MYCORRHIZA AND SOIL MICROBIOTA: DIRECTIONS IN PERSPECTIVE RESEARCH

MIKORIZĖ IR DIRVOŽEMIO MIKROBIOTA: PERSPEKTYVIŲ TYRIMŲ KRYPTYS

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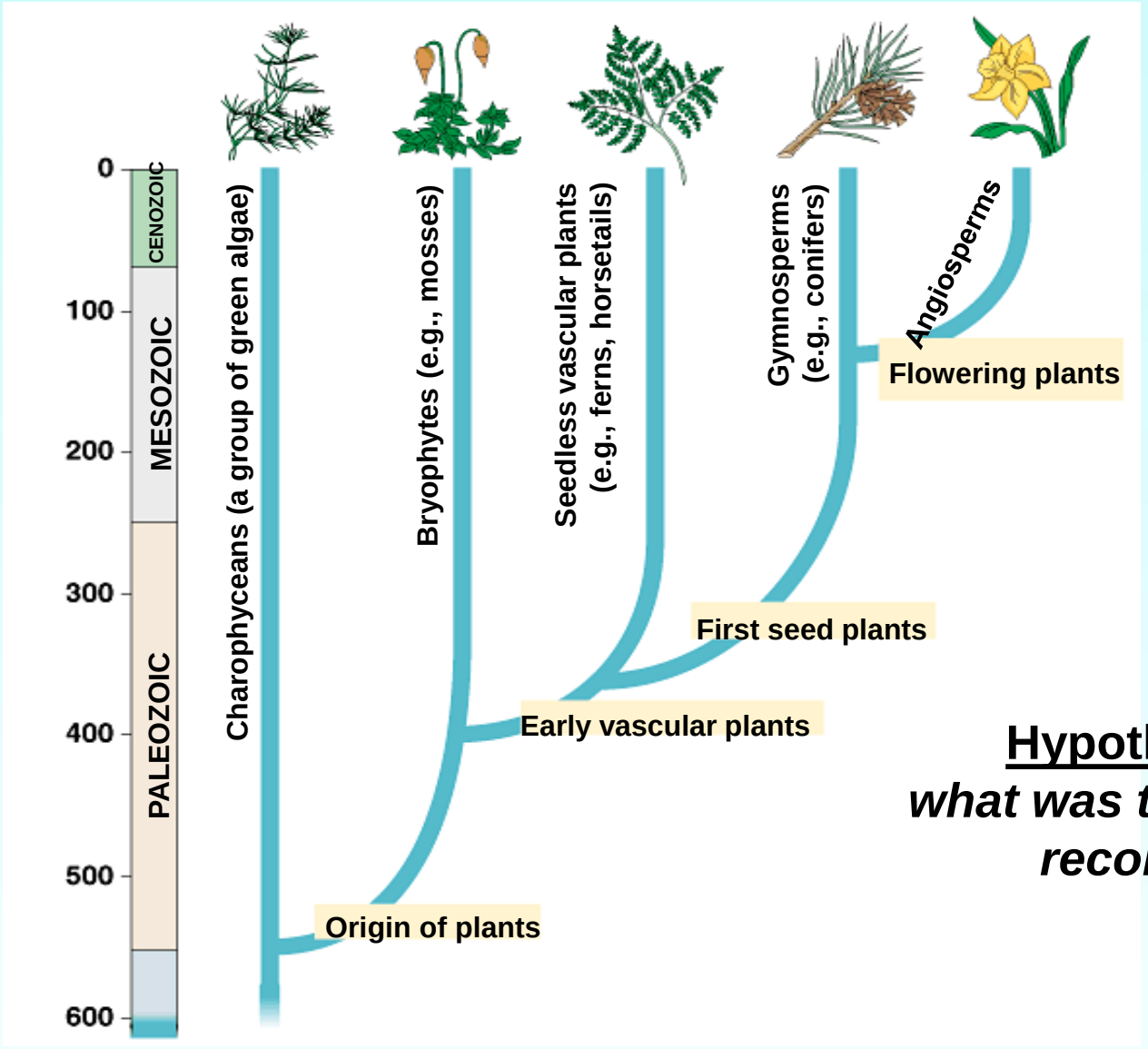
INTRODUCTION

Rhizosphere is the media for the growth of microorganisms in numerous and different populations of which being found on, as well as around, them (Raiesi & Ghollarata, 2006; Frey-Klett et al., 2007; Hartmann et al., 2009).

