149: 107921.

García-Quirós, E.; Alché, J.D.; Karpinska, B.; Foyer, C.H.; Wilson, Z. 2020. Glutathione redox state plays a key role in flower development and pollen vigour. *Journal of Experimental Botany,* 71: 730-741.

Gavira, J.A.; Gumerov, V.M.; Rico-Jiménez, M.; Petukh, M.; Upadhyay, A.A.; Ortega, A.; Matilla, M.A.; Zhulin, I.B.; Krell, T. 2020. How bacterial chemoreceptors evolve novel ligand specificities. *mBio,* 11**:** e03066-19.

González-Gordo, S.; Palma, J.M.; Corpas, F.J. 2020. Appraisal of H_2S metabolism in *Arabidopsis thaliana*: *In silico* analysis at the subcellular level. *Plant Physiology and Biochemistry,* 155: 579-588.

González-Gordo, S.; Rodríguez-Ruiz, M.; Palma, J.M.; Corpas, F.J. 2020. Superoxide radical metabolism in sweet pepper (*Capsicum annuum* L.) fruits is regulated by ripening and by a NO-enriched environment. *Frontiers in Plant Science,* 11: 485.

Gruden, K.; Lidoy, J.; Petek, M.; Podpečan, V.; Flors, V.; Papadopoulou, K.K.; Pappas, M.L.; Martínez-Medina, A.; Bejarano, E.; Biere, A.; Pozo, M.J. 2020. Ménage à trois: Unraveling the mechanisms regulating plant–microbe–arthropod interactions. *Trends in Plant Science,* 25: 1215-1226.

Gupta, K.J.; Hancock, J.T.; Petrivalsky, M.; Kolbert, Z.; Lindermayr, C.; Durner, J.; Barroso, J.B.; Palma, J.M.; Brouquisse, R.; Wendehenne, D.; Corpas, F.J.; Loake, G.J. 2020. Recommendations on terminology and experimental best practice associated with plant nitric oxide research. *New Phytologist,* 225: 1828-1834.

Gupta, K.J.; Kolbert, Z.; Durner, J.; Lindermayr, C.; Corpas, F.J.; Brouquisse, R.; Barroso, J.B.; Umbreen, S.; Palma, J.M.; Hancock, J.T.; Petrivalsky, M.; Wendehenne, D.; Loake, G.J. 2020. Regulating the regulator: nitric oxide control of post-translational modifications. *New Phytologist,* 227: 1319-1325.

Guzmán, J.L.; Pérez-Écija, A.; Zarazaga, L.A.; Martín-García, A.I.; Horcada, A.; Delgado-Pertíñez, M. 2020. Using dried orange pulp in the diet of dairy goats: Effects on milk yield and composition and blood parameters of dams and growth performance and carcass quality of kids. *Animal,* 14: 2212-2220.

Haro, A.; Trescastro, A.; Lara, L.; Fernández-Fígares, I.; Nieto, R.; Seiquer, I. 2020. Mineral elements content of wild growing edible mushrooms from the southeast of Spain. *Journal of Food Composition and Analysis,* 91: 103504.

Hernández, M.L.; Lima-Cabello, E.; Alché, J.D.; Martínez-Rivas, J.M.; Castro, A.J. 2020. Lipid

composition and associated gene expression patterns during pollen germination and pollen tube growth in olive (*Olea europaea* L.). *Plant and Cell Physiology,* 61: 1348-1364.

Huertas, M.J.; Matilla, M.A. 2020. Training bacteria to produce environmentally friendly polymers of industrial and medical relevance. *Microbial Biotechnology,* 13**:** 14-16.

Jiménez López, J.C. 2020. Narrow-leafed lupin (*Lupinus angustifolius* L.) ß-conglutin: A multifunctional family of proteins with roles in plant defence, human health benefits, and potential uses as functional food. *Legume Science*, 2: e33.

Jiménez-Arias, D.; Morales-Sierra, S.; García-Machado, F.J.; García-García, A.L.; Luis, J.C.; Valdés, F.; Valdés, F.; Sandalio, L.M.; Hernández-Suárez, M.; Borges, A.A. 2020. Rejected brine recycling in hydroponic and thermo-solar evaporation systems for leisure and tourist facilities. Changing waste into raw material. *Desalination,* 496: 114443.

Jiménez-López, J.C.; Singh, K.B.; Clemente, A.; Nelson, M.N.; Ochatt, S.; Smith, P.M.C. 2020. Editorial: Legumes for Global Food Security. *Frontiers in Plant Science*, 11: 926.

Jiménez-Zurdo, J.I.; Martínez-Abarca, F.; Cobo-Díaz, J.F.; López-Contreras, J.A.; Fernández-López, M.; Toro, N. 2020. Complete genome sequence of *Sinorhizobium meliloti* strain AK21, a salt-tolerant isolate from the aral sea region. *Microbiology Resource Announcements,* 9: e01432-19.

Kamau, S.; Belanche, A.; Davies, T.; Rees Stevens, P.; Humphreys, M.; Kingston-Smith, A.H. 2020. A route to decreasing N pollution from livestock: Use of *Festulolium* hybrids improves efficiency of N flows in rumen simulation fermenters. *Food and Energy Security,* 9: e209.

Kapravelou, G.; Martínez, R.; Martino, J.; Porres, J.; Fernández-Fígares, I. 2020. Natural fermentation of cowpea (*Vigna unguiculata*) flour improves the nutritive utilization of indispensable amino acids and phosphorus by growing rats. *Nutrients,* 12: 2186.

Kattge, J., *et al.* (includes Garrido, J.L.). 2020. TRY plant trait database-enhanced coverage and open access. *Global Change Biology*, 26: 119-188.

Kaya, C.; Ashraf, M.; Alyemeni, M.N.; Corpas, F.J.; Ahmad, P. 2020. Salicylic acid-induced nitric oxide enhances arsenic toxicity tolerance in maize plants by upregulating the ascorbate-glutathione cycle and glyoxalase system. *Journal of Hazardous Materials,* 399: 123020.

Kharbech, O.; Sakouhi, L.; Ben Massoud, M.; Jose Mur, L.A.; Corpas, F.J.; Djebali, W.; Chaoui, A. 2020. Nitric oxide and hydrogen sulfide protect plasma membrane integrity and mitigate chromium-induced methylglyoxal toxicity in maize seedlings. *Plant Physiology and Biochemistry,* 157: 244-255.

Khelalfa, K.; Arhab, R.; Martín-García, A.I.; Zaabat, N.; Belanche, A. 2020. Effect of Acacia purified tannins extract and polyethylene glycol treatment on *in vitro* ruminal fermentation pattern and methane production. *Asia-Pacific Journal of Molecular Biology and Biotechnology,* 28: 50-62.

Kućko, A.; Wilmowicz, E.; Pokora, W.; Alché, J.D. 2020. Disruption of the auxin gradient in the abscission zone area evokes asymmetrical changes leading to flower separation in yellow lupine. *International Journal of Molecular Sciences,* 21: 3815.

Lami, M.J.; Adler, C.; Caram-Di Santo, M.C.; Zenoff, A.M.; de Cristóbal, R.E.; Espinosa-Urgel, M.; Vincent, P.A. 2020. *Pseudomonas stutzeri* MJL19, a rhizosphere-colonizing bacterium that promotes plant growth under saline stress. *Journal of Applied Microbiology,* 129: 1321-1336.

Lamin, H.; Alami, S.; Bouhnik, O.; Bennis, M.; Benkritly, S.; Abdelmoumen, H.; Bedmar, E.J.; Missbah El Idrissi, M. 2020. Identification of the endosymbionts from *Sulla spinosissima* growing in a lead mine tailings in Eastern Morocco as *Mesorhizobium camelthorni* sv. aridi. *Journal of Applied Microbiology*, 130: 948-959.

Lamrabet, M.; Hanane, L.; Omar, B.; Meryeme, B.; Hanaa, A.; Bedmar, E.J.; El Idrissi Mustapha, M. 2020. Nodulation of *Retama* species by members of the genus *Microvirga* in Morocco. *Symbiosis,* 82: 249-258.

