

1. PHD PROJECT DESCRIPTION (4000 characters max., including the aims and work plan)

Project title: Microorganisms promoting growth of perennial wheat as a support for sustainable agriculture

1.1. Project goals

The goals of the project are following: (i) to select endophytic bacteria or fungi that can promote the growth of perennial wheat at early stage of development when plant is sensitive to weed overgrowth, (ii) to check the level of plant tissue colonization with tested endophytes, (iii) to examine the interaction of applied endophyte/s with host plant and soil microbiome, (iv) to check the potential of selected endophyte/s for application in form of bio-inoculant.

1.2. Outline

Intense crop production impacts natural resources by causing global magnification of soil environment degradation and biodiversity loss. Frequent soil tillage and lack of vegetation cover for long periods are associated with extensive soil erosion, soil carbon loss and nutrient leaching, especially nitrogen. The shift from annual to perennial grain crops supports sustainable land use and favors conservation of both, soil functional biodiversity and soil ecological services. Cultivation of perennial crops is aided by minimal agronomic practices, therefore endophytic microorganisms promoting growth of these plants can be applied to improve their ecological competitiveness over weeds and increase the yield. Furthermore, endophytic bacteria and fungi by stimulation of plant defense mechanisms may serve as biocontrol agents against plant diseases. These beneficial traits of endophytes make them welcome in modern and sustainable agriculture. The Results of experiments planned in the project will enable the assessment of the application potential for inoculants based on endophytic microbes in perennial crop cultivation. It is expected to select such microbes that can be successfully used for perennial wheat growth support under the field conditions. The PhD project will be conducted under the framework of international research project NAPERDIV: Nature-based perennial grain cropping as a model to safeguard functional biodiversity towards future-proof agriculture. Results of the research will be published in journals.

1.3. Work plan

The proposed PhD project includes the following work tasks:

- Testing of endophytic strains isolated from perennial wheat roots and leaves for growth promoting traits including: auxin synthesis, siderophore production, nitrogenase activity and phosphate solubilization.
- Selection of most promising strains for preparation of pot experiments.

- Examination of growth parameters and photosynthetic capacity of plants treated with microbial inocula.
- Testing plant inoculated with beneficial microbes for their competitiveness over common weeds.
- Metagenomic analysis and qPCR to study interactions of applied endophytes with plant and rhizosphere microbiome.

1.4. Literature

Bertola M, Righetti L, Gazza L et al. (2023) Perenniality, more than genotypes, shapes biological and chemical rhizosphere composition of perennial wheat lines. *Frontiers in Plant Science* 14: art. no. 1172857. <https://doi.org/10.3389/fpls.2023.1172857>

Dhiman K, Sharma D, Kumari R et al. (2023) Biofortification of crops using microbes – a promising sustainable agriculture strategy. *Journal of Plant Nutrition*. DOI: 10.1080/01904167.2022.2160755

Arora NK and Fatima T (2022) Role of plant growth promoting microbes in managing sustainability of stressed agroecosystems. *Environmental Sustainability* 5: 1–3. <https://doi.org/10.1007/s42398-022-00222-z>

Malgioglio G, Rizzo GF, Nigro S et al. (2022) Plant-Microbe Interaction in Sustainable Agriculture: The Factors That May Influence the Efficacy of PGPM Application. *Sustainability* 14: 2253. <https://doi.org/10.3390/su14042253>

Soto-Gómez D and Pérez-Rodríguez P (2022) Sustainable agriculture through perennial grains: Wheat, rice, maize, and other species. A review. *Agriculture, Ecosystems & Environment* 325: 107747. <https://doi.org/10.1016/j.agee.2021.107747>

dos Santos Lopes MJ, Dias-Filho MB and Cajueiro Gurgel ES (2021) Successful Plant Growth-Promoting Microbes: Inoculation Methods and Abiotic Factors. *Frontiers in Sustainable Food Systems* 5: art. no. 606454. <https://doi.org/10.3389/fsufs.2021.606454>

Shah A, Nazari M, Antar M et al. (2021) PGPR in Agriculture: A Sustainable Approach to Increasing Climate Change Resilience. *Frontiers in Sustainable Food Systems* 5: art. no. 667546. <https://doi.org/10.3389/fsufs.2021.6675462w>

1.5. Required initial knowledge and skills of the PhD candidate

Following qualifications are required to execute the research tasks planned for PhD student:

- A basic experience in microbiology
- A basic experience in molecular biology methods, including DNA isolation from soil and plant material, PCR and quantitative PCR. Good laboratory skills are important for keeping high quality of obtained results.

- Fluent English written and spoken (at least B2)
- Interpersonal communication skills and good time management and organizational skills.
- An experience in writing for scientific publications and presentation of research to the audience is appreciated.

1.6. Expected development of the PhD candidate's knowledge and skills

- The candidate will gain an expertise in microbiological methods (media and assays) used for testing endophytes for their potential for plant growth promoting.
- The candidate will gain an expertise in analysing the level of plant colonization with inoculated bacterial or fungal strains.
- The candidate will be trained in interpretation of microbiome structure analyses and biodiversity analyses.
- The candidate will be actively involved in the preparation of original manuscripts with the results.
- The candidate will be trained in the presentation of obtained results to the audience (e.g. in the scientific conferences).