The rhizosphere is a physical, chemical and biological environment clearly distinct from the bulk soil, where altered microbial diversity and activity are characteristic (Kennedy & Smith, 1995; Hršelová et al., 1999).

Carbon fluxes are critical for rhizosphere functioning (Toal et al., 2000; Torsvik et al., 2002).



2012, Australian National Botanic Gardens and Australian National Herbarium

<u>Hypothetic question 1:</u>
what was the base for plants to recolonise the soil?

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http://www.motherearthnews.com/organic-gardening/mycorrhizal-fun

Mycorrhizal fungi were in succession with plants in the environment of early Earth as plants moved from water to land, providing efficient nutrient absorption from the low organic matter mineral soil, and assisting in the formation of soil aggregates.

Hypothetic question 2:

what was the base for microbiota recolonise the plants?

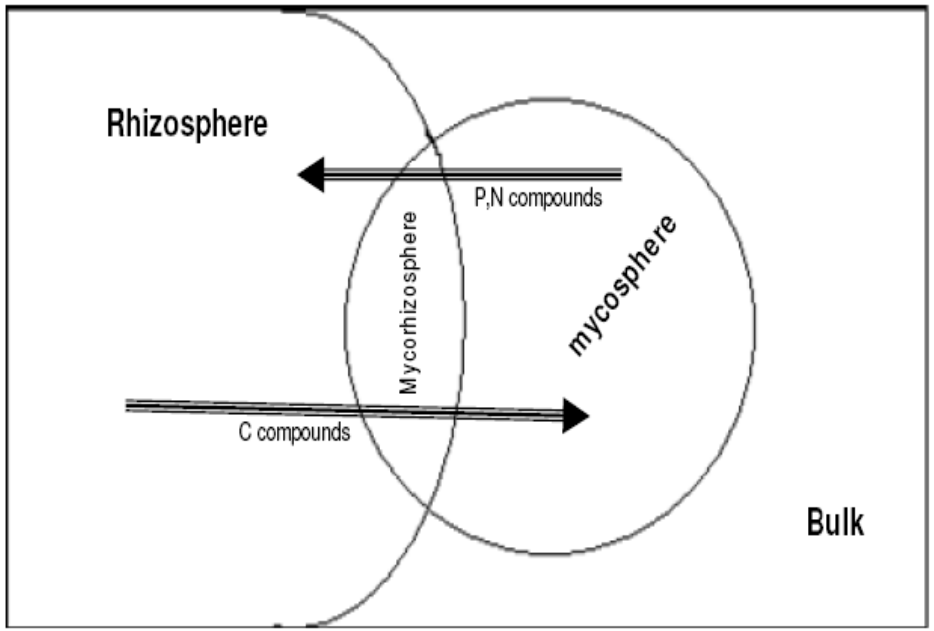
Plants have been given the primary production and released of various carbon compounds by their roots becoming available to soil microbiota (del Giorgio, 1998; Barrios et al., 2006).

Up to 30% of the total plant photosynthetic production can be used by soil microorganisms for growth and cell maintenance (Brundrett, 2002; Walker et al., 2003; Diallo et al., 2006).

The composition and quantity of carbon substrates in root exudates may differ depending on the plant species, rhizosphere location and plant growth stage and also on the nutritional requirements of plants by themselves (Andrade et al., 1997; Schreiner et al., 1997; van Overbeek, van Elsas, 2008).

This spatial and temporal variation in carbon availability greatly influences the structure and functioning of the rhizosphere-inhabiting microbial communities (Bonkowski et al., 2001; Bluéé et al., 2009).

