Reforestation Technologies International

Rhizophagus intraradices (formerly *Glomus intraradices)*

NOTE: Many of these studies reference *Glomus intraradices*, currently known as *Rhizophagus intraradices.*

Introduction

Mycorrhizal fungi are beneficial soil organisms that form mutualistic associations with most terrestrial plant roots and are the driving force of many terrestrial ecosystems (Harley and Smith, 1983). The most prominent type of mycorrhizal fungi are arbuscular mycorrhizal fungi (AMF) and can be characterized by their penetration of cortical root cells, formation of vesicles, arbuscules and hyphal coils (Lowenfels, 2017). In this mutualistic association, photosynthate (carbon source) produced by the host plant is transferred to the mycorrhizal fungi in exchange for soil minerals, especially phosphorus. Other benefits of this mutualistic relationship are increased water uptake and physical and biochemical protection against root pathogens. (Lowenfels, 2017). The result is improved growth and survival of host plants, with particular importance in agricultural lands and adverse habitats (Harley and Smith, 1983). Most agricultural soils are depleted of these beneficial fungi due to agricultural practices, the excessive use of fertilizers and pesticides; therefore, it is of extreme benefit to re-introduce these fungi in these soils to re-establish the belowground fungal activity. *Rhizophagus intraradices*, (formerly *Glomus intraradices*) in the family *Glomeraceae* (Schüßler and Walker, 2010), is the most common fungal species used in commercial inocula worldwide and applied in agriculture and restoration projects. ***R. intraradices* has shown through compelling research, originating from multiple, independent sources, that it is has unique characteristics which enable it to aggressively and efficiently colonize different host plants, adapt to different soil environments, and increase its efficiency in nutrient uptake.**

Different Host Colonization

An important characteristic enabling *R. intraradices* to form mycorrhizae is its capability to form symbiosis with plant roots more efficiently than other mycorrhizal species, and with countless, diverse plant species. In a particular study conducted by the National Institute of Agricultural Sciences (NIAS) in Havana, scientists evaluated AMF "efficiency" through the comparative assessment of seven different mycorrhizal strains. The seven AMF species used were*: G. spurcum, G. scrobiculata, G. occultum, G. clarum, G. mosseae, G. fasiculatum, and G. intraradices*. They analyzed the effects of inoculation on a diverse set of crops grown in the same soil, over a period of three years. The eight crops used were: potato, cassava, sweet potato, malanga, pepper, cucumber, tomato, and banana. Data was analyzed with particular emphasis in: percentage of root colonization, yield of crop colonized (plant response to colonization), and the plant's shoot weight and height. Based on significant and consistent data, the study concluded that regardless of the plant species, the same mycorrhizal strains had the best, consecutive performance in all evaluated crops, for all evaluated variables; particularly identifying *R. intraradices* as the most efficient species able to colonize all crops tested and producing the highest yields for all eight crops tested (Rivera and Fernandez, 2003). These studies confirm that not only is this particular species highly effective, it is also highly adaptive.

Soil Interactions

Soil conditions are able to influence productivity of AMF and are often dependent on pH levels. Tolerance and ability of plants to grow in acidic soils may be associated with AMF root colonization and its adaptability to low pH conditions (Koslowsky and Boerner, 1989). Soil type, associated with fertility, affects the behavior of different AMF strains (Rivera and Fernandez, 2003). A subsequent study published by NIAS in 2000, focused on 15 different types of AMF strains during three consecutive seasons, in three different soil types based on fertility (high, medium and low fertility). Rates of colonization were assessed using a single type of plant species: coffee seedlings. The study showed different AMF species performed better depending on the soil type they were inhabiting. Additionally, the mycorrhizae behavior, related to soil fertility conditions, singled out three AMF species *(G. manihotis, G. fasciculatum and G intraradices*) to successfully colonize plant roots in these three soil types, distinguishing them as highly infective. Among these prevalent species was *R. intraradices*, confirming its high adaptability in varying soil types (Sanchez et al., 2000).