Lekmine, S.; Boussekine, S.; Kadi, K.; Martín-García, A.I.; Kheddouma, A.; Nagaz, K.; Bensouici, C. 2020. A comparative study on chemical profile and biological activities of aerial parts (stems, flowers, leaves, pods and seeds) of *Astragalus gombiformis*. *Biocatalysis and Agricultural Biotechnology,* 27: 101668.

Lima-Cabello, E.; Alché, J.D.; Morales-Santana, S.; Clemente, A.; Jiménez-López, J.C. 2020. Narrow-leafed lupin (Lupinus angustifolius L.) seeds gamma-conglutin is an anti-inflammatory protein

promoting insulin resistance improvement and oxidative stress amelioration in PANC-1 pancreatic cell-line. *Antioxidants,* 9: 12.

Lima-Cabello, E.; Morales-Santana, S.; Alché, V.; Clemente, A.; Alché, J.D.; Jiménez-López, JC. 2020. Blue lupin seed beta-conglutin proteins reverse back the induced insulin resistance in pancreatic cells. *Communications in Agricultural and Applied Biological Sciences*, 83: 67-70.

Lind, V.; Weisbjerg, M.R.; Jørgensen, G.M.; Fernández-Yepes, J.E.; Arbesú, L.; Molina-Alcaide, E. 2020. Ruminal fermentation, growth rate and methane production in sheep fed diets including white clover, soybean meal or *Porphyra* sp. *Animals,* 10: 79.

López, S.M.Y.; Pastorino, G.N.; Pastorino, G.N.; Fernández-González, A.J.; Franco, M.E.E.; Fernández-López, M.; Balatti, P.A. 2020. The endosphere bacteriome of diseased and healthy tomato plants. *Archives of Microbiology,* 202: 2629-2642.

López-Huertas, E.; Palma, J.M. 2020. Changes in glutathione, ascorbate, and antioxidant enzymes during olive fruit ripening. *Journal of Agricultural and Food Chemistry,* 68: 12221-12228.

López-Lara, L.I.; Pazos-Rojas, L.A.; López-Cruz, L.E.; Morales-García, Y.E.; Quintero-Hernández, V.; de La Torre, J.; van Dillewijn, P.; Muñoz-Rojas, J.; Báez, A. 2020. Influence of rehydration on transcriptome during resuscitation of desiccated *Pseudomonas putida* KT2440. *Annals of Microbiology,* 70: 54.

López-Vidal, O.; Olmedilla, A.; Sandalio, L.M.; Sevilla, F.; Jiménez, A. 2020. Is autophagy involved in pepper fruit ripening? *Cells,* 9: 106.

Maach, M.; Baghour, M.; Akodad, M.; Gálvez, F.J.; Sánchez, M.E.; Aranda, M.N.; Venema, K.; Rodríguez-Rosales, M.P. 2020. Overexpression of LeNHX4 improved yield, fruit quality and salt tolerance in tomato plants (*Solanum lycopersicum* L.). *Molecular Biology Reports,* 47: 4145-4153.

Marcos, C.N.; Carro, M.D.; Fernández Yepes, J.E.; Haro, A.; Romero-Huelva, M.; Molina-Alcaide, E. 2020. Effects of agroindustrial by-product supplementation on dairy goat milk characteristics, nutrient utilization, ruminal fermentation, and methane production. *Journal of Dairy Science,* 103: 1472-1483.

Marcos, C.N.; Carro, M.D.; Fernández Yepes, J.E.; Haro, A.; Romero-Huelva, M.; Molina-Alcaide, E. 2020. Effects of agroindustrial by-product supplementation on dairy goat milk characteristics, nutrient utilization, ruminal fermentation, and methane production. *Journal of Dairy Science,* 103: 1472-1483.

Marín-Manzano, M.C.; Hernández-Hernández, O.; Díez-Municio, M.; Delgado-Andrade, C.; Moreno, F.J.; Clemente, A. 2020. Prebiotic properties of non-fructosylated galactooligosaccharides from PEA (*Pisum sativum* L.) using infant fecal slurries. *Foods,* 9: 921.

Matilla, M.A.; Martín-Mora, D.; Krell, T. 2020. The use of isothermal titration calorimetry to unravel chemotactic signalling mechanisms. *Environmental Microbiology,* 22: 3005-3019.

Medina, R.; Fernández-González, A.J.; García-Rodríguez, F.M.; Villadas, P.J.; Rosso, J.A.; Fernández-López, M.; del Panno, M.T. 2020. Exploring the effect of composting technologies on the recovery of hydrocarbon contaminated soil post chemical oxidative treatment. *Applied Soil Ecology,* 150: 103459.

Mentag, R.; Khayi, S.; Azza, N.E.; Gaboun, F.; Pirro, S.; Badad, O.; Claros, M.G.; Lightfoot, D.A.; Unver, T.; Chaouni, B.; Merrouch, R.; Rahim, B.; Essayeh, S.; Ganoudi, M.; Abdelwahd, R.; Diria, G.; Mdarhi, M.A.; Labhilili, M.; Iraqi, D.; Mouhaddab, J.; Sedrati, H.; Memari, M.; Hamamouch, N.; Alché, J.D.; Boukhatem, N.; Mrabet, R.; Dahan, R.; Legssyer, A.; Khalfaoui, M.; Badraoui, M.; Van de Peer, Y.; Tatusova, T.; El Mousadik, A.; Ghazal, H. 2020. First draft genome assembly of the Argane tree (*Argania spinosa*). *F1000Research,* 7: 1310.

Mestre, M.R.; González-Delgado, A.; Gutiérrez-Rus, L.I.; Martínez-Abarca, F.; Toro, N. 2020. Systematic prediction of genes functionally associated with bacterial retrons and classification of the encoded tripartite systems. *Nucleic Acids Research*, 48: 12632–12647.

Mioto, PT.; Matiz, A.; Freschi, L.; Corpas, F.J. 2020. Fluorimetric-Based Method to Detect and Quantify Total S-Nitrosothiols (SNOs) in Plant Samples. *Methods of Molecular Biology,* 2057: 37-43.

Missbah El Idrissi, M.; Lamin, H.; Bouhnik, O.; Lamrabet, M.; Alami, S.; Jabrone, Y.; Bennis, M.; Bedmar, E.J.; Abdelmoumen, H. 2020. Characterization of *Pisum sativum* and *Vicia faba* microsymbionts in Morocco and definition of symbiovar viciae in *Rhizobium acidisoli*. *Systematic and Applied Microbiology*, 43: 126084.

Missbah El Idrissi, M.; Lamin, H.; ElFaik, S.; Tortosa, G.; Peix, A.; Bedmar, E.J.; Abdelmoumen, H. 2020. *Microvirga* sp. symbiovar mediterranense nodulates Lupinus cosentinii grown wild in Morocco. *Journal of Applied Microbiology,* 128: 1109-1118.

Molina, A.S.; Lugo, M.A.; Pérez Chaca, M.V.; Vargas-Gil, S.; Zirulnik, F.; Leporati, J.; Ferrol, N.; Azcón-Aguilar, C. 2020. Effect of arbuscular mycorrhizal colonization on cadmium-mediated oxidative stress in *Glycine max* (L.) Merr. *Plants,* 9: 108.

Molina-Santiago, C.; Matilla, M.A. 2020. Chemical fertilization: a short-term solution for plant productivity? *Microbial Biotechnology,* 13: 1311-1313.

Morcillo, R.J.L.; Zhao, A.; Tamayo-Navarrete, M.I.; García-Garrido, J.M.; Macho, A.P. 2020. Tomato root transformation followed by inoculation with *Ralstonia solanacearum* for straightforward genetic analysis of bacterial wilt disease. *Journal of Visualized Experiments,* 157: e60302.

Mukherjee, S.; Corpas, F.J. 2020. Crosstalk among hydrogen sulfide (H_2S), nitric oxide (NO) and carbon monoxide (CO) in root-system development and its rhizosphere interactions: A gaseous interactome. *Plant Physiology and Biochemistry,* 155: 800-814.

Muñoz-Vargas, M.A.; González-Gordo, S.; Palma, J.M.; Corpas, F.J. 2020. Inhibition of NADP-malic enzyme activity by H_2S and NO in sweet pepper (*Capsicum annuum* L.) fruits. *Physiologia Plantarum,* 168: 278-288.