HETEROGENOUS HABITAT ON THE BASE OF RHIZOSPHERE, MYCOSPHERE AND MYCORHIZOSPHERE



Rambelli, A.: The rhizosphere of mycorrhizae. In: Ectomycorrhizae. Eds. G. C. Marks and T. T. Kozlowski. Acad. Press. New York, London (1973), 299—349.
Definition used by Warmink and van Elsas, 2008

The rhizosphere (narrow zone of influence of plant roots);

The mycorrhizosphere (zone in soil that surrounds plant roots and fungal hyphae associated with these);

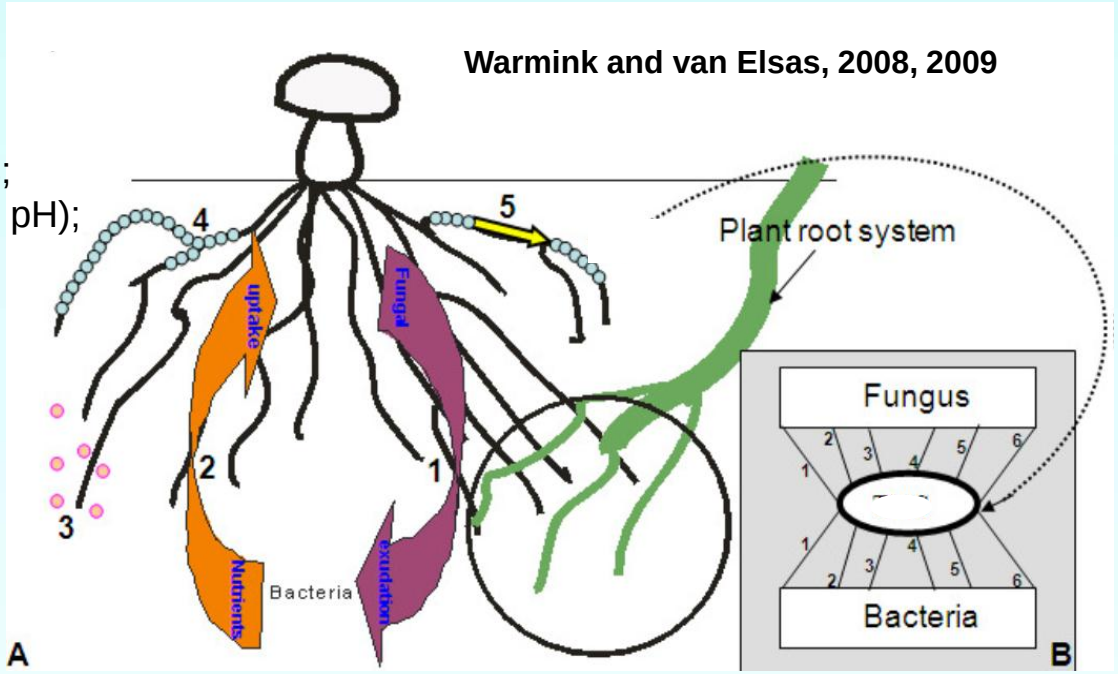
The mycosphere (microhabitat that surrounds the dense fungal hyphae in soil that give origin to fungal fruiting bodies).

HETEROGENOUS HABITAT ON THE BASE OF RHIZOSPHERE, MYCOSPHERE AND MYCORHIZOSPHERE

Bacterial interactions with soil fungi: round circle - the mycorrhizosphere on left of it - the mycosphere

(A) General ecology:

1. fungal exudation;
2. supply of phosphorus and nitrogen compounds to fungus;
3. change in microhabitat (e.g. pH);
4. bacterial biofilm formation;
5. migration along fungal hyphae.



