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Nitrogen Transfer Is Enhanced By AMF Fungi In A Faba Bean/Wheat Intercropping

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Introduction

Intercropping is an agricultural practice that can offer several benefits allowing a better native resources use efficiency and, consequently, a restraint of the auxiliary inputs and often a greater production compared to the monocultures (Brooker et al. 2015). Several authors observed that, in a legume/non-legume mixture, one of the benefits could be the N transfer (up to 80 % of the non-legume N demand; Thilakarathna et al. 2016). The transfer may occur via different pathways: legume rhizodeposition, plant tissue decomposition and direct transfer through arbuscular mycorrhizal fungi (AMF) (Bedoussac et al. 2015). The latter, can simultaneously establish symbiotic relationship with different plant species creating a common mycorrhizal network, which serve as a preferential pathway for exchange among plants (He et al. 2003). However, contrasting results have been reported about the contribution of the AMF on N transfer; for instance, Li et al. (2009) showed that N transfer from mung bean to rice increased from 5.4% to 15.7% due to hyphal linkage, whereas Ikram et al. (1994) showed no significant differences with or without AMF inoculum. This experiment aimed to investigate the role of AMF on N transfer from faba bean to durum wheat grown in mixture, using the stem ^{15}N injecting method.

Materials and Methods

Durum wheat and faba bean in intercropping in presence (+MYC) or absence (–MYC) of AMF have been grown in pot in semi-protected conditions (natural temperature, light and air humidity but protected from atmospheric precipitations). Each treatment was replicated 5 times and the experiment was set up in a completely randomized design. Each pot (d=20 cm; h=50 cm) was filled with 14 kg of a substrate consisting of 30% agricultural perlite (1-2 mm diam.) and 70% of 2 mm sieved agricultural soil (486 g kg^{-1} sand, 247 g kg^{-1} silt, 267 g kg^{-1} clay; 10.8 g kg^{-1} organic matter, pH 8; 0.86 g kg^{-1} total N; 65 ppm P_2O_5; 135 ppm K_2O). The substrate was heat sterilized at 130 °C for 72 hours. Before the substrate sterilization, the natural soil microbial community except AMF was extracted (through filtration of a soil suspension with a 11 µm filter mesh) and added to all pots after sowing. The sowing was done on mid-January; the final density was 6 plants for wheat and 1 plant for faba bean per pot. At the sowing the AMF inoculum was applied in the +MYC treatment using a mix of 8 AMF species (equally present), at the density of 2000 spores pot^{-1}. Simultaneously, the original soil community extracted (excluded AMF) was added in all pots (320 ml of solution pot^{-1}). To evaluate the N-transfer from faba bean to wheat, the faba bean plants have been enriched with ^{15}N using the stem injection method (Chalk et al. 2002): NH_4NO_3 (enriched with 98 atom % of ^{15}N) was directly injected in the faba bean stem in 3 equal applications (55, 66 and 73 DAE) of 200 µl each at the concentration of 115 mM, for a total of 1.925 mg N/pot^{-1}. During the experiment, the soil moisture was continuously maintained above 70% of the holding capacity. At wheat flowering (85 DAE), the aboveground biomass was harvested, oven dried, and ^{15}N content was determined using a Roboprep-CN and 20-20 isotope ratio mass spectrometer. A root sample was stained using the method described by Phillips and Hayman (1970) and the percentage of AMF root colonization (Giovannetti and Mosse, 1980) was determined. The ^{15}N content was used to quantify the N transfer through the direct labelling plant method (Ledgard et al. 1985).

Results

In the inoculated pots (+MYC) the AMF root colonization was 30.3% in durum wheat and 64.4% in faba bean, whereas in –MYC pots root colonization of both species was always lower than 5%. Nitrogen transfer from faba bean to wheat was detected both with and without AMF inoculum. The presence of AMF significantly

increased the percentage of faba bean N transferred to the cereal as well as the %N in the wheat directly derived from faba bean (Fig. 1A and 1B). The amount of N transferred from legume to the non-legume was 2.46 and 2.94 mg pot^{-1} in –MYC and +MYC, respectively (P<0.1; Fig. 1C).

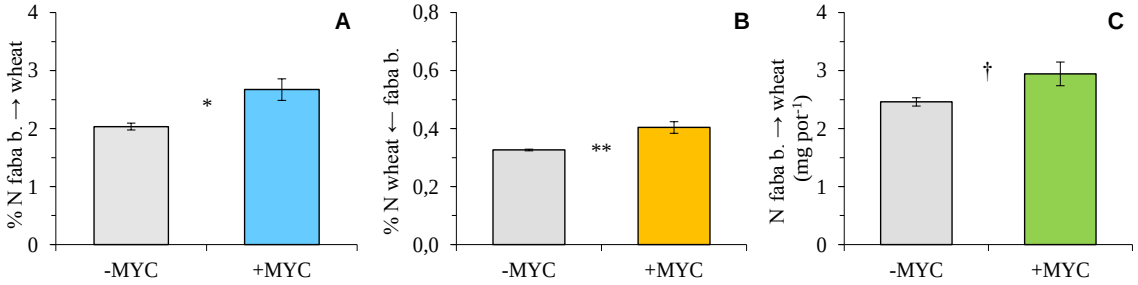

Fig. 1. A) Percentage of N transferred from faba bean to wheat; B) percentage of wheat N derived from the faba bean; and C) amount of N transferred from faba bean to wheat in absence (–MYC) or presence (+MYC) of AMF. †, *, ** P value < 0.1, 0.05, 0.01 respectively.

Conclusions

Results highlighted, thanks also to the method used (^{15}N labelling via stem injection) particularly sensitive and yield-independent (Ledgard et al. 1985), the occurrence of N transfer from faba bean to wheat even if the magnitude of N transferred was relatively low. The short growing period (85 days) and the relatively short time from labelling to harvest may have contributed to the low values of N transfer. Inoculation with AMF increased by 20% the amount of N transferred from faba bean to wheat. This effect can be ascribed to the roots linked by common mycorrhizal networks between the intercropped species, facilitating the N movement from the legume to the associated non-legume crop. Furthermore, AMF can favor the non-legume intercropped species by improving the acquisition of N released by root exudates and mineralization of legume nodules and fine root. In addition, AMF could also have contributed to N transfer indirectly by stimulating the activity of soil bacteria involved in the mineralization processes of plant tissues and nodules. Overall, this experiment confirms that AM symbiosis can have an important ecological role since it can positively drive the biological interactions among neighboring plants by promoting nutrient exchanges and thus limiting competition among plants for the available resources. A deeper comprehension of the importance of each pathway involved in the AMF mediated N transfer is essential to accurately defining management strategies of the soil-plant system to improve this important ecological process. This will require new and creative research approaches.

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