Navarro Marcos, C.; Carro, M.D.; Fernández-Yepes, J.E.; Arbesu, L.; Molina-Alcaide, E. 2020. Utilization of avocado and mango fruit wastes in multi-nutrient blocks for goats feeding: *In vitro* evaluation. *Animals,* 10: 2279.

Nogales, J.; Mueller, J.; Gudmundsson, S.; Canalejo, F.J.; Duque, E.; Monk, J; Feist, AM; Ramos, J.L.; Niu, W; Palsson, BO. 2020. High-quality genome-scale metabolic modelling of *Pseudomonas putida* highlights its broad metabolic capabilities. *Environmental Microbiology,* 22: 255-269.

Nogales, R.; Fernández-Gómez, M.J.; Delgado-Moreno, L.; Castillo-Díaz, J.M.; Romero, E. 2020. Eco-friendly vermitechnological winery waste management: A pilot-scale study. *SN Applied Science,* 2: 653.

Novoa-Garrido, M.; Navarro Marcos, C.; Carro Travieso, M.D.; Molina Alcaide, E.; Larsen, M.; Riis Weisbjerg, M. 2020. Preserving porphyra umbilicalis and *Saccharina latissima* as silages for ruminant feeding. *Animals,* 10: 1957.

Oehl, F.; Sánchez-Castro, I.; Santos, V.M.; Silva, G.A.D.; Palenzuela, J. 2020. *Archaeospora europaea*, a new arbuscular mycorrhizal fungus from France, Germany, Italy and Switzerland, with a key to the Archaeosporaceae species. *Sydowia,* 71: 129-137.

Ortega, A.; Krell, T. 2020. Chemoreceptors with C-terminal pentapeptides for CheR and CheB binding are abundant in bacteria that maintain host interactions. *Computational and Structural Biotechnology Journal,* 18: 1947-1955.

Ortiz, A.; Parrini, S.; Tejerina, D.; Pinto de Araújo, F.P.; Candek-Potokar, M.; Crovetti, A.; J Garcia-Casco, J.M.; González, J.; Hernández-García, F.I.; Karolyi, D.; Margeta, V.; Martins, J.M.; Nieto, R.; Petig, M.; Razmaite, V.; Sirtori, F.; Lebret, B.; Bozzi, R. 2020. Potential use of near-infrared spectroscopy to predict fatty acid profile of meat from different European autochthonous pig breeds. *Applied Sciences (Switzerland),* 10: 5801.

Otero-Asman, J.R.; Quesada, J.M.; Jim, K.K.; Ocampo-Sosa, A.; Civantos, C.; Bitter, W.; Llamas, M.A. 2020. The extracytoplasmic function sigma factor σVrel is active during infection and contributes to phosphate starvation-induced virulence of *Pseudomonas aeruginosa*. *Scientific Reports,* 10: 3139.

Palma, J.M.; Mateos, R.M.; López-Jaramillo, J.; Rodríguez-Ruiz, M.; González-Gordo, S.; Lechuga-Sancho, A.M.; Corpas, F.J. 2020. Plant catalases as NO and H_2S targets. *Redox Biology,* 34: 101525.

Palma, J.M.; Seiquer, I. 2020. To be or not to be... an antioxidant? That is the question. *Antioxidants,* 9: 1234.

Palma, J.M.; Terán, F.; Contreras-Ruiz, A. Rodríguez-Ruiz, M.; Corpas, F.J. 2020. Antioxidant profile of pepper (*Capsicum annuum* L.) fruits containing diverse levels of capsaicinoids. *Antioxidants,* 9: 878.

Pardo, Z.; Mateos, I.; Campos, R.; Francisco, A.; Lachica, M.; Ranilla, M.J.; Fernández-Figares, I. 2020. Heat stress increases in vitro hindgut fermentation of distinct substrates in iberian pigs. *Animals,* 10: 2173.

Parra-Almuna, L.; Pontigo, S.; Larama, G.; Cumming, J.R.; Pérez-Tienda, J.; Ferrol, N.; de la Luz Mora, M. 2020. Expression analysis and functional characterization of two PHT1 family phosphate transporters in ryegrass. *Planta,* 251: 6.

Peco, J.D.; Campos, J.A.; Romero-Puertas, M.C.; Olmedilla, A.; Higueras, P.; Sandalio, L.M. 2020. Characterization of mechanisms involved in tolerance and accumulation of Cd in *Biscutella auriculata* L. *Ecotoxicology and Environmental Safety,* 201: 110784.

Peco, J.D.; Higueras, P.; Campos, J.A.; Olmedilla, A.; Romero-Puertas, M.C.; Sandalio, L.M. 2020. Deciphering lead tolerance mechanisms in a population of the plant species *Biscutella auriculata* L. from a mining area: Accumulation strategies and antioxidant defenses. *Chemosphere,* 261: 127721.

Pech-Canul, A.; Rivera-Hernández, G.; Nogales, J.; Geiger, O.; Soto, M.J.; López-Lara, I.M. 2020. Role of *Sinorhizobium meliloti* and *Escherichia coli* long-chain acyl-CoA synthetase FadD in long-term survival. *Microorganisms,* 8, 470.

Peña, A.; Delgado-Moreno, L.; Rodríguez-Liébana, J.A. 2020. A review of the impact of wastewater on the fate of pesticides in soils: Effect of some soil and solution properties. *Science of the Total Environment,* 718: 134468.

Peralta, J.M.; Travaglia, C.N.; Romero-Puertas, M.C.; Furlan, A.; Castro, S.; Bianucci, E. 2020. Unraveling the impact of arsenic on the redox response of peanut plants inoculated with two different *Bradyrhizobium* sp. strains. *Chemosphere,* 259: 1274102.

Perea, A.J.; Garrido, J.L.; Fedriani, J.M.; Rey, P.J.; Alcántara, J.M. 2020. Pathogen life-cycle leaves footprint on the spatial distribution of recruitment of their host plants. *Fungal Ecology,* 47: 100974.

Piacentini, D.; Corpas, F.J.; D'Angeli, S.; Altamura, M.M.; Falasca, G. 2020. Cadmium and arsenic-induced-stress differentially modulates *Arabidopsis* root architecture, peroxisome distribution, enzymatic activities and their nitric oxide content. *Plant Physiology and Biochemistry,* 148: 312-323.

Pizarro-Tobias, P.; Ramos, J.L.; Duque, E.; Roca, A. 2020. Plant growth-stimulating rhizobacteria capable of producing L-amino acids. *Environmental Microbiology Reports,* 12: 667-671.

Pozo, M.J.; Albrectsen, B.R.; Bejarano, E.R., de la Peña, E.; Herrero, S.; Martínez-Medina, A.; Pastor, V.; Ravnskov, S.; Williams, M.; Biere, A. 2020. Three-way interactions between plants, microbes, and arthropods (PMA): Impacts, mechanisms, and prospects for sustainable plant protection. Teaching Tools in Plant Biology: Lecture Notes. The Plant Cell, 7: 8699118.

Quiroga, G.; Erice, G.; Aroca, R.; Delgado-Huertas, A.; Ruiz-Lozano, J.M. 2020. Elucidating the possible involvement of maize aquaporins and arbuscular mycorrhizal symbiosis in the plant ammonium and urea transport under drought stress conditions. *Plants,* 9: 148.

Quiroga, G.; Erice, G.; Aroca, R.; Ruiz-Lozano, J.M. 2020. Elucidating the possible involvement of maize aquaporins in the plant boron transport and homeostasis mediated by *Rhizophagus irregularis* under drought stress conditions. *International Journal of Molecular Sciences,* 21: 1748.

Quiroga, G.; Erice, G.; Aroca, R.; Zamarreño, A.M.; García-Mina, J.M.; Ruiz-Lozano, J.M. 2020. Radial water transport in arbuscular mycorrhizal maize plants under drought stress conditions is affected by indole-acetic acid (IAA) application. *Journal of Plant Physiology,* 246-247: 153115.

Ramos, J.L.; Lansac, R. 2020. Caring soils for sustainable land uses. *Microbial Biotechnology,* 13: 1309-1310.

Requena-Mullor, J.M.; García-Garrido, J.M.; García, P.A.; Rodríguez, E. 2020. Climatic drivers of *Verticillium dahliae* occurrence in Mediterranean olive-growing areas of southern Spain. *PLoS ONE,* 15: e0232648.