(B) Involvement of the mycorrhiza system:

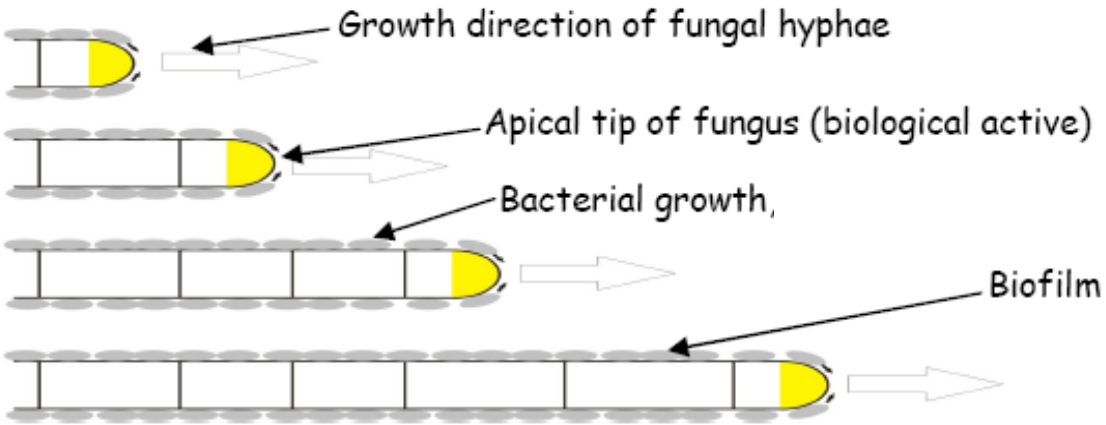
1. bacterial attachment to hyphal surface; 2. injection of effector proteins; 3. suppression of fungal defense system; 4. fungal exudation; 5. facilitation of migration along fungal hyphae; 6. bacterial biofilm.

Soil bacterial-fungal hypothetical interaction

Bacterial functional secretion:

Bacterial proteins can change the biochemical pathways of the colonized fungus (host) cells. This makes the fungus serve as a nutrient source for the bacteria, as likely outcome of the protein intensifying enhancement of the release of nutrients to the bacterium.

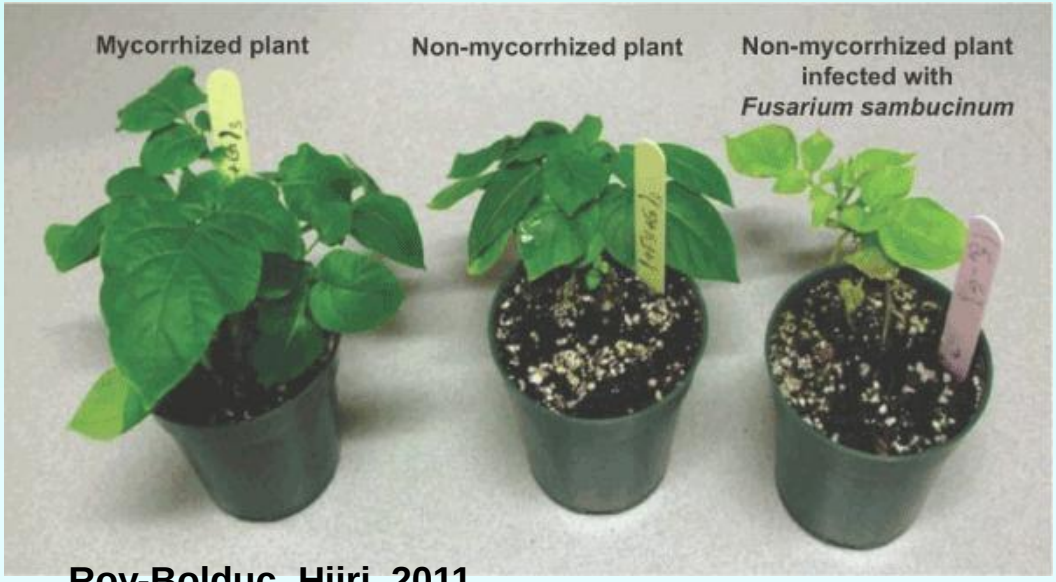
Bacteria may also affect the physiology or biochemistry of the fungal hyphae by changing surface or by stimulating fruiting body formation.



