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Plant carbon partitioning below ground in the presence of different neighboring species

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ABSTRACT

Knowledge about carbon allocation below ground is necessary to understand soil ecosystem functioning and the global C cycle. It is common knowledge that different plant species coexist in natural and agricultural systems. By using a modified ^{13}C pulse-chase approach, which enabled us to label individual plants in either mono- or mixed cultures, we investigated the effect of coexistence of different neighboring species on plant carbon partitioning. Maize and faba bean were used as our test plants and isotope pulse labeling was performed twice at 26 and 54 d after emergence. The results showed that a higher proportion of photoassimilates was distributed below ground in maize than in faba bean, resulting in a greater ratio of root to shoot biomass for maize plants during the experiment. The carbon distribution to roots was slightly higher in mixed cultures at 26 d than the counterpart monocultures. The distribution of the plant-assimilated ^{13}C to soil dissolved organic carbon was also greater in mixed cultures at 26 d relative to the monocultures. The most significant effect of the mixed culturing was a dramatic increase of ^{13}C incorporation into the soil microbial biomass. These results indicated that the plant carbon allocation below ground was altered in the presence of a different neighboring species. The increase of plant diversity probably enhances the soil microbial activity and hence the turnover of the plant-derived carbon in soil.

1. Introduction

It has been estimated that as much as 33% of global annual net primary productivity is used for the production of fine roots (Jackson et al., 1997) and a large proportion of plant photoassimilates transported below ground is quickly transformed to CO_2 and returned to the atmosphere (Kuzyakov and Domanski, 2000; Staddon et al., 2003; Leake et al., 2006). Thus, any subtle change in belowground allocation of plant carbon (C) may exert a great influence on global C cycle (Catovsky et al., 2002). The factors that influence plant C allocation include grazing, liming, CO_2 enrichment, fertilization, ozone, temperature and plant parameters (Cotrufo and Gorissen, 1997; Todorovic et al., 1999; McCrady and Anderse, 2000; Paterson and Sim, 2000; Staddon et al., 2003). In native ecosystems, different plant species naturally coexist together and interspecific competition is common. In order to compete with neighbors, plants usually apply a strategy of investing more C to functional organs such as roots and shoots for obtaining the limited resources (Grime et al., 1986; Callaway et al., 2003). Therefore, a feedback interaction occurs between plant diversity and belowground C allocation (Wardle et al., 2004). In recent years, a trend of accelerated loss of plant diversity appears in connection with the global climate change (Chapin et al., 2000; Thuiller et al., 2005). The loss of plant diversity may greatly affect the C allocation as well as the plant–soil feedback in the long term (Klironomos, 2002; Bartelt-Ryser et al., 2005; Ehrenfeld et al., 2005). However, most of previous studies on C allocation have been done in monoculture systems (Kuzyakov and Domanski, 2000), which hinder the extrapolation of plant C distribution in natural systems with different plant diversity.

Using a mass balance approach, Forrester et al. (2006) reported that the belowground C allocation in a mixture of *Eucalyptus globulus* and *Acacia mearnsii* was decreased compared with their monocultures. On the contrary, C exported from soil increased with the plant diversity in a grassland soil (Craine et al., 2001). These results suggest that the belowground C allocation changes with the change of plant diversity. Using ^{14}C-CO_2 pulse labeling, De Neergaard and Gorissen (2004) showed that the root-derived C used by microbes was greater in a mixture of ryegrass and clover than in monocultures. However, it was unclear how the individual plants contributed to this increase. Similarly, Warembourg et al. (2004) reported that plant C distributed to rhizosphere respiration and soil solution in a mixture of bromegrass and clover was greater than in monocultures. However, the response of soil microbes to the increased C flow was not measured.

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