Ríos-Ruiz, W.F.; Torres-Chávez, E.E.; Torres-Delgado, J.; Rojas-García, J.C.; Bedmar, E.J.; Valdez-Nuñez, R.A. 2020. Inoculation of bacterial consortium increases rice yield (*Oryza sativa* L.) reducing applications of nitrogen fertilizer in San Martin region, Peru. *Rhizosphere*, 14: 100200.

Robledo, M.; García-Tomsig, N.I.; Jiménez-Zurdo, J.I. 2020. Riboregulation in nitrogen-fixing endosymbiotic bacteria. *Microorganisms,* 8: 384.

Rodríguez, J.M.; Clemente, A.; Requena, T. 2020. Dysbiosis and its modulation through the use of probiotics, prebiotics and other members of the biotics family. General concepts. *Approaches to Aging Control,* 24: 36-47.

Rodríguez-Calvo, A.; Silva-Castro, G.A.; Olicón-Hernández, D.R.; González-López, J.; Calvo, C. 2020. Biodegradation and absorption technology for hydrocarbon-polluted water treatment. *Applied Sciences (Switzerland),* 10: 841.

Rodríguez-González, A.; Terrón-Camero, L.C.; Romero-Puertas, M.C. 2020. Nitric oxide functions in plant response to cadmium toxicity/Funciones del

óxido nítrico en la respuesta de la planta a la toxicidad por cadmio. *Ecosistemas,* 29: 1935.

Romero-Aranda, M.R.; González-Fernández, P.; López-Tienda, J.R.; López-Díaz, M.R.; Espinosa, J.; Granum, E.; Traverso, J.A.; Pineda, B.; Garcia-Sogo, B.; Moreno, V.; Asins, M.J.; Belver, A. 2020. Na^+ transporter HKT1;2 reduces flower Na^+ content and considerably mitigates the decline in tomato fruit yields under saline conditions. *Plant Physiology and Biochemistry,* 154: 341-352.

Rubio, L.A.; Aranda-Olmedo, I.; Contreras, S.; Góngora, T.; Domínguez, G.; Peralta-Sánchez, J.M.; Martín-Pedrosa, M. 2020. Inclusion of limited amounts of extruded legumes plus cereal mixes in normocaloric or obesogenic diets for rats: effects on intestinal microbiota composition. *Journal of the Science of Food and Agriculture,* 100: 5546-5557.

Rubio, L.A.; Aranda-Olmedo, I.; Martín-Pedrosa, M. 2020. Inclusion of limited amounts of extruded legumes plus cereal mixes in normocaloric or obesogenic diets for rats: Effects on lipid profile. *Foods,* 9: 704-722

Rubio-Gómez, J.M.; Santiago, C.M.; Udaondo, Z.; Garitaonaindia, M.T.; Krell, T.; Ramos, J.L.; Daddaoua, A. 2020. Full transcriptomic response of *Pseudomonas aeruginosa* to an inulin-derived fructooligosaccharide. *Frontiers in Microbiology*, 11: 202.

Ruiz, R.; Olías, R.; Clemente, A.; Rubio, L.A. 2020. A pea (*Pisum sativum* l.) seed vicilins hydrolysate exhibits PPAR ligand activity and modulates adipocyte differentiation in a 3T3-L1 cell culture model. *Foods,* 9: 793-809

Salas, A.; Tortosa, G.; Hidalgo-García, A.; Delgado, A.; Bedmar, E.J.; Richardson, D.J.; Gates, A.J.; Delgado, M.J. 2020. The hemoglobin Bjgb from *Bradyrhizobium diazoefficiens* controls NO homeostasis in soybean nodules to protect symbiotic nitrogen fixation. *Frontiers in Microbiology*, 10: 2915.

Sandalio, L.M.; Peláez-Vico, M.A.; Romero-Puertas, M.C. 2020. Peroxisomal metabolism and dynamics at the crossroads between stimulus perception and fast cell responses to the environment. *Frontiers in Cell and Developmental Biology,* 8: 505.

Sanjuán, J.; Delgado, M.J.; Delgado, M.J.; Girard, L. 2020. Editorial: Microbial control of the nitrogen cycle. *Frontiers in Microbiology,* 11: 950.

Sanmartín, N.; Sánchez-Bel, P.; Pastor, V.; Pastor-Fernández, J.; Mateu, D.; Pozo, M.J.; Cerezo, M.; Flors, V. 2020. Root-to-shoot signalling in mycorrhizal tomato plants upon *Botrytis cinerea* infection. *Plant Science,* 298: 110595.

Santander, C.; Ruiz, A.; García, S.; Aroca, R.; Cumming, J.; Cornejo, P. 2020. Efficiency of two arbuscular mycorrhizal fungal inocula to improve saline stress tolerance in lettuce plants by changes of antioxidant defense mechanisms. *Journal of the Science of Food and Agriculture,* 100: 1577-1587.

Seguel, A.; Meier, F.; Azcón, R.; Valentine, A.; Meriño-Gergichevich, C.; Cornejo, P.; Aguilera, P.; Borie, F. 2020. Showing their mettle: extraradical mycelia of arbuscular mycorrhizae form a metal filter to improve host Al tolerance and P nutrition. *Journal of the Science of Food and Agriculture,* 100: 803-810.

Senovilla, M.; Abreu, I.; Escudero, V.; Cano, C.; Bago, A.; Imperial, J.; González-Guerrero, M. 2020. MtCOPT2 is a Cu+ transporter specifically expressed in *Medicago truncatula* mycorrhizal roots. *Mycorrhiza,* 30: 781-788.

Siddiqui, M.H.; Alamri, S.; Nasir Khan, M.; Corpas, F.J.; Al-Amri, A.A.; Alsubaie, Q.D.; Ali, H.M.; Kalaji, H.M.; Ahmad, P. 2020. Melatonin and calcium function synergistically to promote the resilience through ROS metabolism under arsenic-induced stress. *Journal of Hazardous Materials,* 398: 122882.

Soares, R.; Trejo, J.; Lorite, M.J.; Figueira, E.; Sanjuán, J.; E Castro, I.V. 2020. Diversity, phylogeny and plant growth promotion traits of nodule associated bacteria isolated from *Lotus parviflorus*. Microorganisms, 8: 499.

Solórzano, E.; Corpas, F.J.; González-Gordo, S.; Palma, J.M. 2020. Reactive oxygen species (ROS) metabolism and nitric oxide (NO) content in roots and shoots of rice (*Oryza sativa* L.) plants under arsenic-induced stress. *Agronomy,* 10: 1014.

Souri, Z.; Karimi, N.; Farooq, M.A.; Sandalio, L.M. 2020. Nitric oxide improves tolerance to arsenic stress in *Isatis cappadocica* desv. shoots by enhancing antioxidant defenses. *Chemosphere,* 239: 124523.

Talbi, S.; Rojas, J.A.; Sahrawy, M.; Rodríguez-Serrano, M.; Cárdenas, K.E.; Debouba, M.; Sandalio, L.M. 2020. Effect of drought on growth, photosynthesis and total antioxidant capacity of the Saharan plant *Oudeneya africana*. *Environmental and Experimental Botany,* 176: 104099.

Terrón-Camero, L.C.; del Val, C.; Sandalio, L.M.; Romero-Puertas, M.C. 2020. Low endogenous NO

levels in roots and antioxidant systems are determinants for the resistance of *Arabidopsis* seedlings grown in Cd. *Environmental pollution,* 256: 113411.

Terrón-Camero, L.C.; Rodríguez-Serrano, M.; Sandalio, L.M.; Romero-Puertas, M.C. 2020. Nitric oxide is essential for cadmium-induced peroxule formation and peroxisome proliferation. *Plant, Cell and Environment,* 43: 2492-2507.

Tortosa, G.; Pacheco, P.J.; Hidalgo-García, A.; Granados, A.; Delgado, A.; Mesa, S.; Bedmar, E.J.; Delgado, M.J. 2020. Copper modulates nitrous oxide emissions from soybean root nodules. *Environmental and Experimental Botany*, 180: 104262.

