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Functional Diversity of Mycorrhiza and Sustainable Agriculture

Functional Diversity of Mycorrhiza and Sustainable Agriculture

Management to Overcome Biotic and Abiotic Stresses

Michael J. Goss
School of Environmental Sciences, University of Guelph, Guelph, Ontario, Canada AU:1

Mário Carvalho
Institute of Mediterranean Agriculture and Environmental Sciences, University of Évora, Évora, Portugal

Isabel Brito
Institute of Mediterranean Agriculture and Environmental Sciences, University of Évora, Évora, Portugal

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ACADEMIC PRESS
An imprint of Elsevier
elsevier.com

Academic Press is an imprint of Elsevier
125 London Wall, London EC2Y 5AS, United Kingdom
525 B Street, Suite 1800, San Diego, CA 92101-4495, United States
50 Hampshire Street, 5th Floor, Cambridge, MA 02139, United States
The Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, United Kingdom

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication Data
A catalog record for this book is available from the Library of Congress

ISBN: 978-0-12-804244-1

For Information on all Academic Press publications
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Publisher: Nikki Levy
Acquisition Editor: Nancy Maragioglio
Editorial Project Manager: Billie Jean Fernandez
Production Project Manager: Lisa Jones
Cover Designer: Mark Rogers

Typeset by MPS Limited, Chennai, India

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Goss-1611461 978-0-12-804244-1 00011

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5. Impacts on Host Plants of Interactions Between AMF and Other Soil Organisms in the Rhizosphere*

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Preface

The current world population of 7.5 billion is expected to be 20% greater by 2050 and so we have little over 33 years to ensure the means of producing sufficient food to meet the expected demand. One of the options that previously were available to us for expanding world production of cereals, vegetables, fruits, and meat, namely bringing more land into production, is no longer possible and consequently we must everywhere increase the productivity of the land. But this time we must not attempt it without making every effort to safeguard the environment. Put in a slightly different way, we have to grow more but conserve the soil and its biodiversity, be more efficient in terms of water use, improve nutrient-use efficiency so that fewer applied nutrients end up contaminating our freshwater and eutrophying our lakes and shallow seas or adversely affecting the quality of our air and contributing to the atmospheric loading of greenhouse gases. If we add in a desire to reduce the application of pesticides, especially those targeting root pathogens, it would seem to represent an extremely challenging task. Perhaps it will be a surprise to some that the answer to many of these challenges might well be one result of the development of techniques that allow us to determine the make-up of microorganisms, which has had huge impacts on soil science and its application in agronomy.

Beginning with the ability to differentiate the fatty acid and phospholipid profiles of microbial communities in soil and reaching the current status, where the whole genetic code of an organism can be determined, the previously rather opaque world of soil microbiology is being clarified at an unprecedented rate. From around the time that the word mycorrhiza was coined by Frank in 1885, mycorrhizal fungi have been of interest because of their special relationship with the vast majority of land plants. For agronomists the most important are the endomycorrhizal fungi that produce tree-shaped branched structures called arbuscules inside the cortex of most crop plants. Evidence steadily accrued that established their importance in supplying the essential element phosphorus to plants but the availability of mineral fertilizers, such as superphosphate, caused many to assume that the contribution from mycorrhiza was unnecessary and even in fertile soils the organisms were more like parasites than partners of their hosts. But eventually there came the realization that arbuscular mycorrhiza provided far more services than supplying phosphorus. The recent appreciation of the biological

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diversity of mycorrhizal fungi and the functional consequences for mycorrhiza with different abilities to protect their host from the impacts of toxic metals, to counter the invasion of root diseases and to enhance the formation and stabilization of soil aggregates, renewed interest in the ecological significance of mycorrhiza.

The challenge for agronomists and those interested in availing their crops of the potential benefits from arbuscular mycorrhiza is how to manage them. One obvious approach is to develop a source of inoculum that can be applied to a field prior to or as part of seeding a crop that could benefit from the formation of a mycorrhizal symbiosis. However, not only is that a relatively expensive activity it is also fraught with uncertainty over its efficacy. Another approach is to encourage the adoption of farming practices that support a wide variety of indigenous arbuscular mycorrhizal fungi (AMF) that will provide specific benefits sought for the crop. But in many respects this is not enough. It is a long way from providing the supportive environment for a specific fungus or consortium of fungi to dominate the mycorrhiza that form on most crop plants in a field. That goal requires the development of new farming strategies.