Definition used by: **He et al., 2004; Warmink and van Elsas, 2008, 2009; Warmink et al., 2011**

Mycorrhiza and soil microbiota: directions in perspective research

1. Plants as drivers of the soil microbiota and the role of mycorrhizae



Roy-Bolduc, Hijri, 2011

The mycorrhizal fungi associated with plants can modify plant root functions (Marschner and Crowley, 1996), may affect the carbohydrate metabolism of the plant (Shachar-Hill et al., 1995), influence bacterial populations in the rhizosphere (Andrade et al., 1998).

Selected soil microorganisms are able to decompose plant-fixed carbon (interaction with plant tissue). The complex structures of plant components composed of cellulose fibrils in lignin matrices, can be successfully penetrated by the hyphal structures of, in particular, mycorrhizal fungi (de Boer et al., 2005; Taylor, Osborn, 1996).

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2. Roles of bacteria and fungi in soil and their interactions

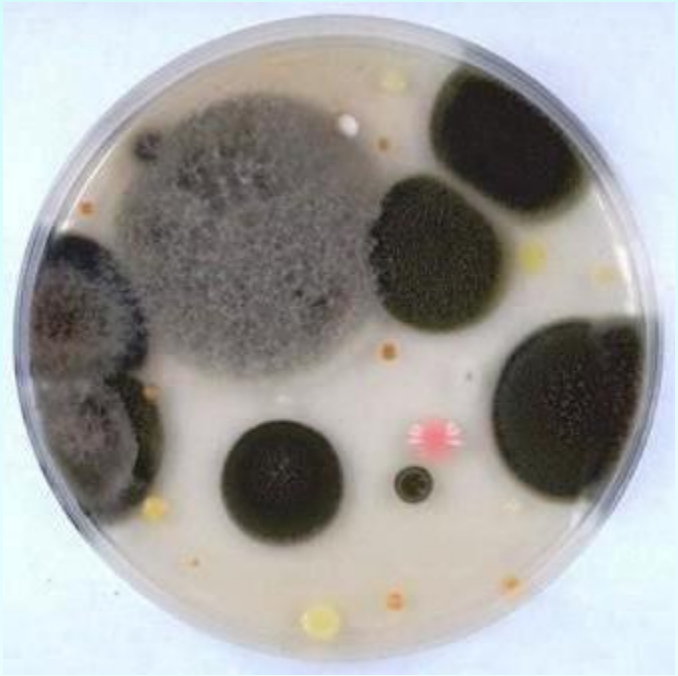
In soil, many bacteria and fungi occupy a shared microhabitat, which is called the bacterial-fungal interface (Johansson et al., 2004).

Traditional studies have revealed the presence of bacterial cells on top of fungal hyphae and spores, on mycorrhized roots and in association with fungal fruiting bodies (de Boer et al., 2005).

Interactions may vary with bacterial-fungal ecophysiology and the local conditions in the soil.

Fungal-associated bacteria are as-yet-uncultured and phenotypically still undescribed (Barbieri et al., 2005).

3. Fungi as selectors of bacteria in soil



Mycorrhizal fungi often release substances such as acids that, in addition to solubilizing phosphate from surrounding minerals, also affect the microbial communities (Duponnois et al., 2005) by stimulating their growth.

Bacteria associated with mycorrhizal fungi are driven by the suitable carbon and energy sources are provided and colonization sites are available. Soil bacteria may be involved in activities that provide benefits for the fungus (supply of the phosphate, nitrogen fixation).

Carbon sources is a key factor, in the latter case the local conditions may be turned hostile to bacteria.

4. Effects of bacteria on (mycorrhizal) fungi in soil

The mycorrhization of plant roots is often affected by the bacteria that are locally present (Garbaye, 1994; Frey-Klett et al., 2007; Pivato et al., 2009) in either positive, neutral or negative ways.