Tortosa, G.; Torralbo, F.; Maza-Márquez, P.; Aranda, E.; Calvo, C.; González-Murua, C.; Bedmar, E.J. 2020. Assessment of the diversity and abundance of the total and active fungal population and its correlation with humification during two-phase olive mill waste ("alperujo") composting. *Bioresource Technology,* 295: 122267.

Udaondo, Z.; Duque, E.; Daddaoua, A.; Caselles, C.; Roca, A.; Pizarro-Tobías, P.; Ramos, J.L. 2020. Developing robust protein analysis profiles to identify bacterial acid phosphatases in genomes and metagenomic libraries. *Environmental Microbiology,* 22: 3561-3571.

Udaondo, Z.; Matilla, M.A. 2020. Mining for novel antibiotics in the age of antimicrobial resistance. *Microbial Biotechnology,* 13: 1702-1704.

Valdivia, M.; Galan, J.L.; Laffarga, J.; Ramos, J.L. 2020. A research and technology valuation model for decision analysis in the environmental and renewable energy sectors. *Renewable and Sustainable Energy Reviews,* 122: e109726.

Vargas, J.E.; Andrés, S.; López-Ferreras, L.; Snelling, T.J.; Yáñez-Ruíz, D.R.; García-Estrada, C.; López, S. 2020. Dietary supplemental plant oils reduce methanogenesis from anaerobic microbial fermentation in the rumen. *Scientific Reports,* 10: 1613.

Vejvodová, K.; Száková, J.; García-Sánchez, M.; Praus, L.; García-Romera, I.; Tlustoš, P. 2020. Effect of dry olive residue based biochar and arbuscular mycorrhizal fungi inoculation on the nutrient status and trace element contents in wheat grown in the As-, Cd-, Pb-, and Zn-contaminated soils. *Journal of Soil Science and Plant Nutrition,* 20: 1067-1079.

Velando, F.; Gavira, J.A.; Rico-Jiménez, M.; Matilla, M.A.; Krell, T. 2020. Evidence for pentapeptide dependent and independent CheB methylesterases. *International Journal of Molecular Sciences,* 21: 8459.

Wang, S.P.; Rubio, L.A.; Duncan, S.H.; Donachie, G.E.; Holtrop, G.; Lo, G.; Farquharson, F.M.; Wagner, J.; Parkhill, J.; Louis, P.; Walker, A.W.; Flint, H.J. 2020. Pivotal roles for pH, lactate, and lactate-utilizing bacteria in the stability of a human colonic microbial ecosystem. *mSystems,* 5: e00645-20.

Wettstadt, S. 2020. Breaking free from home: biofilm dispersal by a glycosidase from *Desulfovibrio vulgaris*. *Environmental Microbiology,* 22: 557-558.

Wettstadt, S. 2020. Death in a sphere: *Chromobacterium violaceum* secretes outer membrane vesicles filled with antibiotics. *Environmental Microbiology Reports,* 12: 255-257.

Wettstadt, S. 2020. Protect thy host: Pf4 phages shield *Pseudomonas aeruginosa* from antibiotics. *Environmental Microbiology,* 22: 2461-2462.

Wettstadt, S. 2020. Should I kill or should I go: T6SS regulation networks in *Vibrio*. *Environmental Microbiology,* 22: 1-4.

Wettstadt, S. 2020. Some have it all: multicellularity, magnetotaxis and photokinesis in one bacterium. *Environmental Microbiology,* 22: 2993-2995.

Wettstadt, S.; Filloux, A. 2020. Manipulating the type VI secretion system spike to shuttle passenger proteins. PLoS ONE, 15: e0228941.

Wettstadt, S.; Llamas, M.A. 2020. Role of regulated proteolysis in the communication of bacteria with the environment. Frontiers in Molecular Bioscience, 7: 586497.

Zhao, P.; Ye, Q.; Yu, K.; Whalen, J.K.; Rajesh Kumar, R.; Cheng, X.; Delgado-Moreno, L.; Wang, W. 2020. Uptake and transformation of decabromodiphenyl ether in different rice cultivars: Evidence from a carbon-14 study. *Science of the Total Environment,* 704: 135398.

EDITION OF BOOKS

Arbuscular Mycorrhizal Fungi. Methods and Protocols. In the collection 'Methods in Molecular Biology'**.** 2020. Editors: Ferrol, N.; Lanfranco, L. Springer. 254 pages. ISBN: 978-1-0716-0602-5.

Production of organic fertiliser from waste accumulated in the effluent ponds generated in olive oil mills / Elaboración de abono orgánico a partir de residuos acumulados en las balsas de efluentes generados en almazaras. Vol. 1. 2020. Editors: Rodríguez, A.; Camacho, J.A.; Nogales, R. Consejo Andaluz de Colegio Oficiales de Ingenieros Técnicos Agrícolas. 44 pages. ISBN: 978-84-17970-94-9.

Seed Dormancy and Germination. 2020. Editors: Jiménez-López, J.C. InTechOpen. 158 pages. ISBN: 978-1-78984-861-8.

BOOKS CHAPTERS

Castro, A.J.; Clemente, A.; Alché, J.D. 2020. A protocol for minimal single protein labelling with CyDye fluors for live cell internalization assays. In: Fluorescent methods for investigation of living cells and microorganisms. InTechOpen, pp. 1-14. ISBN: 978-1-83968-040-3.

Clemente, A.; Requena, T. 2020. Efectos beneficiosos de los prebióticos en la salud humana: evidencia científica. In: Inmunonutrición y Estilo de Vida. Panamericana Editorial, pp. 417-430. ISBN: 978-84-9110-121-5.

García, J.M.; Pozo, M.J.; López-Ráez, J.A. 2020. Histochemical and molecular quantification of arbuscular mycorrhiza symbiosis. In: Methods in Molecular Biology. Springer, pp. 293-299. ISBN: 978-1-4939-9951-4.

Ho-Plágaro, T.; Tamayo-Navarrete, M.I.; García-Garrido, J.M. 2020. Functional analysis of plant genes related to arbuscular mycorrhiza symbiosis using *Agrobacterium rhizogenes*-mediated root transformation and hairy root production. In: Hairy Root Cultures Based Applications. Rhizosphere Biology. Springer, pp. 191-215. ISBN: 978-981-15-4055-4.

Ho-Plágaro, T.; Tamayo-Navarrete, M.I.; García-Garrido, J.M. 2020. Histochemical staining and quantification of arbuscular mycorrhizal fungal colonization. In: Arbuscular Mycorrhizal Fungi. Methods and Protocols. Springer, pp. 43-52. ISBN: 978-1-0716-0602-5.

Mesías, M.; Seiquer, I.; Delgado-Andrade, C. 2020. The Mediterranean diet and mineral composition. In: The Mediterranean Diet: an Evidence-based Approach. Second Edition. Elsevier, pp. 151-163. ISBN: 978-0-12-818649-7.

Sánchez-Romera, B.; Aroca, R. 2020. Plant roots - The hidden half for investigating salt and drought stress responses and tolerance. In: Salt and Drought Stress Tolerance in Plants. Signaling Network and Adaptive Mechanisms. Springer, pp 137-175. ISBN: 978-3-030-40276-1.

Sánchez-Romera, B.; Aroca, R. 2020. Techniques to determine the effects of jasmonates on root hydraulic conductivity. In: Methods in Molecular Biology (Clifton, N.J.) 2085: 29-39.

Sbrana, C.; Pepe, A.; Ferrol, N.; Giovannetti, M. 2020. A whole-plant culture method to study structural and functional traits of extraradical mycelium. In: Arbuscular Mycorrhizal Fungi. Methods and Protocols. Springer, pp 33-41. ISBN: 978-1-0716-0602-5.

Silvestri, A.; Pérez-Tienda, J.R.; López-Ráez, J.A. 2020. Arbuscular mycorrhizal fungal gene expression analysis by real-time PCR. In: Arbuscular Mycorrhizal Fungi. Methods and Protocols. Springer, pp. 157-170. ISBN: 978-1-0716-0602-5.

Tamayo, E.; Gómez-Gallego, T.; Ferrol, N. 2020. Functional analysis of arbuscular mycorrhizal fungal genes in yeast. In: Arbuscular Mycorrhizal Fungi. Methods and Protocols. Springer, pp. 197-211. ISBN: 978-1-0716-0602-5.