Nutrient Uptake

AMF colonize plant roots and often enhance host plant growth and mineral nutrient acquisition, particularly for plants grown under infertile, mineral stressed and disturbed soil conditions (Abbott and Robson, 1991). *R. intraradices* has additional characteristics that increase its efficiency in nutrient uptake**.** *R. intraradices* has been shown to increase phosphorus uptake in multiple plants as well as improve soil aggregation due to hyphae network and glomalin secretion, as is characteristic of the *Glomales* family (Jansa et al. 2003, Morell et al. 2010). In this particular study conducted by the Swiss Federal Institute of Technology, the effect of an AMF, *G. intraradices*, was tested on the uptake of phosphorus (P) and zinc (Zn) by maize in specific types of experimental containers. These containers were compartmentalized to separate colonized AMF roots from AMF hyphae, see Figure 1. The results showed significantly improved uptake of both P and Zn by the maize plants inoculated by AMF than the non-mycorrhizal plants. The uptake of both P and Zn was significantly correlated with the mycelium length density. It was deduced that the exploration of soil zones not accessible to the roots can be assessed by a large mycelium network that can adapt to the spatial localization of nutrients explaining the high efficiency of this *G. intraradices* isolate to supply maize plants with P and Zn (Jansa et al. 2003).

In a similar study conducted by UC Davis, the distribution of nutrients in patchy soils with colonized AMF roots was observed to analyze their ability to uptake P in these adverse soil conditions. The relationship between *Linum usitatissimum* (flax seeds) and three AMF (*G. intraradices*, *G. mosseae* and *Gigaspora margarita*) was analyzed in pots with two side-arm compartments allowing for directional growth to separate lateral hyphae from roots extending downward, see Figure 2. Soil in one side-arm was either unamended or enriched with P; simultaneous labelling of this soil with a P isotope revealed that *G. intraradices* responded to P enrichment both in terms of hyphal proliferation and P uptake, whereas the other AMF did not. *R. intraradices* was found to be the only AMF that was able to control nutrient uptake amounts by individual hyphae depending on differing phosphorus levels in the surrounding soil. (Cavagnaro et al., 2005). It also revealed this characteristic may have important ecological consequences; for example, a plant colonized by an AMF, such as *R. intraradices*, might have a competitive advantage in a patchy environment over plants colonized by other AMF species (Cavagnaro et al., 2005).

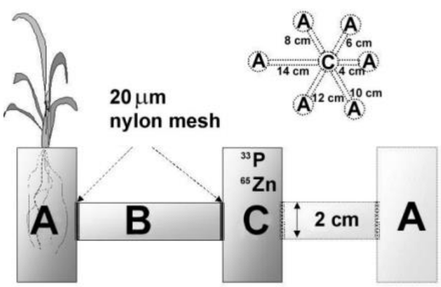

Figure 1. Starpot container design consisting of 3 compartments: (A)Root compartment where plant is grown, (B) a hyphal buffer compartment and (C) a hyphal labelled compartment where the radioactive tracers were added.

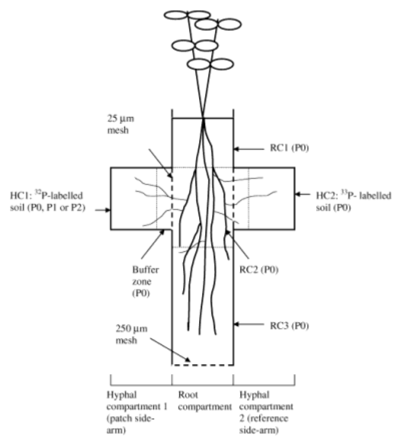

Figure 2. Schematic diagram of cross-pot with two side-arms. RC1+2+3 = root compartment; HC1 and HC2 = hyphal compartments; soil treatments: P0, P1, P2.

Through experimentation, accumulated data and research, Reforestation Technologies International (RTI) has confirmed the effectiveness of the *R. intraradices* strain. Numerous trials have been conducted on-site at RTI, with variable crops, in both indoor and outdoor settings. RTI has concluded ***R. intraradices*** **is a particularly infective and aggressive species that is highly adaptive and makes it one of the most efficient AMF species in biotechnology.**

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