Editorial: Insights in Microbe and Virus Interactions With Plants: 2021

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Keywords: plant-microbe interaction, plant colonization, detection, climate change, disease control

Editorial on the Research Topic

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Both aerial and underground plant organs and tissues are colonized by a composite microbiota that continuously interacts with the host and the surrounding environment. Phytopathogens, beneficial, symbionts, and commensal microbes and viruses are all members of a network that communicate either with the plant or between different microbial taxa through refined molecular mechanisms (Venturi and Bez, 2021). These interactions shape microbial communities according to plant organ/tissue, climatic parameters, and edaphic features (Chaudry et al., 2021). Currently, these interactions should be also assessed considering the climate change scenario (Chaloner et al., 2021).

The knowledge of the basic interactions that rule out each specific pathosystem is a fundamental prerequisite to achieving a sustainable control of plant diseases (Leung et al., 2020). Different and complementary techniques can assist such a purpose. Apart from the "omics", computational software can provide genome-scale metabolic models related to the interplays occurring between co-occurring microbes and viruses, and plants (Lam et al., 2020), whereas detection techniques can benefit from targeted genome sequencing (Maina et al., 2021).

The objective of this Research Topic was to publish high-quality research papers and review articles focusing on the following aspects: (a) new insights on plant-microbes/virus molecular interaction; (b) plant colonization; (c) detection; (d) sustainable control.

This Research Topic contains 12 research papers that cover different aspects of viral, bacterial, and fungal pathogens in relation to plant-microbe molecular interaction, plant colonization, detection, or disease control. In addition, it contains a meta-analysis review that concerns the microbe-mediated thermotolerance in plants.

PLANT-MICROBE/VIRUS MOLECULAR INTERACTION

The study by Zhang et al. analyzed the function of nuclear export signals (NESs) and nuclear localization signals (NLSs) of the Nlb protein of turnip mosaic virus. NES and NLS are key signatures of proteins for controlling nuclear import and export. Two functional NESs and one functional NLS were identified in the Nlb protein. Mutation of the identified functional NESs or NLS inhibited viral RNA accumulation and systemic infection. Exportin 1 (XPO1), a nuclear export receptor that binds directly to cargo proteins harboring a leucine-rich NES and translocates them to the cytoplasm, was found to contain two Nlb-binding domains, which recognize the NLS and NES of Nlb, respectively, to mediate the nucleocytoplasmic transport of Nlb and promote viral infection.

The expression of miRNAs in Nicotiana benthamiana in response to the infection of tobacco curly shoot virus (TbCSV) via small RNAs sequencing was studied by Wu et al. The results showed that 15 up-regulated miRNAs and 12 down-regulated miRNAs were differentially expressed,
It is based on the biochar (a rich carbon product obtained by pyrolysis of biomass under a limited supply of oxygen) obtained from olive pruning, have been analyzed through the functional annotation of the 16S sequence data (Ren et al.). The study showed that bacteria communities in both samples and library preparation are selected, nanopore MinION sequencing could be used for the detection of plant viruses and viroids with similar performance as Illumina sequencing.

PLANT COLONIZATION

The bacterial community inhabiting the fruiting body of the saprotrophic and necrotrophic Basidiomycetes Heterobasidium species complex, and the associated wood, have been analyzed through the functional annotation of the 16S sequence data. The study highlighted the involvement of plastids and endoplasmic reticulum in the production of terpenoids and the consequent secretion of terpenoids directly through the plasma membrane, without exhibiting vesicle formation. Plastids are also involved in the polyphenol production that accumulates in the vacuole.

DETECTION

The work carried out by Taglianti et al. evaluates the antiphytoviral effectiveness of treatments with three essential oils and corresponding hydrosols extracted from Origanum vulgare, Thymus vulgaris, and Rosmarinus officinalis on Cucurbita pepo plants infected by zucchini yellow mosaic virus or tomato leaf curl New Delhi virus (ToLCNDV). Treatments were applied either concurrently or after virus inoculation to ascertain an inhibition or curative activity, respectively. Treatments were effective against ToLCNDV whether applied simultaneously with the inoculation or after and the major inhibition was observed with O. vulgare essential oil and hydrosol. The curative activity gave maximum results with all three essential oils and T. vulgaris and R. officinalis hydrosols.

The effects of biochar (a rich carbon product obtained by pyrolysis of biomass under a limited supply of oxygen) obtained from olive pruning, have been evaluated on tomato seedling growth and response to systemic agents’ infection alone or added with the beneficial microorganisms Bacillus spp. and Trichoderma spp. (Luigi et al.). Biochar seems to promote the development of tomato seedlings without showing any antimicrobial effects on the beneficial soil bacteria at the tomato.
rhizosphere level and even improving their growth. Biochar at 10–15% and when added with \textit{Trichoderma} spp. caused a reduction of the replication and symptoms of potato spindle tuber viroid. Also, results obtained showed that biochar could contribute to reducing both infection rate and virus replication of tomato spotted wilt virus.

A study regarded the isolation and characterization of bacteriophages obtained from melon and watermelon infected by the destructive bacterium \textit{Acidovorax citrulli}, and the further genomic characterization and evaluation of the systemic persistence and translocation of a phage from the roots to the upper parts of watermelon plants (Gasic et al.). The persistence of the phages in the plant environment upon their release is one of the critical points for their successful utilization in plant disease control, being that UV light is one of the most adverse factors. The study ascertained a persistence and survival of 10 days within the plant post distribution of the phage in the soil, allowing a relevant decrease in the severity of the disease and the survival of the plants. These findings corroborate previous studies on the possibility to control endophytic bacterial pathogens through phages distributed to the root system.

\textit{Fusarium oxysporum} is one of the most dangerous soilborne fungal pathogens, capable of infecting many crops worldwide. Iida et al. assessed the biocontrol activity of non-pathogenic mutants of \textit{F. oxysporum} ff. spp. \textit{melonis} and \textit{lycopersici}, which infect melon and tomato, respectively. The mutants were obtained by disruption of the \textit{FOW2} gene. The pre-inoculation of melon and tomato roots with the mutants allowed to reduce the disease incidence. The study indicated that the ability to reduce the pathogen activity was due to the relevant capability showed by the non-pathogenic mutants to colonize the root system and compete for nutrients with the pathogens.

### CLIMATE CHANGE AND PLANT SYMBIONTS

A meta-analysis review performed by Dastogeer et al. investigated the interaction of microbial symbionts and plants within a climate change scenario. One of their main conclusions is the lack of experiments that demonstrate how microbes influence plant responses to high temperature stress in the natural environment. Moreover, the Authors indicated that microbial colonization influenced plant growth and physiology, but their effects were more noticeable when the host plants were exposed to high-temperature stress than when they grew under ambient temperature conditions. Another relevant conclusion of the meta-analysis is that, in addition to microbe-plant interaction, microbe-microbe and microbe-environment interaction should be taken into account to understand the stable functions of a particular microbe in its potential application in agricultural settings.

### AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

### ACKNOWLEDGMENTS

The Topic Editors are thankful to all authors who participated in this Research Topic. Special thank are due to the reviewers, Editors, and staff of Frontiers for their time and assistance in the articles’ production.

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