WORKSHOPS AND MEETINGS

XI Workshop Spanish Society of Microbiota, Probiotics and Prebiotics (SEMiPyP).

Granada, 12-14 February 2020.
Chairman: Alfonso Clemente Gimeno.

Webinar Zootechnical Documents.

Organizer: Group of Small Ruminants Production in the framework of The Spanish Excellence Net work NUEVA (Network for Updating Emissions Values in Spanish Agriculture) .
21st May 2020 (Online).

Webinar on Advances in Resilience of Sustainable Crop Production. Centenary Celebrations.

Aligarh, India, 9th December 2020 (Online).
Member of the Organizing Committee: F. Javier Corpas Aguirre.
Organizing Secretary/Chairperson: Professor Nafees Ahmad Khan, Aligarh Muslim University.

AWARDS

Extraordinary Doctorate Award in the area of Health Sciences, call 2016/2017, to Mª del Carmen Arqués Mengual, for her Thesis "Polymorphism and biological activity of legume Bowman-Birk inhibitors", directed by Alfonso Clemente Gimeno.

First Award in the XXI Edition of "Science in Action", section "Biology Laboratory" (Award SEBBM) to the work "How do you know if a bacterium has CRISPR elements? (Emulating the discovery of F. Mojica Alicante 2003)". Martínez-Abarca, F.; Amorós, N.; Puig, M.D.; Martín, D.; Nieves, M.; López, S.; Fijo, M. (Event Online, published 6th July 2020).

https://cienciaenaccion.org/resolucion-del-jurado-de-ciencia-en-accion-xxi-opcion-presencial/

MicroMolecular 2020 Award: Selected presentation in the Virtual Congress: González-Delgado, A.; Rodríguez Mestre, M.; Martínez-Abarca, F.; Toro, N. 2019. Spacer acquisition from RNA mediated by a natural reverse transcriptase-Cas1 fusion protein associated with a type III-D CRISPR–Cas system in *Vibrio vulnificus*. *Nucleic Acids Research*, 47: 10202-10211. Presented by Alejandro González Delgado. 21st October 2020.

TEACHING ACTIVITIES

DOCTORAL PROGRAMMES

Doctoral Programme in Biochemistry and Molecular Biology. University of Granada.

Academic Committee member: Mariam Sahrawy Barragán.
https://escuelaposgrado.ugr.es/doctorado/escuelas/ayudas_y_becas/intoffer/index#_doku_phd_program_in_biochemistry_and_molecular_biology

Doctoral Programme in Nutritional and Food Sciences. University of Granada.

Academic Committee members: Ignacio Fernández-Fígares Ibáñez, Isabel Seiquer Gómez-Pavón.
https://www.ugr.es/en/study/masters-degrees/doctoral-programme-nutrition-and-food-sciences

Doctoral Programme in Economic, Business and Social Sciences. University of Seville.
http://www.doctorado.us.es/oferta-estudios-doctorado/oferta-plan-2011/ciencias-economicas-empresariales-y-sociales-plan-2011

Doctoral Programme in Fundamental and Systems Biology. University of Granada.

Academic Committee secretary: Nuria Ferrol González.

Academic Committee members: José Manuel Palma Martínez, Adela Olmedilla Arnal, Mª Jesús Delgado Igeño.

Committee for Internal Quality members: Nuria Ferrol González, Juan Manuel Palma Hidalgo.
https://www.ugr.es/en/study/masters-degrees/doctoral-programme-fundamental-and-systems-biology

MASTER PROGRAMMES

Participation in Commitees and/or teaching activities in the next Master programmes:

Master in Advances in Agricultural Biology and Aquaculture. University of Granada.

Academic Committee members: María C. Romero Puertas, A. Ignacio Martín García.
Committee for Internal Quality member: Juan de Dios Alché Ramírez.
https://masteres.ugr.es/agrariayacuicultura/

Master in Biotechnology. University of Granada.
Academic Committee member: Manuel Fernández López.
https://masteres.ugr.es/biotecnologia/

Master in Genetics and Evolution. University of Granada.
Academic Committee member: Francisco Martínez-Abarca Pastor.
https://masteres.ugr.es/genevol/

Master in Research and Advances in Microbiology. University of Granada.

Academic Committee member: Mª Socorro Mesa Banqueri.
https://masteres.ugr.es/microbiologia/

Master in Microbiota, Microbiota, Probiotics and Prebiotics. European University Madrid.

Coordinator of the Master: Alfonso Clemente Gimeno.
https://universidadeuropea.com/master-microbiota-probioticos-prebioticos-online/

Master in Research and Advances in Molecular and Cellular Immunology. University of Granada.
https://masteres.ugr.es/masterinmunogia/

Master in Molecular Biology Applied to Biotechnology Companies (BioEnterprise). University of Granada.
https://masteres.ugr.es/bioenterprise/

Master in Olive Growing and Oil Technology. University of Córdoba.
https://www.uco.es/idep/olivicultura-elaiotecnia

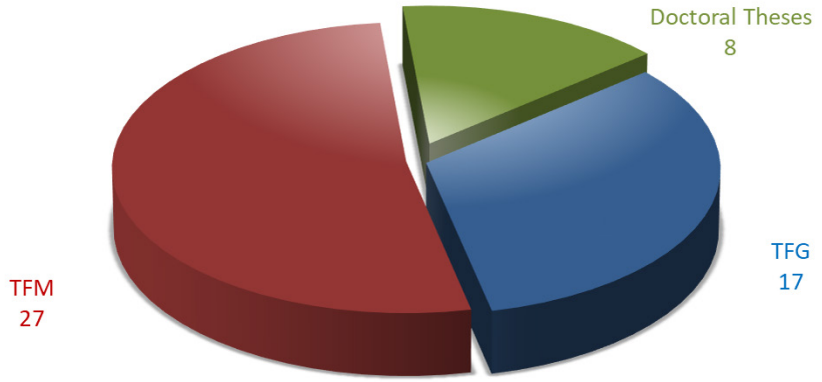
Master in Advances in Food Security. University of Jaén.
https://www.ujaen.es/estudios/oferta-academica/masteres/master-universitario-en-avances-en-seguridad-de-los-alimentos

Master in Advanced Biotechnology. University of Málaga and International University of Andalusia.
https://www.uma.es/master-en-biotecnologia-avanzada/

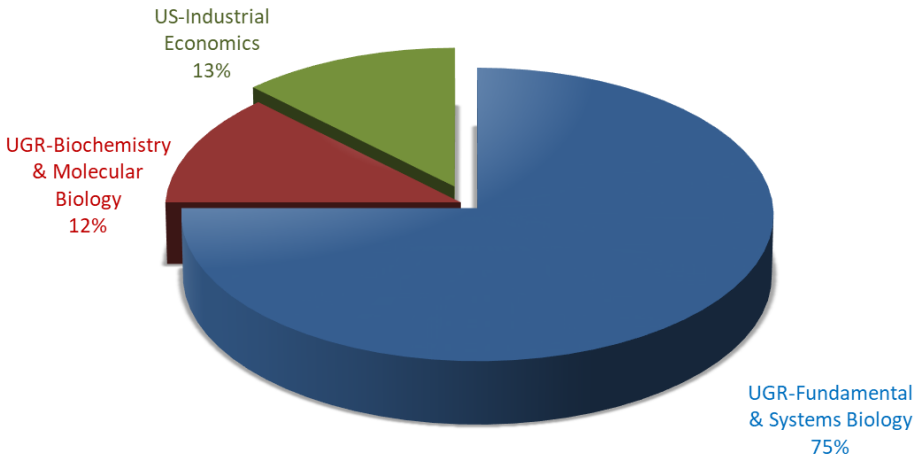
Master in Management, Treatment and Use of Organic Waste. Miguel Hernández University of Elche.
http://masterresiduos.edu.umh.es/

Master in Organic Agriculture and Livestock. International University of Andalusia (UNIA).
https://www.upo.es/postgrado/Master-Oficial-Agricultura-y-Ganaderia-Ecologicas

