Are all arbuscular mycorrhizal fungi beneficial for crops and soils?

Fritz Oehl, Mike Anderson Corazon-Guivin, Atti Tchabi, Danny Coyne and Ewald Sieverding

Objectives

During the last 40 years, studies on structural and functional diversity of Arbuscular Mycorrhizal Fungi (AMF; Mucoromyceta) have greatly advanced, in different continents, under different climatic conditions, and everywhere especially in soils subjected to different farming systems or soil cultivation practices (e.g. Table 1). Here, we summarize some of our major results from functional screening tests of single AMF species, grown in living cultures and prepared as soil microorganism inocula, on their effects on crop growth and soil health.

Table 1 AM fungi are great indicators for soils and their use intensity. Here, AMF species richness is presented as number of species in different land use types and cropping systems around the world.

Soil type	Natural ecosystems	Natural systems	Organic farming/ Low input	Reduced tillage systems	High-input systems
Calcaric Leptosol Oehl et al. 2010	Grasslands	27-33	20-25		21-23
Calcaric Regosol Oehl et al. 2003	Grasslands	24-31			13
Calcaric Chernosem Baltruschat et al.			26-33	23-27	16-19
Haplic Luvisol Oehl et al. 2003, 2004, 2005, 2009	Grasslands	26-32	25-31	25-33*	16-19 (2-10)
Humic Cambisol Oehl et al. 2010	Grasslands	32-39			21-25
Vertic Cambisol Säle et al. 2015	Grasslands	38	28-33	32-33	
Cambisol/Luvisols Maurer et al. 2018	Grasslands	33-35	26-30	25-27	20
'Moist' Ferralsol (semi-humid) Pontes et al. 2017a	Cerrado savanna forest	26-33		24-26	15-21 (-28)
Ferralsol (semi-arid) Pontes et al. 2017b	Caatinga dry savanna	44	29-36		
Ferralsol (semi-arid) Marinho et al. 2019	Caatinga dry savanna	51-56	25-42		

Materials and Methods

Living collections of indigenous AMF have been developed by the authors since 1980 at: I) CIAT (International Center for Tropical Agriculture), Colombia, ii) IITA (International Institute of Tropical Agriculture), Benin/Nigeria (together with the University of Basel, UNIBAS), iii) at UNIBAS a tri-national collection from the countries surrounding Basel), iv) the Swiss Agroscope collection of AMF (SAF), into which the trinational collection was integrated. Recently another collection was initiated at the National University of San Martín in Peru. These collections contain ~350 AMF isolates, belonging to over 50 species, most of which have been screened for their beneficial effects on crop growth, nutrient uptake and soil health on various crops: e.g. cassava, beans, white yam, coffee, inka nut, soybean, wheat, strawberry, and leek.

Introduction

Arbuscular mycorrhizal fungi (AMF) deliver important ecosystem services and play a key role for major soil and plant functions, including root health and plant nutrition, soil health and fertility, as well as preventing soil erosion and facilitating water infiltration. Importantly, they contribute to climate smart agriculture.

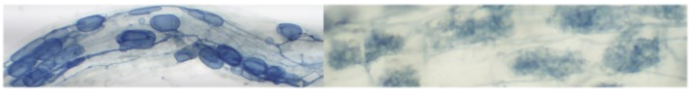

Fig.1 Vesicular-Arbuscular Mycorrhiza. For functional screening and knowledge about their potential ecosystem services AMF species have to be cultivated in living cultures, which is, however, a time consuming and laborious job (Photo: Mike Anderson Corazon-Guivin, 2019)

Results

Within our collections, ~100 AMF isolates stimulated plant growth and/or improved plant health. Rarely, slightly negative effects were observed, Most isolates demonstrating beneficial effects belonged to the Glomeraceae, which is opportune for their use in agricultural settings, as this family tend to be easiest to propagate, and to scale up. However, within Glomeraceae (Glomerales, Glomeromycetes) there are also genera, which had no effect on plant growth, while others had short-term (few months) or long-term (several to multiple months) effects, but rarely both. Several *Rhizoglomus* spp. and *Funneliformis mosseae* promote crop growth within a few months only, while *Dominikia aurea* and *Septoglomus constrictum* impact plant growth over several crop cycles. This may be linked to their life cycle and survival strategies.

From experiments performed in the Tropics, isolates belonging to *Rhizoglomus*, *Funneliformis*, *Sclerocystis*, *Entrophospora*, *Diversispora* and *Acaulospora*, proved most effective, while species in the early ancestral clades, *Archaeospora* and *Paraglomus*, rarely showed a positive effect. In experiments performed in Europe, isolates of *Rhizoglomus*, *Oehlia*, *Funneliformis*, *Entrophospora* and *Diversispora* were among the most effective, while again species from *Archaeospora* and *Paraglomus* were least effective on crop growth.

Conclusions Living AMF collections offer potentially colossal benefits to agriculture and beyond. This is particularly pertinent under the current sociopolitical climate with rising fertilizer and synthetic farming input costs, as well as the challenges that climate change presents, and the need to more efficiently use our water resources. The maintenance of these living reservoirs is therefore critical, but requires an equally colossal effort to keep them alive and available.

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