Survival trade-offs in plant roots during colonization by closely related beneficial and pathogenic fungi

Stéphane Hacquard, Kei Hiruma, Barbara Kracher, Nina Gerlach, Soledad Sacristán, Ryohei Thomas Nakano, Michael R Thon, Marcel Bucher, Richard O'Connell, Paul Schulze-Lefert

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HACQUARD Stéphane *(1), HIRUMA Kei (1), KRACHER Barbara (1), GERLACH Nina (2), SACRISTÁN Soledad (3), NAKANO Ryohei Thomas (1), THON Michael R. (4), BUCHER Marcel (2), O'CONNELL Richard J. (5), SCHULZE-LEFERT Paul (1)*
(1) Department of Plant Microbe Interactions, Max Planck Institute for Plant Breeding Research, Cologne, Germany
(2) Botanical Institute, Cologne Biocenter, CEPLAS, University of Cologne, Cologne, Germany
(3) Centro de Biotecnología y Genómica de Plantas (UPM-INIA) and E.T.S.I. Agrónomos, Universidad Politécnica de Madrid Campus de Montegancedo, Madrid, Spain
(4) Instituto Hispano-Luso de Investigaciones Agrarias (CIALE), Departamento de Microbiología y Genética, Universidad de Salamanca, Villamayor, SPAIN
(5) BIOGER, INRA, AgroParisTech, Thiverval-Grignon, France

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Although most characterized species of the fungal genus *Colletotrichum* are destructive pathogens, we found recently that *C. tofieldiae* (*Ct*) is an endemic endophyte in natural *A. thaliana* populations in Central Spain. Colonization by *Ct* initiates in roots, but can also spread systemically into shoots. *Ct* transfers the macronutrient phosphorus to shoots, promotes plant growth and increases fertility only under phosphorus-deficient conditions, a nutrient status that might have facilitated the transition from pathogenic to beneficial lifestyles. Comparative genome and transcriptome analyses between *Ct* and its closely related pathogenic species *C. incanum* (*Ci*) identified genomic signatures reflecting this recent transition from pathogenic to beneficial lifestyles, including a narrowed repertoire of secreted effector proteins, expanded families of secondary metabolism-related proteins, and limited activation of pathogenicity-related genes *in planta*. Analysis of the *Arabidopsis* transcriptome during root colonization by *Ct* revealed that beneficial responses are prioritized under phosphorus-deficient conditions whereas defense responses, involving ethylene and glucosinolate pathways, were activated under phosphorus-sufficient conditions. These data, together with the analysis of *Arabidopsis* mutants that are impaired in indole glucosinolate metabolism and the phosphate starvation response (PSR), provide evidence for a specific coordination between the PSR, the plant immune system and invasive fungal growth during beneficial interaction with *Ct*. Importantly, *Arabidopsis* immune responses were retained in phosphate-starved roots colonized by pathogenic *Ci*, illustrating the extraordinary ability of plants to maximize survival in response to conflicting stresses.