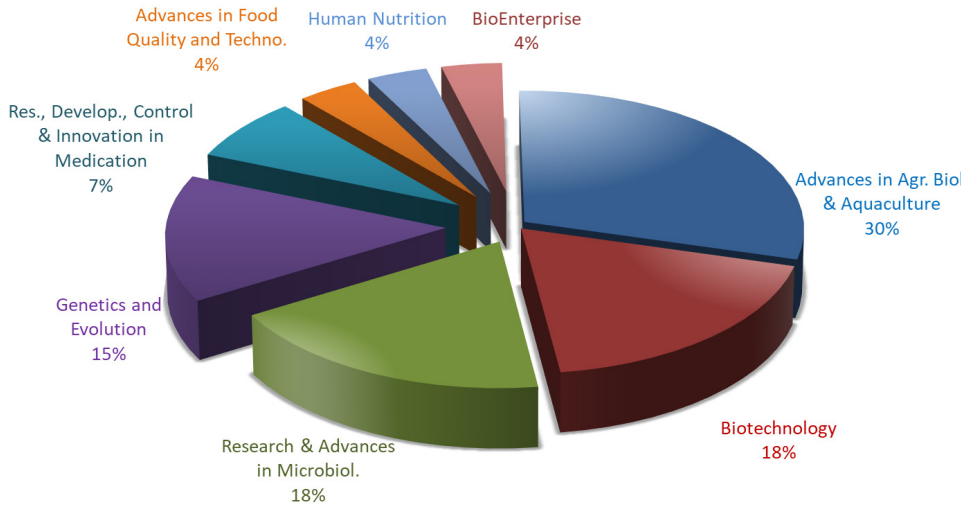
DOCTORAL THESES, MASTER´S THESES (TFM) & FINAL DEGREE PROJECTS (TFG)



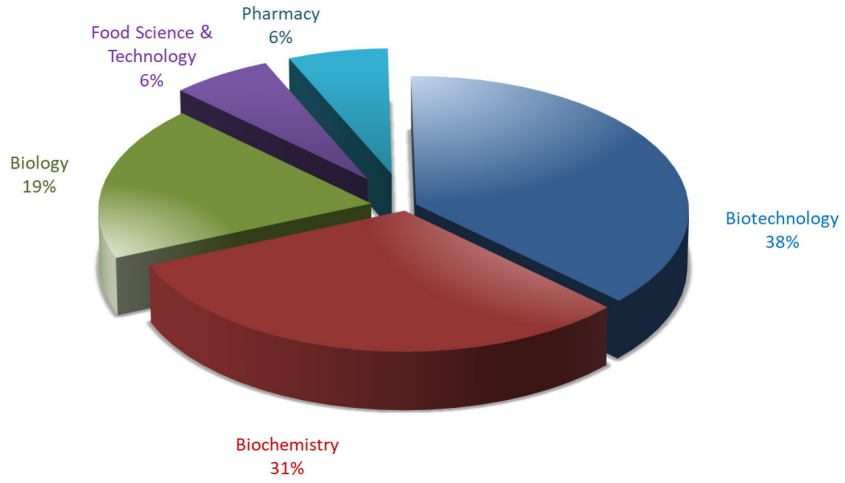
Number of Doctoral Theses, Master's Theses (TFM) & Final Degree Projects (TFG) defended at EEZ during 2020



Distribution of theses carried out in the different Doctoral Programmes



Distribution of the Master's Theses (TFM) in the UGR Programmes



Distribution of the Final Degree Projects (TFG) in the UGR Programmes

DOCTORAL THESES

Biobed biopurification systems with agroindustrial wastes to remove organic contaminants from water: microbiological and molecular aspects

Author: Inés Mª Aguilar Romero
Supervisors: Mª Esperanza Romero Taboada, Pieter van Dillewijn
University of Granada, 10th December 2020

Role of glutathione in the olive reproductive biology

Author: Estefanía García Quirós
Supervisor: Juan de Dios Alché Ramírez
University of Granada, 17th January 2020
International Doctorate Mention

Assessment of the phosphorus acquisition related root traits of two wheat cultivars differing on efficiency: towards phosphorus sustainability

Author: Pedro Montesano de Souza Campos
Supervisor: Juan Antonio López Ráez
University of Granada, University La Frontera (UFRO), Temuco, Chile, 22th April 2020

Role of nitric oxide signaling in beneficial and pathogenic plant-fungal interactions

Author: Leyre Pescador Azofra
Supervisors: María C. Romero Puertas, Mª José Pozo Jiménez
University of Granada, 20th July 2020
International Doctorate Mention

Deciphering the contribution of maize aquaporins regulated by arbuscular mycorrhizae to the transport in planta of water and/or other solutes of physiological importance under drought

Author: Gabriela Quiroga García
Supervirsors: Juan Manuel Ruiz Lozano, Gorka Erice Soreasu
University of Granada, 24th January 2020
International Doctorate Mention

Exploring the role of the haemoglobin from *Bradyrhizobium diazoefficiens* in nitric oxide detoxification during free-living and endosymbiotic lifestyles

Author: Ana Salas Huertas
Supervisor: Mª Jesús Delgado Igeño
University of Granada, 6th March 2020
International Doctorate Mention

Role of nitric oxide (NO) in plant response to cadmium and *Fusarium oxysporum*: Possible crosstalk

Author: Laura Carmen Terrón Camero
Supervisors: María C. Romero Puertas, Luisa Mª Sandalio González
University of Granada, 22th July 2020
International Doctorate Mention

R&D Management in industrial companies: Tools and organizational changes

Author: Miguel Valdivia Borrero
Supervisors: Juan Luis Ramos Martín, José Luis Galán González, Joaquina Laffarga Briones
University of Seville, 16th June 2020

JAE-INTRO STUDENTS

Mª Ángeles Chico Lozano
Supervisor: Juan Antonio López Ráez

Jesús Espinosa Rodríguez
Supervisor: Andrés Belver Cano

Alba Ortigosa Palomo
Supervisor: José Manuel Palma Martínez

María Padial de Jáudenes
Supervisor: Alfonso Clemente Gimeno

Alejandro Rodríguez González
Supervisors: Mª José Pozo Jiménez, María C. Romero Puertas

Anna Mª Rodríguez Pohnlein
Supervisor: Alfonso Clemente Gimeno

INHOUSE COURSES

LVII EDAPHOLOGY, SOIL FERTILITY AND PLANT BIOLOGY INTERNATIONAL COURSE

On 4th February started the LVII International Course of Edaphology, Soil Fertility and Plant Biology hosted by the CSIC and the University of Granada. This course is one of the most emblematic activities of the EEZ, since it has been imparted during 57 years continuously. Since 2018 is coordinated by Dr. Ricardo Aroca. The EEZ supports this course with most of the professors, installa-

tions and equipment. The Andalusian Institute of Earth Sciences and the University of Granada also support the course with lecturers. The course addresses different biological subjects like soil characteristics, plant microbial interactions or plant molecular biology.

This course is recognized by the University of Granada as an "Own Training", dispatching an official diploma to all the students that do the course. In 2020 twenty- three students, coming from Holland, Pakistan and Spain, attended this Course.

Unfortunately, this edition had to be suspended on 14th March because of the COVID pandemic and it will be continued in 2021 when possible, most probably in an online platform.

STUDENTS

Sebastián Acosta Jurado

Mª del Carmen Aguilera Serrano

Ali Ahmad

Mónica Burrueco Duro

Raquel Colorado Rosa

Andrea Domínguez Donoso

Julián José Duque Pedraza

Fernando Manuel García Rodríguez

Zuleima González Rodríguez

Pedro Jesús Jabalera Ortiz

Ylenia Mª Jabalera Ruz

Amanda Mª Martín Martínez

Marcos F. Martínez Moreno

Silko Fernando Mergenthal

Lázaro Molina Delgado

Mª Dolores Molina Sánchez

Juan Antonio Moreno Aragón

Felipe Luis Pérez Gordillo

Ana Mª Prados Fernández

Martín Ramos-Alvelo Cancellieri

Cristina Ropero Moreno

Eduardo Salas Espejo

Nataly Taco Taype

CSIC SPECIALISATION COURSES

Electrophoretic Techniques and their Applications in Agri-Food Research.

Organization: CSIC Training Office, Deputy General Secretary for Human Resources, in collaboration with the EEZ Department of Biochemistry and Molecular and Cellular Biology of Plants. Granada, 5-9 October, 2020.

