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EDITORIAL

Editorial to Special Issue "Plant-Microbe Interactions"

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The topic of plant-microbe interactions has been intensively studied since the discovery that causal agents of plant diseases are microbes. The attractiveness and relevance of plant-microbe interactions in the research were brilliantly illustrated by the publication of the review by Jones and Dangl in 2006 with the "innocent" title "The Plant Immune System" (Jones and Dangl 2006). This review brought to light the so-called "Zig-Zag" model, which is one of the most cited articles in plant science. It conveys the breadth, complexity, and potential applicability of research on plant-microorganism interactions involving pathogens and symbionts. The current Special Issue of Biologia Plantarum features five manuscripts, four original research articles and one review, highlighting diverse aspects of modern research on plant-microbe interactions. Nowadays, the main division (and quite controversial) line in the domain lies in attributing particular topics to "basic" or "applied" research. For example, basic research deals with questions such as the effect of interactions with microorganisms on plant physiological or developmental parameters (Šašek et al., 2012), the involvement of particular plant genes in resistance to pathogens (Kalachova et al., 2022), the influence of the environment on immune responses (Janda et al., 2019), the mechanism of pathogen virulence (Almási et al., 2023) or, for example, the study of pathogen occurrence and transmission in a given area (Kyrychenko et al., 2023). The applied research focuses on developing new approaches and products to protect crops against pathogens (Buziashvili et al., 2023; Kovalenko et al., 2023) or to increase crop yield by exploiting interactions with symbionts (Fekete et al., 2024).

The discovery of genome editing using CRISPR-based technology (CRISPR) has proven revolutionary in plant-microbe interactions, as in other research areas. Based on the EU-SAGE database https://www.eu-sage.eu/genome-search (the site was visited 5th December 2023), more than 700 papers using CRISPR in crops have been published. Of these, more than 150 are devoted to enhanced tolerance to biotic stress. CRISPR enables unprecedentedly fast and accurate genome editing in crops. In this Special Issue, gene editing is the focus of a review article addressing biotechnological approaches that should help us to increase tomato resistance to bacterial infections. Interestingly, the bacterial pathogens capable of infecting tomato, *Pseudomonas syringae* and *Ralstonia solanacea*, were ranked highest in the "Top 10" list of bacterial pathogens (Mansfield et al., 2012), demonstrating the importance of development of the strategies for the protection of tomato against bacteria. Among biotechnological approaches, techniques based on genome editing (NGTs) are likely to play the most important role in current and future research (Buziashvili et al., 2023). However, NGTs are not omnipotent, and their effective use requires knowledge of the processes in plants that are affected by (or play a role in) interactions with pathogens or symbionts. Traditional approaches will still likely play their part in disease management in the fields or greenhouses.

Three of the publications in the Special Issue deal with viral infections in plants. Viral infections are indeed an important source of yield reduction in crops with a significant economic effect. According to https://www.sciencedaily.com/releases/2019/10/191011112238.htm (the site was visited 5th December 2023) rough estimates suggest that viral infections have an economic impact of more than $30 billion annually. Publications in this Special Issue represent diverse aspects of plant-virus interactions, building a bridge from basic research into application. Almási et al. (2023) focused on the intercellular behavior of Tomato Spotted Wilt Virus (TSWV), in particular on NS protein self-interaction and its impact on the gene silencing that TSWV causes during pepper colonization. TSWV belongs to the "Top 10" viruses (Scholthof et al., 2011) and causes $1.2 billion losses (Ong et al., 2020). It is known that the NS protein can be detected by the host and trigger immune responses. Almási et al. (2023) showed that NS protein self-interaction leads to increased gene silencing, but the biological outcome of this process remains to be clarified, as the absence of this interaction prevents neither the silencing nor the recognition of NS protein by the plant immune system. Such information is important for breeding new resistant tomato cultivars in the future, as the use of resistant cultivars based on enhanced gene silencing capacities is still the most effective approach to protect crops from viral infection. Kyrychenko et al. (2023) used an epidemiological approach and investigated the occurrence of several agriculturally relevant viruses in garlic mustard (*Alliaria petiolata*) in Ukraine. This weed is a proposed alternative host for the tested viruses and may act as an intermediate host and source of crop infection. Authors demonstrated the occurrence of cucumber mosaic virus (CMV), which belongs to the "Top 10" viruses (Scholthof et al., 2011), and turnip mosaic virus (TuMV), while turnip yellow mosaic virus (TYMV) and watermelon mosaic virus II (WMV II) were not detected. Both CMV and TuMV have a wide host range, more than 1 000 species, and such studies are an important source of information about the possible natural reservoirs of viruses. The reservoirs can allow viruses to survive from year to year and spread to crops. Kovalenko et al. (2023) focused on testing a new product - a complex compound containing glycans, glycolipids (rhamnolipids) and thiosulfonates - as a potent treatment of plants with the aim of increasing their resistance to viral infection. The authors showed that the treatment with the compound decreased symptom development and viral load in *Nicotiana tabacum* and *Datura metel* plants infected with tobacco mosaic virus (TMV) (Scholthof et al., 2011). We will see in future if such a product has the potential to be marketed and used in agriculture.

Crop management was the subject of the last original research article in the Special Issue. Notably, its focus was on the mutually beneficial context of plant-microbe interaction - on symbiosis, in particular, on the arbuscular mycorrhizae. The idea of applying symbiotic interactions in agriculture is not new (Sawers et al., 2008) and the research in this field has recently intensified along with the EU "Farm to Fork" legislation (https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en) aiming to reduce pesticides and fertilisers. Fekete et al. (2023) investigated the effect of three different mulching techniques on the development of arbuscular mycorrhizae in lettuce (*Lactuca sativa*) and observed that mulching has a positive effect and can reduce plant stress.

The plant-microbe interactions are indeed a fascinating field of research, and a focal point of various plant-centered domains, from cell biology to population dynamics. Above all what is known about plant physiology in the changing environment, plant-microbe interactions provide a unique context, in which previously known cellular processes show another dimension of complexity. Only by understanding the contribution of all sides can we get a fuller view on communication between organisms, which is crucial for the understanding of life in the ecosystem. We are happy that Biologia Plantarum has now put plant-microbe interactions into focus, and we are looking forward to presenting more exciting research highlights about it in the future.

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