Climate-resilient biological control of fire blight in apple: biocontrol efficacy, host response and microbiome dynamics under RCP8.5 conditions

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Italy is the second largest EU producer of apples (2.2 Mt/year). In 2021, Italy was the 4th EU largest pear producer (273,450 t/year), but lost its leadership due to the high losses caused by pathogens like *Erwinia amylovora* and climate change. The World Apple and Pear Association (WAPA) forecasts for 2024 that EU apples and pear will reach ~11.4 Mtons and ~1.7 Mtons respectively, below 3.3% and 12.8%, the values of 2022. This decrease is mainly due to prolonged heat/drought episodes and extreme out-season storms (e.g., Portugal/Spain had during 2023 a severe prolonged drought, and the northern/eastern EU had a drought period in June/July). Italy was mostly affected by extreme storms and heat/drought, which, according to WAPA. Climate change impacts are aggravated by the increasing number of hectares infected with pathogens, whose behavior under climate change remains unquantified. The main pathogens are:
E. amylovora causes sudden and severe disease in Rosaceae and may lead to the tree death. Primary infection occurs at blooming, when pathogen control is very challenging and the risk of phytotoxicity high. Furthermore, secondary infections may occur from May to late October posing serious difficulty for a seasonal-long control of this disease. In addition, no efficient treatments are available (only sanitary pruning and use of Cu-based compounds). Finally, no in-site, fast and reliable diagnostic methods exists to precisely tailor control inputs and minimize pesticide use.

AIMS:

TASK 1 — Develop biocontrol tools under RCP8.5 conditions
Selected biocontrol agents (BCAs) will be evaluated for their ability to control fire blight under environmental conditions simulating the RCP8.5 scenario, including elevated temperature, high relative humidity and increased CO_2 concentration.
The work will assess BCA efficacy against *E. amylovora*, their ability to colonize and persist in the apple phyllosphere, and their impact on the structure and functional potential of the phyllosphere microbiome. Particular attention will be given to identifying microbial taxa and functions promoted under RCP8.5 conditions, with the aim of selecting BCAs better adapted to future climatic scenarios.
In parallel, specific protocols will be developed and validated for the precise tracking of individual BCA strains, allowing their persistence, spatial distribution and population dynamics to be monitored after application.
Main activities:

1. Testing of BCA efficacy against fire blight under current and RCP8.5-like environmental conditions.
2. Analysis of apple phyllosphere microbiome changes induced by high humidity, temperature and CO_2.
3. Identification of microbial taxa and functions associated with improved biocontrol performance.
4. Development and validation of strain-specific tracking protocols, such as qPCR, digital PCR or marker-based detection systems.

TASK 2 — Dissect the effects of RCP8.5 conditions on plant response to *E. amylovora*

Apple plants will be inoculated with *E. amylovora* under the same environmental conditions used in Task 1. The objective is to determine how RCP8.5-like conditions influence the physiological and molecular response of apple to fire blight infection.

This task will compare plant responses under current climatic conditions and future-scenario conditions, focusing on disease severity, oxidative stress, photosynthetic performance, hormone signaling and defense-related gene expression. The results will clarify whether future climate conditions increase plant susceptibility, alter defense activation or modify the timing and intensity of immune responses.

Main activities:

1. Inoculation of apple plants with *E. amylovora* under controlled current and RCP8.5-like conditions.
2. Quantification of disease progression and symptom severity.
3. Assessment of physiological parameters, including photosynthetic efficiency, stomatal conductance, chlorophyll content and oxidative stress markers.
4. Analysis of defense-related molecular responses, including genes involved in salicylic acid, jasmonic acid, ethylene and abscisic acid signaling.
5. Integration of disease, physiological and molecular datasets to define the impact of climate change on apple susceptibility.

TASK 3 — Biologically induce resistance through selected BCAs

Candidate BCAs will also be screened for their ability to induce resistance in apple by modulating host defense signaling pathways. The project will evaluate whether selected BCAs can prime plant defenses and reduce fire blight severity under both current and RCP8.5-like climatic conditions.

The effects of resistance-inducing BCAs will be assessed at physiological, molecular and microbiome levels. This will allow the identification of BCAs that combine direct antagonistic activity against *E. amylovora* with indirect protection through activation of host defenses and beneficial modulation of the plant-associated microbiome.

Main activities:

1. Screening of BCAs for their ability to induce plant resistance before pathogen challenge.
2. Evaluation of disease reduction after BCA treatment and subsequent *E. amylovora* inoculation.
3. Analysis of host defense activation, including hormone-related pathways and defense-marker genes.
4. Identification of BCAs able to maintain resistance-inducing activity under RCP8.5 conditions.

Applicants should have a background in plant molecular biology and/or plant physiology and/or plant pathology/plant-microbe interactions

Research involves laboratory and field trials. The selected candidate will assist the program leader with all aspects of the planning, implementation and management of the research program. The main duties will be collecting and analyzing data, preparing presentations and scientific publications, and supervision of students.

Position Duties:

70% – Laboratory analysis (in Bologna). Design and manage trials to assess the influence of microbiome in plant response to diseases. Design and management of trials to develop and validate BCA. Isolate, identify and characterize bacteria from different plant organs. Study the gene expression in plants treated with selected PGPB/BCA/pathogens. Analysis plant metabolic (e.g. VOCs emission, secondary metabolite production) and physiological response (e.g. photosynthetic activity, stomata conductance) to microbial treatments in different stress conditions (e.g. drought or water logging conditions).

20% – Green house and field work. Collect plant samples from apple and pear affected orchard. Collect sampling form different growing conditions and geographical areas. Appling selected strains in green-house or filed conditions. Assess physiological and productivity performances of tree (bud differentiation, fruit set, trunk diameter, shoot length and canopy development, yield, root development, starch allocation in different organs). Collect and analyses environmental conditions (climatic data) and agricultural inputs (irrigation, fertilisation). Communicate with growers and technicians for the correct management of the experimental plots.

10% – Train and supervise bachelor and master students and trainees. Supervision includes planning, assigning, and approving work. Assist other faculty and technicians in carrying out cooperative experiments.