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Interactions between plant species and mycorrhizal colonization on the bacterial community composition in the rhizosphere

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Abstract

This study assessed the effect of mycorrhizal colonization by *Glomus intraradices* (Gi) and *G. versiforme* (Gv) on the bacterial community composition in the rhizosphere of canola, clover and two tomato genotypes (wild type (76R) and its mutant with reduced mycorrhizal colonization (rmc)). Additionally, the effect of light intensity on the rhizosphere bacterial community composition of the tomato genotypes was studied. The bacterial community composition was assessed by denaturing gradient gel electrophoresis (DGGE). In canola, which is considered to be a non-mycorrhizal species, inoculation with Gi increased the shoot dw compared to Gv and the non-mycorrhizal control plants and also induced changes in the bacterial community composition in the rhizosphere. These fungal effects were observed although less than 8% of the root length of canola was colonized. On the other hand, about 50% of the root length of clover was colonized and inoculation with Gv resulted in a higher shoot dw compared to Gi or the control plants but the rhizosphere bacterial community composition was not affected by inoculation. Plant growth, mycorrhizal colonization and bacterial community composition of the two tomato genotypes were affected by a complex interaction between tomato genotype, AM fungal species and light intensity. Low light intensity (photosynthetic photon flux 200–250 μmol m^{-2} s^{-1}) increased the shoot–root ratio in both genotypes and reduced colonization in the wild type. The differences in bacterial community composition between the two genotypes were more pronounced at low than at high light intensity (550–650 μmol m^{-2} s^{-1}).

Keywords: AM fungi; Bacterial community composition; Canola; Clover; Light intensity; Rhizosphere; Tomato

1. Introduction

Rhizosphere microbial communities carry out fundamental processes that contribute to nutrient cycling, plant growth, and root health. The extent to which

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these communities vary in relation to various environmental factors is thus of considerable interest to microbial ecologists. Practical interests include the manipulation of microbial communities to promote plant-beneficial interactions involving hormone production, enhanced nutrient availability in nutrient-limited soils, and the suppression of root disease causing microorganisms. It is therefore important to understand how rhizosphere communities are influenced by environmental factors such as plant species, mycorrhizal colonisation and light intensity. Rhizosphere communities of different plant species growing in the same soil are often distinct (Ibekwe and Kennedy, 1998; Marschner et al., 2001b). Plants may even have very similar rhizosphere microbial community compositions in different soils (Grayston et al., 1998; Miethling et al., 2000). This emphasises the strong selective effect plant species have on rhizosphere microorganisms. Among rhizosphere microbial ecologists there is currently a consensus that differences in exudate amount and composition are likely to affect rhizosphere community composition because microbial species differ in their ability to metabolise and compete for different carbon sources.

A wide range of factors have been shown to affect root exudation, including plant genotype (Rovira, 1959; Rengel, 1997; Grayston et al., 1998), plant age (Martin, 1971; Van Veen et al., 1991; Marschner et al., 2002), nutritional status (Hoffland et al., 1989; Liljeroth et al., 1990; Fan et al., 2001) and colonisation by mycorrhizal fungi (Marschner et al., 1997; Po and Cumming, 1997). Mycorrhizal plants transfer more assimilates to the roots than non-mycorrhizal plants (Wang et al., 1989; Eissenstat et al., 1993), which may be explained by the carbon demand of the fungus for growth and respiration (Kucey and Paul, 1982; Fitter, 1991). Mycorrhizal colonization has been shown to change the number of aerobic bacteria in the rhizosphere (Meyer and Linderman, 1986; Posta et al., 1994) and affect bacterial growth rate (Christensen and Jakobsen, 1993; Marschner and Crowley, 1996). Mycorrhizal roots also differ in microbial community composition of the rhizosphere from non-mycorrhizal roots as some microbial groups are stimulated while others are suppressed (Amoralezcano et al., 1998; Belimov et al., 1999; Fillion et al., 1999; Vazquez et al., 2000). Moreover, some studies indicate that mycorrhizal fungal species differ in their effect on the bacterial community composition in the rhizosphere (Paulitz and Linderman, 1989; Krishnaraj and Sreenivasa, 1992; Timonen et al., 1998; Marschner et al., 2001a; Marschner and Baumann, 2003). The soil around the external mycelium (the hyphosphere) of mycorrhizal fungi represents another unique habitat and in ectomycorrhiza and different parts of the external mycelium differ in bacterial community composition (Nurmiaho-Lassila et al., 1997; Timonen et al., 1998). The effect of mycorrhizal colonisation on the bacterial community composition in the rhizosphere and hyphosphere (the soil surrounding the extraradical hyphae) may be explained by changes in root exudation (Graham et al., 1981; Dixon et al., 1989) and carbohydrate metabolism of the plant (Buwalda and Goh, 1982; Shachar-Hill et al., 1995). Furthermore, mycorrhizal fungi themselves may exude substances that have a selective effect on the microbial community.

Plants allocate less carbon to their roots under low light intensity (Ryle and Powell, 1976; Son and Smith, 1988) and root exudation is decreased (Cakmak et al., 1998). Additionally, root exudate composition can be altered (Rovira, 1959). The decreased carbon allocation to the roots under low light intensity is probably the cause for the observed decrease in mycorrhizal colonization (Daft and El Giahmi, 1978; Bethlenfalvay and Pacovsky, 1983) and root-derived CO_2 production (Chen et al., 2002) On the other hand, Kurtz et al. (2003) reported that the number of bacteria in the rhizosphere may be higher at low than at high light intensity and they suggested that this could be due to decreased longevity of the roots.

In the studies mentioned above, a single factor such as plant species, mycorrhizal colonization or light intensity has been studied in relation to plant growth, root exudation and microbial communities. It is, however, unclear how these factors interact. The aim of the present study was to study the interactions between four plant genotypes (canola, clover and two tomato genotypes) and two mycorrhizal fungi (*Glomus intraradices* and *Glomus versiforme*) on the bacterial community composition in the rhizosphere and hyphosphere. The effect of light intensity on these interactions was assessed in the two tomato genotypes.