The approach we take in this book is to expand on the current challenges to meeting the requirements for feeding a much larger world population and suggest how arbuscular mycorrhiza can contribute to the solution under many agricultural climatic zones. We consider the farming practices that can be deleterious to maintaining a diverse population of mycorrhizal fungi and the systems and practices that can encourage their survival and effectiveness. We discuss the interactions between the fungi and other soil organisms, some of which are now known to improve the functioning of arbuscular mycorrhiza, and how the symbiosis influences many of the basic plant processes. The possibilities for obtaining specific information on individual fungi offered by the new generation of molecular methods are also presented. Finally we present a view as to how indigenous AMF might be managed in a practical setting.

The opportunity to put our combined thoughts and ideas into a book owes a lot to the discussions we had with Marisa LaFleur, commissioning editor with Elsevier, and subsequently with commissioning editor Nancy Maragioglio. Both have been wonderfully supportive and we can't thank them enough. We are equally indebted to Billie Jean Fernandez, who has been of enormous help in pulling us over the finish line. Lisa Jones, the Production Editor, has been superb in converting our ideas on presentation into reality; she has worked tirelessly to ensure we would be proud of the finished product. We sought the help of two experts to ensure that the chapters on new generation molecular methods and diversity among the AMF would be as up-to-date as possible. It is difficult to express just how grateful we are to Diederik van Tuinen, a very good friend and colleague, for his contribution on modern molecular methods in relation to the elaboration of

functional diversity. The contribution of Clarisse Brígido in developing the chapter discussing the complexity of functional diversity in AMF was also critical and she too has been of incalculable help and support. We are extremely grateful to Sabaruddin Kadir and Luis Alho, who generously provided material used in Chapter 5, Impacts on Host Plants of Interactions Between AMF and Other Soil Organisms in the Rhizosphere, as well as provided important feedback on the contents.

Michael Goss, Mário Carvalho, and Isabel Brito
March 2017

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Taxonomy of Arbuscular Mycorrhizal Fungi Referred to in this Book AU:1

There have been some major changes in the taxonomy associated with arbuscular mycorrhizal fungi (AMF). In consequence, some have undergone more than one name change in the last 30 years. To avoid as much confusion as possible, the names used in the text are those reported by the authors of the papers referenced. We have used Schüßler and Walker (2010) and Redecker et al. (2013) to provide a list of the current names of these species.

Former Name	Genera	Specific Epithet
Acalulospora leavis	*Acalulospora*	*leavis*
Acaulospora morrowiae	*Acaulospora*	*morrowiae*
Entrophospora schenckii	*Archaeospora*	*schenckii*
Gigaspora albida	*Gigaspora*	*albida*
Gigaspora gigantea	*Gigaspora*	*gigantea*
Gigaspora margarita	*Gigaspora*	*margarita*
Gigaspora rosea	*Gigaspora*	*rosea*
Glomus caledonium (Nicol. & Gerd.) Trappe and Gerdemann	*Funneliformis*	*caledonium*
Glomus claroideum	*Claroideoglomus*	*claroideum*
Glomus clarum	*Rhizophagus*	*clarus*
Glomus constrictum = Funneliformis constrictum	*Septoglomus*	*constrictum*
Glomus coronatum	*Funneliformis*	*coronatus*
Glomus diaphanum	*Rhizophagus*	*diaphanus*
Glomus etunicatum	*Claroideoglomus*	*etunicatum*
Glomus fasciculatum	*Rhizophagus*	*fasciculatus*
Glomus fasciculatum Gerd. And Trap	*Rhizophagus*	*fasciculatus*
Glomus fasciculatum (Thaxter sensu Gerd)	*Rhizophagus*	*fasciculatus*
Glomus geosporum	*Funneliformis*	*geosporum*

(*Continued*)

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(Continued)

Former Name	**Genera**	**Specific Epithet**
Glomus intraradices[a]	*Rhizophagus*	sp.
Glomus intraradices	*Rhizophagus*	*irregularis*
Glomus intraradices	*Rhizophagus*	*intraradices*
Glomus macrocarpum	*Glomus*	*macrocarpum*
Glomus mosseae	*Funneliformis*	*mosseae*
Glomus tenue	*Glomus*	*tenue*
Rhizophagus intraradices	*Rhizophagus*	*intraradices*
Scutellospora calospora	*Scutellospora*	*calospora*
Scutellospora fulgida	*Racocetra*	*fulgida*

[a]Identifying the current name for *Glomus intraradices* is problematic. The isolate DAOM197198 was renamed from *Glomus intraradices* to *Glomus irregularis* and then to *Rhizophagus irregularis*. As not all isolates have been reanalyzed, we now have some which are *Rhizophagus* sp., some *R. irregularis,* and some still *R. intraradices.*

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