Teachers: Antonio Jesús Castro, Juan de Dios Alché, José Manuel Palma, F. Javier Corpas, Carmelo Ruiz.

Chromatographic Techniques: GC-MS, LC-MS.

Organization: CSIC Training Office, Deputy General Secretary for Human Resources, in collaboration with the EEZ Scientific Instrumentation Service. Granada, 19-23 October, 2020.

Teachers: Rafael Núñez Gómez, Lourdes Sánchez Moreno.

Reproductive Biology in Higher Plants. Agronomic and Biotechnological Implications.

Organization: CSIC Department for Postgraduate and Specialisation. 24TH November, 2020.

Teachers: Juan de Dios Alché Ramírez, Antonio Jesús Castro López, Adoración Zafra Álvarez, José Carlos Jiménez López, Mª Elena Lima Cabello.

OTHER COLLABORATIONS IN TRAINING & SCIENTIFIC EDUCATION

Medical education course "**Taking care of the microbiota from the beginning of life**", organized by DANONE Foundation. Teacher: Alfonso Clemente Gimeno.

Training programme **"Microbiota, probiotics and prebiotics"**, organized by General Council of Official Associations of Pharmacists. Teacher: Alfonso Clemente Gimeno.

Workshop **"Lechos biológicos en tiempos de COVID-19"**, organized by University of the Republic, Uruguay. Teacher: Esperanza Romero Taboada.

VII Cycle of Postgraduate Conferences, organized by University of Jaén. 2020. Teacher: Isabel Seiquer Gómez-Pavón.

Postgraduate Course **"Plant-Beneficial Bacteria Interactions"**, organized by the National University of Río Cuarto, Argentina (Online). 2020. Teacher: Manuel Espinosa Urgel.

SEMINARS

Scientific and informative seminars are organized annually at the EEZ. Since September 2017, the coordinators of these cycles are Drs. Mª José Soto Misffut and María C. Romero Puertas. In November 2020, Dr. Emilio Benítez León replaced Dr. María C. Romero Puertas as coordinator. The variety of topics and invited speakers reflects the multidisciplinary nature of the EEZ. Attendance to these seminars is also open to the rest of the scientific and university community of Granada. The seminars are part of the training plan for personnel hired through the Youth Guarantee Fund and for students in Doctoral Programmes, for whom the corresponding certificates of attendance are issued.

The situation generated by COVID-19 forced the cancellation of the EEZ seminars cycle this year, but given the importance of this training and dissemination activity, in November it was decided to resume seminars virtually using the CONECTA platform of the CSIC (https://conectaha.csic.es).

Dr. Víctor Flors Herrero. Jaume I University in Castellón. "Induced resistance and multi-way interactions to protect crops against phytophagous spider mites". 22/01/2020.

Dr. Miguel A. Matilla Vázquez. Department of Environmental Protection, EEZ-CSIC. "Biohazard assessment and work in biological containment facilities: an overview of the biosafety training course". 31/01/2020.

Dr. Patricia Bernal Guzmán. University of Seville. "Type VI Secretion System: structure and function of a bacterial killing machine". 5/02/2020.

Dr. Víctor Flors Herrero. Jaume I University in Castellón. "Targeted and untargeted metabolomics. LC-MS Techniques and Research applications". 11/02/2020.

Felícitas Ramírez Malo. EEZ-CSIC Library. "Institutional Mandate (29th March, 2019), Open Access and CSIC Repository". 12/02/2020.

Dres. Alfonso García-Ferrer Porras and Francisco Javier Mesas Carrascosa. School of Agricultural and Forestry Engineering, University of Córdoba. "Flights with drones: from data to information". 19/02/2020.

Dr. Thomas Wood. Massachusetts General Hospital, Harvard Medical School, Boston (Massachusetts), EEUU. "Modulation of host metabolism by *Shigella flexneri*". 02/03/2020.

Drs. Miguel A. Viribay Lorite and Marcus Jansen, Fluidigm Corporation, Cambridge, United Kingdom, and LemnaTec, Aachen, Germany. Seminar coordinated by Izasa Scientific. "From genotype to phenotype. Present and future technical solutions". 06/03/2020.

Dr. Rafael Molina Sánchez, Polytechnic University of Madrid. "I meet, therefore I exist: Key elements of an efficient meeting". 27/11/2020.

VISITING SCIENTISTS

Ana Margarida Batista Pereira. University of Oporto, Portugal. Group of Gastrointestinal Health.

Safia Boukhedami. Univesrity of Bejaia, Algeria. Group of Nitrogen Metabolism.

Juan J. Cabrera Rodríguez. University of East Anglia, Norwich, United Kingdom. Group of Nitrogen Metabolism.

Carlos Comino Merino. University of Granada. Group of Animal Nutrition.

José Juan da Paixão Teixeira. State University of Campinas (UNICAMP), São Paulo, Brazil. Groups of Animal Nutrition and Gastrointestinal Health.

Victoria Eugenia García Casas. University of Guayaquil, Ecuador. Group of Animal Nutrition.

Vanina Giselle Maguire. National University of General San Martín, Argentina. Group of Small Ruminants Production.

Nicolás Marro, Institute of Botany, Czech Republic. Group of Mycorrhiza.

Silko Mergenthal. Universty of Nijmegen, Netherlands. Group of Nitrogen Metabolism.

Zhivko Minchev, Koppert Biological Systems, The Netherlands. Group of Mycorrhiza.

Beatriz Ramírez Serrano, Institute de Researche sur la Biologie de Insecte (IRBI-CNRS), France. Group of Mycorrhiza.

Ana Shein Lee, Netherlands Institute of Ecology, NIOO-KNAW, The Netherlands. Group of Mycorrhiza.

EEZ STAFF STAYS

Andrea Jiménez Leiva. University of East Anglia, Norwich, United Kingdom.

Victor Manuel López Lorca. University of Karlsruhe, Karlsruhe, Germany.

David R. Yáñez-Ruiz. CSIRO-University of Queensland, Australia.

LOCATION AND CONTACT

www.eez.csic.es

Twitter / @EEZCSIC

Facebook / @EEZCSIC

Youtube / @EEZCSIC

MAILING ADDRESS

ESTACIÓN EXPERIMENTAL DEL ZAIDÍN

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

APDO. DE CORREOS 419
E-18080 GRANADA
ESPAÑA

GRANADA CENTRAL HEADQUARTERS

C/ PROFESOR ALBAREDA Nº 1

E-18008 GRANADA
ESPAÑA

TELÉFONO:
(34) 958 18 16 00

FAX:
(34) 958 12 96 00

ARMILLA HEADQUARTERS

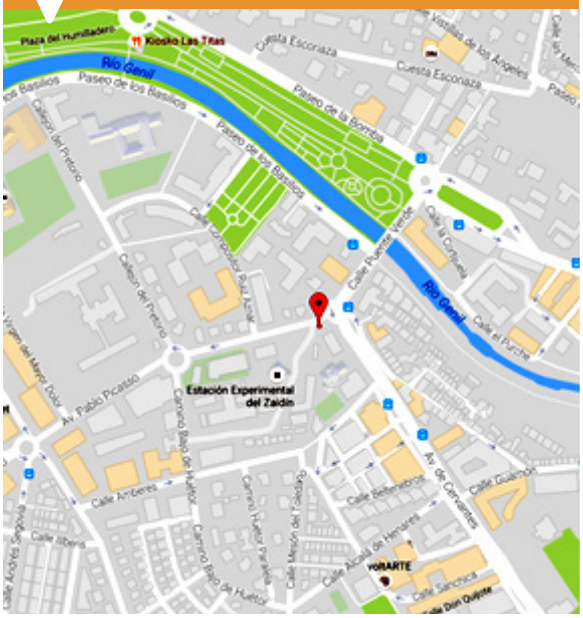
C/ SAN MIGUEL, Nº 101

E-18100 ARMILLA (GRANADA)
ESPAÑA

TELÉFONO
(34) 958 57 27 57

FAX
(34) 958 57 27 53

GRANADA CENTRAL HEADQUARTERS
C/ PROFESOR ALBAREDA Nº 1



ARMILLA HEADQUARTERS
C/ SAN MIGUEL, Nº 101

Report 2020