**OFERTA DE CONTRATO PREDOCTORAL PARA LA FORMACIÓN DE PERSONAL INVESTIGADOR**

**Lugar:** Departamento de Biotecnología Vegetal Aplicada del Instituto de Agrobiotecnología-CSIC

**Duración:** 4 años

**Investigadores Responsables**: Edurne Baroja y Francisco Muñoz

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**Research Project**

**PIF2024-Bioestimulantes de origen microbiano: estrategia sostenible para mejorar el rendimiento de los cultivos y reducir el empleo de fertilizantes nitrogenados (PID2023-149449OB-I00)**

The general objective of this project is to help efforts to develop new sustainable and environmentally friendly biotechnological strategies for improving crops’ yields under low nitrogen availability in a changing climate by using biostimulants derived from microbes. Therefore, we will study the extent to which soil application of exudates obtained from *P. aurantiogriseum* can improve root development, N acquisition and assimilation (NAE), and yield of an important agronomic crop (tomato) cultured in N-deficient soils. We will also explore the mechanisms involved in the crop’s response to soil-applied fungal-derived biostimulants, that promote plants’ acquisition and assimilation of N. In addition, we will generate Arabidopsis and tomato plants with improved NAE by increasing the expression of genes involved in root architecture and/or N assimilation whose expression is influenced by VCs emitted by *P. aurantiogriseum*. Use of massive data acquisition technologies will allow us to acquire a holistic view and broaden our knowledge of the biochemical and molecular mechanisms triggered in plants by soil-applied microbial compounds during ‘beneficial’ plant-pathogen interactions. The demand for new biostimulants is expected to increase for both conventional and sustainable farming. Nowadays, there is a scarce number of methods to evaluate the biostimulant potential of an extract. In this proposal, we also will design engineering genetically encoded plant biosensors to be used by the biostimulant industry. The generated knowledge is expected to strengthen and facilitate the sustainable and eco-friendly commercialization of microbial-based biostimulants to improve plant productivity and quality under N-deficiency.

**Research group description**

To advance in the knowledge of the biochemical and molecular mechanisms involved in plants’ responses to compounds emitted by microbial phytopathogens, during the last 20 years our **international, collaborative, and multidisciplinary** research has been funded by grants awarded for national (BIO2013-49125-C2-1-P, BIO2016-78747-P and PID2019-104685GB-I00TED2021-130603B-C22), international (EIG CONCERT-Japan/PCIN-2017-081, I-Link0939, Wheat-Qual (EIT Food Europe: EIT18112 and EIT19164) and regional projects (**PI044 AGROESTI , PI004 PROMEBIO, PI046 MICROBIOME**, **PC036-037 BIOMEF, PC148-149 REPABIO**). In recent years we have also collaborated with Dr. Dolezal (CRHBAR, Olomouc University, Czech Republic), who has long experience in hormone analysis), Dr. De Diego (CATRIN, Olomouc University, Czech Republic), who has experience in N metabolism analysis and high-throughput plant phenotyping platforms, Dr. Mitsui (Niigata University, Japan), who has excellent facilities for redox-proteomics studies, and Dr. Hajirezaei (IPK Gatersleben, Leibniz Institute, Germany), who has broad experience in ionomics and metabolomics. This **international, collaborative, and multidisciplinary** research activity. We have also collaborated with CERES Biotics SL and with Timac-Agro SL, which is the titleholder of two patents, WO2022/189690A2 and WO2017/174503A1, that protect the utilization of compounds emitted by microbial phytopathogens to promote plants’ growth, yield and drought resistance.

