Press Release

A wall to stop bacterial wilt

- **A team led by CRAG researchers unveils the physico-chemical nature of the xylem barriers responsible for bacterial wilt resistance in tomato plants.**

- **The study provides new insights into the formation of vascular coatings that restrict bacterial movement and prevent cell wall degradation.**

- **Researchers have been able to engineer disease resistance to R. solanacearum in commercial susceptible varieties of tomato plants.**

Bellaterra, 14 February 2022

A new work led by Núria Sánchez Coll, CSIC researcher at the Centre for Research in Agricultural Genomics (CRAG), elucidates how tomato plant varieties resistant to the bacterial wilt pathogen *Ralstonia solanacearum* have the ability to restrict bacterial movement in the plant. The study, recently published in the journal ***New Phytologist***, analyses the composition and formation of the xylem barriers that confer resistance to *R. solanacearum*, a soil bacterium with devastating effects on many solanaceous crops such as tomato, potato, pepper and eggplant. Results have allowed researchers to engineer resistance to *R. solanacearum* in commercial susceptible varieties of tomato plants.

The agro-economic impact of *R. solanacearum*, the pathogen responsible for the bacterial wilt disease, preoccupies farmers all over the world due to the large number of species it affects, its broad geographical distribution, and its persistence in soil and water. This pathogen enters the plant through the roots and colonizes the xylem vessels that carry water and nutrients to the stems and leaves, spreading systemically and eventually killing the plant. Tomato plant varieties resistant to bacterial wilt are able to synthesize reinforcement coatings that confine *R. solanacearum* into infected vessels, preventing bacterial spread to healthy tissues. Despite being a key factor of resistance, the composition and formation of these barriers had not been studied in detail until now.

Wall reinforcements to confine the infection

In order to understand how bacterial wilt resistance works, researchers compared a susceptible commercial tomato plant variety with a highly resistant tomato cultivar which, despite producing very small fruits unfit for consumption, contributes a reliable source of resistance in breeding programmes. After infecting both varieties with *R. solanacearum*, histological, live-imaging and spectroscopic analysis revealed the formation of vascular coatings containing ligno-suberin and related phenolic compounds (such as HCAAs) in resistant plants. Such structural wall reinforcements, which were not present in susceptible plants, provide a physico-chemical barrier that confines the bacteria into the xylem and makes its vessels resilient to pathogenic degradation.

ICMAB researchers **Anna Laromaine** and **Sumithra Srinivasan**, from the Nanoparticles & Nanocomposites (NN) group, collaborated in the analysis of the xylem structure using materials science characterization techniques such as attenuated total reflection - Fourier Transform infrared spectroscopy (ATR-FTIR) and scanning electron microscopy (SEM).

«In our previous work, we identified the bottlenecks through which resistant tomato is able to limit R. solanacearum *spread, uncovering that the xylem tissue is a major battleground for the interaction between vascular wilt pathogens and their hosts, where the outcome of the infection is at stake. Thanks to the collaboration with our colleagues at the Institute of Materials Science of Barcelona (ICMAB, CSIC), the Institute of Natural Resources and Agrobiology of Sevilla (IRNAS, CSIC) and Universitat de Girona, now we have been able to identify the intense structural and metabolic modifications the xylem vasculature of resistant plants undergoes in response to pathogens, preventing the bacterial colonization of the surrounding tissues and cells»*, points out Núria Sánchez Coll, CSIC researcher at CRAG in charge of this study.

Engineering tomato resistance to bacterial wilt

In line with the observed accumulation of ligno-suberin and related compounds in vascular coatings, further analysis showed that the genes involved in the synthesis pathways of these molecules were overexpressed in resistant plants infected with *R. solanacearum*. Based on these results, researchers set to determine whether overexpressing such genes in susceptible tomato plants would increase their resistance to bacterial wilt.

«Our experiments demonstrate that overexpressing genes of the ligno-suberin pathway in a commercial susceptible variety of tomato provides a very effective resistance mechanism against R. solanacearum*, drastically restricting bacterial spread and blocking the onset of disease»*, explains Álvaro Luis Jiménez, PhD researcher at CRAG involved in the study.

«Interestingly, the accumulation of suberin has also been reported in response to drought, and the synthesis of ligno-suberin compounds is well-conserved across the plant kingdom. Therefore, engineering these pathways could have a double impact both on bacterial and drought resistance, improving plant performance in the field under adverse conditions», concludes Sánchez Coll.

New Phytologist is a leading international plant science journal. It is published by Wiley and owned by the New Phytologist Foundation, a not-for-profit organisation that is dedicated to the promotion of plant science.

