



Editorial SI EJPP 2023 (Biocontrol using beneficial fungi and bacteria)

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Agriculture is facing several big challenges: to feed a constantly rising global population, to increase productivity based on sustainable agricultural, preserving the environment and population health. World commodities cultivating areas may be expanded to satisfy the global needs, but the use of natural areas for agriculture is negatively impacting on the environment, causing displacements of animals, disappearance of native flora and climate perturbations. All these conditions, in addition to the increasing demand of consumers for healthy, organic, pesticides free food, makes it quite difficult to feed an increasing population. Moreover, the impact of chemical pesticides on the environment and the reduction of their effectiveness against pathogens due to resistance development, generates the need for alternative strategies with less impact on the environment and reduced chances of resistance. In this context, several integrated management strategies have been developed to maintain or increase (desired) productivity, to protect crops from phytopathogens and to help with the adaptation of

crops to the changing climatic conditions. Additionally, the “One health” goal (“*The health of soil, plant, animal and man is one and indivisible*” as stated in 1943 by Lady Eve Balfour) deals with new integrative concepts in order to fight against plant, human, and animal pathogens with a special focus on the impact of these strategies on the environment, animals and humans. Multiple actors from many different disciplines should unify efforts to achieve one goal: to feed the world population with minimum perturbation of the ecosystem. For this reason researchers are, already for decades, investigating and exploiting interactions between microorganisms where the “good ones” interact through several mechanisms with the “bad ones”, the pathogens, decreasing the survival and the detrimental activity of the bad ones. This is termed biological control, which is based on the beneficial microorganism (bacteria, filamentous fungi or yeasts) itself – generally indicated as biocontrol agent or BCA—or a natural product derived from it, that has antagonistic activity on spore germination, growth, reproduction, metabolite production, nutrient availability, space competence, direct action through parasitism or indirect effect by triggering plant defense activation. Some other beneficial microorganisms may have an extra role as biofertilizers, making inorganic or chelated molecules such as nitrogen, potassium and phosphorus, among others, available for plant intake. Another advantage of this group of microorganisms over chemicals is that the former has multiple mechanisms to counteract pathogens, which

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leads to a lower possibility of resistance development in comparison with chemical pesticides that normally rely on one mode of action. Currently it is not realistic to consider a total replacement of chemicals since we cannot, for example, eliminate grasses and other undesired plants by the use of "bioherbicides", mainly because they have not been developed at present. In many cases where biocontrol is applied (experimental or field developments), it is not possible to completely eliminate a disease symptom or the pathogen itself, but there are many positive-case-studies where final yield and quality improved by using biocontrol over chemical control. So, what we can do is reduce the use of chemicals, combine them with compatible BCAs or alternate applications in order to protect the crops from pathogens. This is in agreement with actual EU policies where a 50% reduction in the use and risk of chemical pesticides and a 50% reduction in the use of more hazardous pesticides by 2030 (the Farm to Fork Strategy, at the heart of the European Green Deal) for both extensive and horticultural crops. Based on this, agro-chemical companies are landing on the commercialization of biological control products either by developing themselves, simply buying biological products under development or just acquiring the manufacturing plant.

Some challenges that biocontrol faces are the upscaling of biocontrol technologies and transference to companies; development of easy-to-use formulations that remain stable in time and conserve effectiveness; product quality controls and integration or adaptation of biological systems to actual productive systems. Besides, environmental conditions can play a substantial role in the effectiveness of the biocontrol product against pathogens. This results in an opportunity for local or regional developments that are better adapted to the prevailing environmental conditions.

A forecast for the global biopesticide market, which is currently about USD 6.7 billions, shows that it will reach USD 13.9 billions by 2028 (Marketsandmarkets web page, 2023). Demand for biological control is increasing due to many factors that involve free-pesticides commodities, healthier foods, including organic food and cropping systems with less impact on the environment (plants, soil, micro and macro animals, microorganisms). This is also strengthened by organic farming production when consumers are demanding high quality and the safety of food.

Biological products aimed to control fungal pathogens are a key demand in the current market, and the sector that has increased the most in commercial biocontrol agents' registration is fruits and vegetables, based mainly on target specificity, non-harming beneficial insects and maintaining a balanced ecosystem. Based on all these facts, the present special issue collects original research studies and reviews of the main beneficial microorganisms capable of mitigating the detrimental activity of phytopathogens of worldwide interest. Across the reviews, *Trichoderma* spp., *Bacillus* spp., *Actinomyces* spp. and several endophytic fungi and bacteria are presented as potential BCAs on several crops against a wide range of pathogens. Among them are several *Fusarium* species, which are distributed worldwide and can persist in soils due to several resistant structures such as chlamydoconidia or simply by ascospores or mycelium surviving in stubble of the previous crop or some alternative host. These pathogens are reviewed by Djemouai et al.; Palazzini, J.; Jan et al.; Petrucci et al., and Auer & Ludwig-Müller. The way climate change is altering the ecophysiology of important mycotoxigenic fungi such as *Aspergillus* and *Fusarium* and their associated mycotoxins in maize is revised by Alaniz Zanon et al.

Trichoderma species are among the most widely used biocontrol products in the world. In this special issue Sharma et al., Pastor et al., Rattan Bhardwaj et al. and Stange et al. investigate relevant aspects and characteristics of these systems such as parasitism, antibiosis and resistance induction that justify why this genus is so important and used in so many commercial products.

We all know that weeds are undesired plants harming the cropping systems, but wouldn't they be a positive fact if they can provide some beneficial microorganisms for increasing crop yield and quality? This is the approach that Jelena Ilic discusses in her review. Bacterial consortia for either biocontrol or plant growth promotion are being explored, and in this special issue Yinxue et al. present a combination of *Bacillus* and *Pseudomonas* strains and their metabolites that antagonize *Alternaria alternata* in tomato. Additionally, Li et al. describe a novel fungal biocontrol combination of *T. harzianum* and *Clonostachys rosea* with great effectiveness in the control of *Botrytis cinerea* both *in vitro* and *in vivo* by activating the salicylic acid resistance pathway on tomato plants.

Readers of this special issue will be updated about the status of the biocontrol of plant diseases as well as be given an overview of the perspectives this approach will have in a near future. Now more than ever research represents the basic support to improve our knowledge and to create a continuous and indissoluble net of companies whose primary role will be to transfer the know-how to a practical level, thus

improving the development and registration of new commercial biocontrol agents.

On behalf of the editors of this IS and the editor-in-chief of the EJPP, we hope you enjoy this collection of high-level papers and to continue to give your contribution to overcome the challenge of a sustainable agriculture and of the availability of safe and safety food for all.