**Scientific articles:**

1. Baroja-Fernández E, Bahaji A, Muñoz FJ. (2024) Fungal phytopathogens as a source of metabolites for agricultural applications. In: Poveda, J; Santamaría, O; Martín-García, J (eds) Fungal metabolites for agricultural applications. Springer (in press).
2. Morcillo RJL,Baroja-Fernández E, et al. (2022) Cell-Free microbial culture filtrates as candidate biostimulants to enhance plant growth and yield and activate soil- and plant-associated beneficial microbiota. [*Frontiers in Plant Sci. 13:1040515 doi: 10.3389/fpls.2022.1040515*](https://www.frontiersin.org/articles/10.3389/fpls.2022.1040515)
3. Gámez-Arcas S., Muñoz F.J., et al. (2022) Glucose-6-P/phosphate translocator2 mediates the phosphoglucose-isomerase 1-independent response to microbial volatiles.[*Plant Physiol. 190: 2137-2154. doi.org/10.1093/plphys/kiac433*](https://pubmed.ncbi.nlm.nih.gov/36111879/)
4. Gámez-Arcas S., Baroja-Fernández E., et al. (2021) Action mechanisms of small microbial volatile compounds in plants. J. Exp. Bot erab463. <https://doi.org/10.1093/jxb/erab463>.
5. Baroja-Fernández E., et al. (2021) Enhanced yield of pepper plants by soil application of volatiles from cell-free fungal culture filtrates is associated with activation of the beneficial soil microbiota. Front. Plant Sci. 12:752653. doi: 10.3389/fpls.2021.752653.
6. Ameztoy K., et al. (2021) Proteostatic regulation of MEP and shikimate pathways by redox-activated photosynthesis signaling in plants exposed to microbial volatiles. Front. Plant Sci. 12:637976. doi: 10.3389/fpls.2021.637976.
7. García-Gómez P., et al. (2020) Volatiles from the fungal phytopathogen *Penicillium aurantiogriseum* modulate root metabolism and architecture through proteome resetting. Plant Cell Environ. doi: 10.1111/pce.13817.
8. Ameztoy K., et al. (2019) Plant responses to fungal volatiles involve global post-translational thiol redox proteome changes that affect photosynthesis. Plant Cell Environ. 42: 2627-2644.
9. García-Gómez P., et al. (2019) Volatile compounds other than CO2 emitted by different microorganisms promote distinct post-transcriptionally regulated responses in plants. Plant Cell Environ. 42: 1729-1746.
10. Bahaji A., et al. (2018) Plastidial phosphoglucose isomerase is an important determinant of seed yield through involvement in gibberellin-mediated reproductive development and biosynthesis of storage reserves in Arabidopsis. Plant Cell. 30: 2082-2098.
11. Sánchez-López et al. (2016) Volatile compounds emitted by diverse phytopathogenic microorganisms promote plant growth and flowering through cytokinin action. Plant Cell Environ. 39: 2592-2608.
12. Sánchez-López A.M., et al. (2016) Arabidopsis responds to *Alternaria alternata* volatiles by triggering plastid phosphoglucose isomerase-independent mechanisms. Plant Physiol. 172: 1989-2001.
13. Li J., et al., (2011) Microbial volatiles induced accumulation of exceptionally high levels of starch in Arabidopsis leaves is a process involving NTRC and starch synthases class III and IV. Mol. Plant Microb. Interact. 24: 1165-1178.
14. Ezquer I., et al. (2010) Microbial volatile emissions promote accumulation of exceptionally high levels of starch in leaves in mono- and di-cotyledonous plants. Plant Cell Physiol. 51: 1674-1693.

**Patents:**

1. Composiciones obtenidas de Microorganismos y sus usos. Inventors: Pozueta Romero J., Baroja Fernández E., Muñoz Pérez FJ. Publicación Internacional No: WO2022/189690A2. Patent Holder: Consejo Superior de Investigaciones Científicas y Timac Agro España, S.A.
2. Microorganism-produced compositions having stimulatory activity on plants. Inventors: Bejarano Tovar CP., Molina Guevara PR., Fernández Ortiz de Jócano N., Belastegui Macadam XM., Bahaji A., Sánchez López AM., Baroja-Fernández E., Muñoz Pérez FJ., Pozueta Romero J. Publicación Internacional No.: WO2017/174503A1. Patent Holder: Timac-Agro

**Job position description**

We are seeking a talented and enthusiastic student to be incorporated in a vibrant scientific environment. Our group provides an optimal environment for young and talented scientists to start an academic career in the field of life sciences.