Article of reference:

Induced ligno-suberin vascular coating and tyraminederived hydroxycinnamic acid amides restrict Ralstonia solanacearum colonization in resistant tomato
New Phytologist
Anurag Kashyap, Álvaro Luis Jiménez-Jiménez, Weiqi Zhang, Montserrat Capellades, Sumithra Srinivasan, Anna Laromaine, Olga Serra, Mercè Figueras, Jorge Rencoret, Ana Gutiérrez, Marc Valls, Nuria S. Coll*
Online Version of Record before inclusion in an issue, 2022
DOI: 10.1111/nph.17982

Images:

Tomate_1.jpg, Tomate_2.jpg y Tomate_3.jpg Researchers working with tomato plants at CRAG greenhouse | CRAG.
Nuria_Alvaro.jpg: Núria Sánchez Coll, CSIC researcher at CRAG, and Álvaro Luis Jiménez, PhD researcher, working with tomato plans at CRAG | CRAG
Susceptible_vs_Resistente.jpg: Cross-sections of tomato plant stems observed with fluorescence microscopy from susceptible (left) and resistant (right) tomato plant varieties infected with Ralstonia solanacearum. Resistant plants show an accumulation of phenolic compounds (blue fluorescence) and ligno-suberin-related compounds (green fluorescence) at their vasculature that provide a restriction mechanism against the bacterium. | CRAG
Download images:
https://drive.google.com/drive/folders/1vm2GR_tF56V3yfeOSTPEhGbZewes9Mzc?usp=sharing

About the authors and the funding of the study: this research is funded by the Ministry of Science and Innovation and Innovation State Research Agency PID2019-108595RB-I00/AEI/10.13039/501100011033 (Nuria S. Coll), PID2019-110330GB-C21 (Mercè Figueras, Olga Serra) and PID2020-118968RB-I00 (Jorge Rencoret, Ana Gutiérrez), as well as through the "Severo Ochoa Programme for Centres of Excellence in R&D" (SEV-2015-0533, CEX2019-000917 and CEX2019-000902-S) and by Generalitat de Catalunya (2017SGR765 grant). Anurag Kashyap is the recipient of a Netaji Subhas – Indian Council of Agricultural Research International Fellowship. Sumithra Srinivasan acknowledges financial support from DOC-FAM, European Union's Horizon 2020 research and innovation program under the Marie Sklodowska-Curie grant agreement No 754397. This work was also supported by the CERCA Programme/Generalitat de Catalunya.

About the Centre for Research in Agricultural Genomics (CRAG): The Centre for Research in Agricultural Genomics (CRAG) is a centre that forms part of the CERCA system of research centres of the Government of Catalonia (Spain), and which was established as a partnership of four institutions: the Spanish National Research Council (CSIC), the Institute for Agri-Food Research and Technology (IRTA), the Autonomous University of Barcelona (UAB) and the University of Barcelona (UB). CRAG's research spans from basic research in plant and farm animal molecular biology, to applications of molecular approaches for breeding of species important for agriculture and food production in close collaboration with industry. In 2016, CRAG was recognized as a "Severo Ochoa Centre of Excellence" by the Spanish Ministry of Economy and Competitiveness.

About the Spanish National Research Council (CSIC): The Spanish National Research Council (CSIC) is the largest public institution in Spain dedicated to scientific and technical research, and one of the most prominent in the European Research Area. It is attached to the Ministry of Science and Innovation through the General Secretariat for Research. It has great multidisciplinary potential, both due to its size (more than 11,000 people) and its distribution (it is present in almost all the Autonomous Communities). It has 120 institutes, 68 own and 52 of mixed ownership with other institutions. Its research ranges from basic science to technological developments in all fields of knowledge: human and social sciences, food science and technology, biology, biomedicine, physics, chemistry, materials, natural resources and agricultural sciences.

About the Institute of Materials Science of Barcelona (ICMAB-CSIC): The Institute of Materials Science of Barcelona (ICMAB-CSIC) is a multidisciplinary research centre focused on cutting-edge research in functional advanced materials in the fields of energy, electronics, nanomedicine and application fields yet to imagine. ICMAB is integrated within the Barcelona Nanocluster in Bellaterra (BNC-b), a research network that includes the UAB, the CSIC (ICMAB, IMB-CNM and ICN2), part of the Research Park of the Universitat Autònoma de Barcelona (PRUAB) and the ALBA Synchrotron. The BNC-b aims to share advanced scientific equipment and promote and disseminate nanoscience and nanotechnology. Since

2016, ICMAB is recognized as a "Severo Ochoa Center of Excellence" and is part of the SOMM Alliance (SOMMa).

About the Institute of Natural Resources and Agrobiology of Seville (IRNAS): The Institute of Natural Resources and Agrobiology of Seville (IRNAS) is a research centre of the State Agency Spanish National Research Council (CSIC), attached to the Ministry of Science and Innovation (MICINN). The purpose of the IRNAS is to conduct research on the use and conservation of soil-plant-water natural resources, focusing mainly on tackling problems derived from their exploitation in arid and semi-arid areas. Besides pursuing high standard scientific production of international relevance, IRNAS develops applications and tools useful for stakeholders in the agriculture and forest industries, environment protection Agencies, and Public Administration. IRNAS's aim is to improve productivity with the minimum impact on the environment in order to ensure the sustainability of natural resources.

About the Universitat de Girona: The University of Girona is a public institution that integrates into the system of Catalan public universities, excels in teaching and research and participates in the progress and development of society, through the creation, transmission, dissemination and critique of science, technology, humanities, social sciences and health and the arts. It is the economic and cultural engine of its environment, and expresses the vocation of universality and openness to all the traditions, advances and cultures of the world.

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EXCELENCIA SEVERO OCHOA 2020-2023