During the free-living stage, mycorrhizal fungi may interact with specific bacterial populations in the rhizosphere, and such bacteria (especially pseudomonads) may enhance mycorrhizal establishment (Garbaye, 1994; Pivato et al., 2009). Hence, these bacteria are called mycorrhization helper bacteria (Garbaye, 1994).

Bacterial-fungal binding during the first stage of the interaction is governed by general physicochemical parameters, such as electrostatic attraction. In a second stage, more stable binding may ensue, involving attachment and the production of bacterial extracellular polymers.

The mycorrhization helper bacteria effect is usually measured by assessing the ergosterol contents of mycorrhizospheric soil.

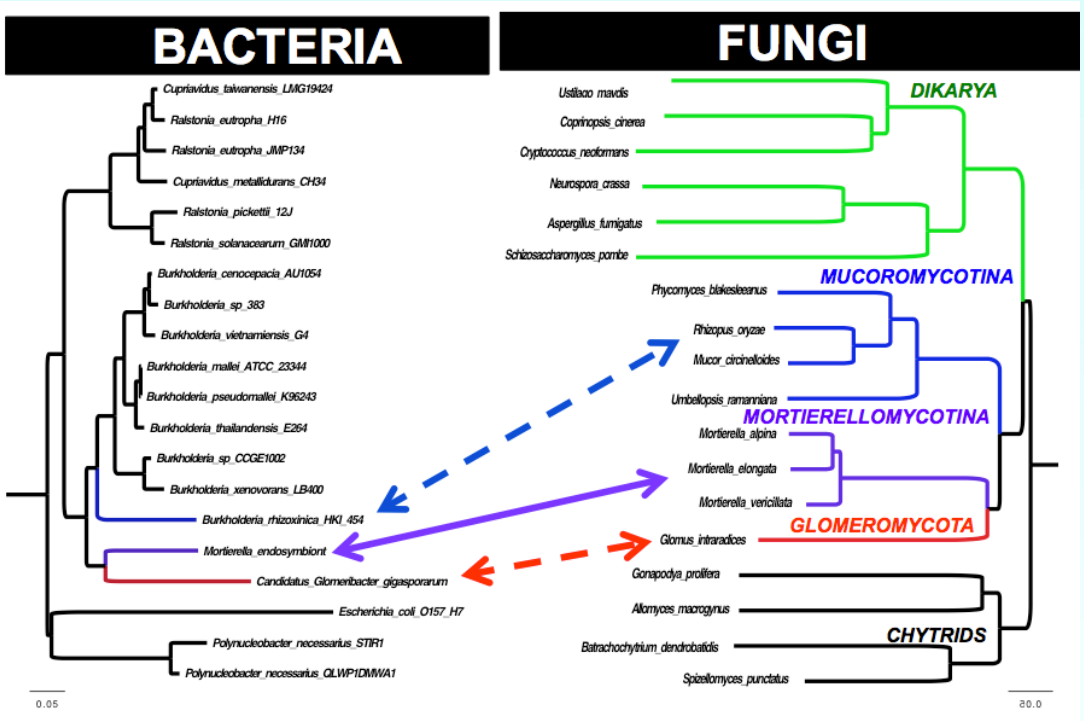
5. Bacterial mechanisms that enhance mycosphere competence

Bacteria is stimulating the competence by producing and extracting the inositol, xylitol, mannitol and ribose among the main sugars and polyols.

Toljander et al. (2007) reported formiate, acetate, and glucose, and glycogen, along with di- and oligosaccharides and some polymeric compounds, in the exudates of *Glomus sp.* MUCL 43205.

The most promising...

It is increasing availability of fungal and bacterial genome sequencing for achieving an improved picture of the impact (mycorrhizal) soil fungi on the evolution of fungal-associated soil bacteria.



Comparative genomics of early diverging terrestrial fungi and their bacterial endosymbionts (http://sites.duke.edu/vilgalyslab/2013/11/20/)

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The mycorrhizosphere includes NOT ONLY the plant roots and mycorrhizal fungi BUT ALSO a complex of microbial components