Forestry Sciences

Volume 86

More information about this series at http://www.springer.com/series/5991

Anna Maria Pirttilä · A. Carolin Frank
Editors

Endophytes of Forest Trees

Biology and Applications

Second Edition

Springer

Editors
Anna Maria Pirttilä
Ecology and Genetics
University of Oulu
Oulu
Finland

A. Carolin Frank
School of Natural Sciences
University of California, Merced
Merced, CA
USA

ISSN 0924-5480 ISSN 1875-1334 (electronic)
Forestry Sciences
ISBN 978-3-319-89832-2 ISBN 978-3-319-89833-9 (eBook)
https://doi.org/10.1007/978-3-319-89833-9

Library of Congress Control Number: 2018940624

Printed on acid-free paper

This Springer imprint is published by the registered company Springer International Publishing AG
part of Springer Nature
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

Endophytes are commonly known as microorganisms, mainly bacteria and fungi, which live inside plant tissues without inducing symptoms. While compiling this book, it became obvious that even though the endophyte definition has been defined, re-defined, and explained many times in the past, the use of the term endophyte still varies considerably among researchers. Some include pathogens in the definition, however, if we consider all pathogens colonizing plant tissue asymptomatically at the onset of infection as endophytes, do we need the definition of endophyte anymore? Should we just discuss plant-associated microbes? But what would we then call the high numbers of microbes that occupy the interior of plant tissue without ever becoming visible? Therefore, it would be worthwhile to take the symptomless colonization of a plant host into the focus of the endophyte definition. We could say, "while colonizing a healthy plant, endophytes do not create symptoms during their life cycle." This would exclude true pathogens that induce disease symptoms and can kill an otherwise healthy host. This would not exclude latent pathogens that can live inside a healthy plant host without ever inducing symptoms of disease, but can cause a disease in a stressed plant. In this respect, the endophytic microbiota of plants can be compared with animal microbiota, which includes latent pathogens (e.g., *Staphylococcus aureus* or *Escherichia coli* in humans) that can cause disease in compromised hosts.

Since the first volume, endophytes have increasingly been shown crucial in the lifestyle of their hosts. Considering the long-lived trees, endophytes have an even more emphasized role in preparing their hosts to face extreme weather conditions, drought, heat, cold, and pathogen and herbivore attacks. In our changing world, forests are especially important in buffering Earth's climate, acting as carbon sinks and producing oxygen. Due to the decrease in fossil fuel use, alternatives, such as bioethanol, are developed from tree biomass. While the reduced use of fossil fuels is a step forward in preventing climate warming, deforestation is increasing throughout the globe. Forestry practices are creating young tree monocultures instead of diverse, old-growth forests, which harbor rich endophyte communities. New forest pathogens have already emerged and spread at alarming rates on all continents. The tiny but extremely diverse companions of trees, endophytes, play a

crucial part in their health, both in good and in bad ways. In this second volume of "Forest Tree Endophytes," besides interesting updates on the diversity, host specificity, and mechanisms by which endophytes induce growth and health of their hosts, we have collected chapters focusing on the role of endophytes in forest health, diseases, and their biocontrol.

The current knowledge clearly demonstrates the importance of endophytes in shaping the plant diversity in a forest, whether temperate or tropical. Through protection of the host against insect pests, a selection is imposed on the forest, leaving the most tolerant trees standing due to combination of tree genetics and defensive endophytes. On the other hand, specific endophytes may help the tree grow faster and taller than its neighbors, which are left in the shade. Upon environmental stress, some trees hosting specific endophytes may be more resistant, whereas other hosts with a different composition of endophytes can become susceptible even to their own microbiota and die.

Due to human activity, plants and their microbes are being moved between countries and continents at an increasing rate. In a new environment, the transferred endophytes may colonize novel hosts and transform into devastating pathogens. This is the case, for example, in *Fraxinus* dieback. This is an aggressive disease originating from an endophyte of an Asian ash species that has spread across Europe during the last decades, killing the majority of European ashes.

Another question is the spread of insect pests due to global warming. For example, mountain pine beetle has expanded its host range to the trees of boreal forest, and spruce budworm continues to spread as the most destructive pest of spruce and fir trees in Canada. Endophytes can play a crucial role in the natural and artificial protection—biocontrol—of these insect pests, which unlikely will remain the only examples.

Endophytes have an important and still underutilized capacity for biocontrol of forest diseases. In general, the use of pesticides is not easily accepted in natural settings such as a forest. Therefore, endophytes offer an environmentally friendly alternative, and their use is continually increasing in various forest management programs. For example, biocontrol of the spruce budworm by endophytic fungi, using *Trichoderma* spp. against fungal pathogens, or treatment of tree stumps with *Phlebiopsis gigantea* are currently in development or already in use for biocontrol of forest trees. However, there is much unused potential for endophytes in supporting forest health, and endophyte-based applications should be extensively studied and developed for forestry.

Considering endophyte diversity and the range of various compounds and enzymes they can produce, endophytes can be used for biotechnological applications on other arenas as well. The widely understudied and underutilized diversity of bioactive compounds of forest endophytes is discussed in updated chapters. Clear progress has been made within this area to benefit the humanity in curing diseases, as the bioactive compounds produced by endophytes have high prospects for development as leads for various applied purposes. However, stressed equally important, the diversity of the forests in boreal, temperate, as well as tropical zones

and in between, is crucial to keep the library of bioactive endophytes alive for future generations.

With this new edition of *Endophytes of Forest Trees*, we wish to bring out the important role that endophytes have in shaping and protecting our forests for the future.

Oulu, Finland — Anna Maria Pirttilä
Merced, USA — A. Carolin Frank

Contents