This project will provide rare (possibly unique) opportunities for participants to obtain a holistic view of the biochemical and molecular mechanisms that mediate plants’ responses to **soil-applied microbial metabolites** retained in CF. Moreover, they will acquire clues to develop novel biostimulants and design strategies for increasing crops’ growth and yields in collaboration with private companies in the agro-sector. The recruited PhD student will be supervised by Drs. Baroja and Muñoz, to receive multidisciplinary training in a broad range of techniques, including molecular biology methods, plant (Arabidopsis and tomato) genetic engineering, microbiology and analytical techniques (e.g. HPLC and GC-MS). The PhD student will enrol in the Doctoral Program of Biotechnology of the Public University of Navarra with mention towards excellence (Ref. 2011-00141) (https://www.unavarra.es/escuela-doctorado/). During the first 3 months, the PhD student will be trained and evaluated for her/his capacity to work and reproduce laboratory techniques. From then, the PhD student should work more independently, suggest new proposals, and participate actively in the laboratory group meetings. The PhD student will have opportunities to receive additional training in laboratories in foreign countries such as the CRHBAR and CATRIN (where s/he will learn how to measure hormones by UPLC-MS, polyamines by UPLC-MS/MS and phenotyping) and the IPK (where s/he will have access to high-throughput metabolomics and ionomics platforms). All our PhD students must visit other laboratories (preferably in foreign countries) at least twice, and stay for at least 2 months each time, during their training programme.

El objetivo de este proyecto es desarrollar nuevas estrategias biotecnológicas respetuosas con el medio ambiente para mejorar el rendimiento de los cultivos con dosis reducida de nitrógeno mediante el uso de bioestimulantes microbianos. Estudiaremos hasta qué punto la aplicación al suelo de exudados obtenidos de *P. aurantiogriseum* puede mejorar el desarrollo de las raíces, la adquisición y asimilación de N (NAE) y el rendimiento de tomate cultivado en suelos deficientes en N. Además, generaremos plantas de tomate con NAE mejorada aumentando la expresión de genes implicados en la arquitectura radicular y/o asimilación de N cuya expresión está influenciada por las VCs emitidas por *P. aurantiogriseum*. El uso de tecnologías de adquisición masiva de datos nos permitirá adquirir una visión holística y ampliar nuestro conocimiento de los mecanismos bioquímicos y moleculares desencadenados en las plantas por compuestos microbianos aplicados al suelo durante las interacciones "beneficiosas" entre plantas y patógenos. Hoy en día existe un escaso número de métodos para evaluar el potencial bioestimulante de un extracto. En esta propuesta, también diseñaremos plantas biosensoras para ser utilizados por la industria de bioestimulantes. Se espera que el conocimiento generado fortalezca y facilite la comercialización sostenible y ecológica de bioestimulantes de base microbiana para mejorar la productividad y la calidad de las plantas en condiciones de deficiencia de N.

The objective of this project is to help efforts to develop new sustainable and environmentally friendly biotechnological strategies for improving crops’ yields under low nitrogen availability in a changing climate by using biostimulants derived from microbes. We will study the extent to which soil application of exudates obtained from *P. aurantiogriseum* can improve root development, N acquisition and assimilation (NAE), and yield of an important agronomic crop (tomato) cultured in N-deficient soils. In addition, we will generate tomato plants with improved NAE by increasing the expression of genes involved in root architecture and/or N assimilation whose expression is influenced by VCs emitted by *P. aurantiogriseum*. Use of massive data acquisition technologies will allow us to acquire a holistic view and broaden our knowledge of the biochemical and molecular mechanisms triggered in plants by soil-applied microbial compounds during ‘beneficial’ plant-pathogen interactions. Nowadays, there is a scarce number of methods to evaluate the biostimulant potential of an extract. In this proposal, we also will design engineering genetically encoded plant biosensors to be used by the biostimulant industry. The generated knowledge is expected to strengthen and facilitate the sustainable and eco-friendly commercialization of microbial-based biostimulants to improve plant productivity and quality under N-deficiency.