Trans-sectorial approaches sustainable disease control across agribusiness districts

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Figure 1. PROTECTA investigates the biology and control of diverse oomycete diseases. A) ESR Noelia López-García samples rhizosphere soil in a forest stand as part of her project investigating the biology and ecology of oomycete forest pathogens, B) Salmon eggs infected with the oomycete disease Saprolegniosis, C) symptoms of chronic root rot in sugar beet caused by the oomycete Aphanomyces cochlioides D) potato late blight caused by Phytophthora infestans E) the mycoparasitic oomycete and biological control agent Pythium oligandrum parasitising P. infestans.

Professor Laura Grenville-Briggs shares her stance on working together to counter the threat of oomycete diseases, focussing on trans-sectoral approaches to support sustainable plant and fish production systems in Europe

Oomycetes-microbes that superficially resemble fungi- are devastating pathogens affecting many plants and animals. Oomycete diseases in our agriculture, horticulture and aquaculture production systems, as well as natural or managed ecosystems constitute a significant threat to food security, environmental sustainability and economic stability. Moreover, under current climate change predictions, oomycete diseases are predicted to spread polewards [1] and, with more unpredictable weather patterns, are likely to be more disruptive in the future.

Are these diseases a cause for concern?

These diseases could be a significant barrier to meeting objectives such as the European Green Deal and the Farm2Fork strategy. For example, potato late blight is managed in conventional cropping systems with multiple fungicide applications. In Europe alone, more than 2 million tonnes of pesticides are applied annually in potatoes (which accounts for 7% of all pesticides used in EU agriculture)[2], primarily to control late blight caused by the oomycete Phytophthora infestans.

How can the scientific research community support efforts to manage, mitigate and minimize these threats?

In the PROTECTA project, funded through Horizon 2020 EU-MSCA-ITN-2017 grant agreement number 766048, we believe the pathways to achieve this are through training the next generation of early-stage researchers (ESRs) in scientific interdisciplinarity and trans- sectoral innovations.

Despite decades of research, there are still many unanswered questions about the biology of oomycete diseases and their control. We need to train the next generation of scientists to answer these questions, with modern tools across molecular biology, genetics, ecology, evolutionary biology, plant breeding and the applied sciences. In PROTECTA, we have done precisely this. The goal is to develop and evaluate strategies to control these diseases.

Our ESRs are mentored in their doctoral studies by co-tutelage teams comprising industry and academic scientists from the sectors most affected by oomycete diseases. It is rare to encounter forest ecologists discussing their data with biochemists or fish vets. But interdisciplinary and trans-sectoral approaches, such as these, are needed to spark innovation and creativity in our scientific problem-solving. PROTECTA provides an environment for just that. As the project draws to a close, I am happy to say that we have made fundamental discoveries that deepen our knowledge of oomycete-host interactions and management. We identified pathogen-mediated stomatal opening as a previously overlooked pathogenicity strategy used by oomycetes<sup(3) and uncovered the activation mechanism of a specific plant immune response to P. infestans[4]. We have also catalogued[5] and pinpointed a particular mechanism of, [6] pathogenicity determinants in the legume pathogen Aphanomyces euteiches. The project has also identified new frontiers for oomycete pathogens, such as the recent discovery of the tree-pathogenic oomycete Pythium kashmirense in the UK[7]. Tree pathogenic oomycetes can be very challenging to control, but our research has, for example, developed novel lignin nanoparticles containing essential oils for the control of Phytophthora cactorum diseases in trees[8].

Achieving trans-sectoral approaches

New scientific data need to be gathered and reviewed to shape effective policies to protect against invasive oomycetes and the movement of diseases under climate change. We have achieved trans-sectoral approaches in PROTECTA, gathering current practices and new possibilities to control the spread of oomycetes in both terrestrial and aquatic production systems within an EU context[9]. During the COVID-19 pandemic, the ESRs wrote a series of review articles together[9-12] as a way to stay connected to one another to promote interdisciplinary and trans-sectoral approaches. They reviewed our knowledge on the molecular dialogue between oomycete effectors and their diverse hosts[10] and the latest transformation and gene editing technologies in the oomycetes to help researchers find the tools they need to work with these organisms[11].

Some oomycete species parasitize fungi and other oomycetes. These so-called mycoparasites have the potential to unlock the keys to the control of plant diseases. For example, we can develop these organisms as biological control agents to deploy in field or greenhouse settings. However, these organisms also suffer a loss of efficacy from greenhouse to field, as we have also seen with the use of Pythium oligandrum[13], so more research is desperately needed to find better ways to use biological control in open field agriculture. Added to this, the development of such approaches is highly laborious, expensive and hindered by complex legislation (as our ESRs recently reviewed)[13]. However, even without such direct practical applications, if we can unravel the complex mechanisms behind oomycete mycoparasitism, as we have begun to do in PROTECTA[14], we can use this knowledge to develop sustainable tools that could provide durable control of oomycete pathogens and valuable new targets to enhance resistance breeding programs.

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