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Root dynamics and soil-enzyme activities in field bean/barley intercrops

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The study and design of cropping systems that better exploit ecological processes is a priority of the scientific community and intercrops, involving two or more crop species growing simultaneously on the same field, are considered valuable to increase the productivity of traditional family farming and for the sustainable intensification of industrial agriculture.

Advantages of intercrops are based on ecological principles such as diversity, complementarity, facilitation and replacement, which are enhanced in cereal/legume associations because of the differences in the morphology and distribution of the root systems and in the use of different N sources. Understanding the complexity of plant-plant and plant-soil interactions is crucial because beneficial complementarity and facilitation relationships can rapidly turn into negative competition.

The field experiment consisted of a barley (Hordeum vulgare L. subsp. polystichum, var. Jallon) field bean (Vicia faba minor Beck, var. Vesuvio) intercrop (IC) and the respective sole crops (SC) grown at low (0 kg ha^{-1}) and high (120 kg N ha^{-1} and 100 kg P ha^{-1}) fertilizer inputs. Seed density was100 seeds m^{-2} for Fb, 250 seeds m^{-2} for B, and 100:125 seeds m^{-2} in the Fb:B IC, where plants were arranged in a 1:1 row ratio spaced 15 cm. At barley heading, soil and root samples were collected from the 0-20 cm soil profile and roots were cleaned from the soil with a water flow and then separated by species. Root morphological traits such as length, diameter, surface area and volume were analysed with WinRhizo, then samples were oven dried. On soil samples dehydrogenase, ß-glucosidase, alkaline phosphatase and arylsulphatase activities were determined, and the geometric mean (GMea) of the assayed soil enzyme activities was calculated.

Root density of IC was intermediate between Fb and B SC, the former displaying the highest density on dw basis, the latter on length basis. In both SCs root density was higher without fertilizer input, demonstrating a higher investment in roots in response to NP limitation. In contrast, fertiliser input increased root density in the IC, which we interpreted as a competitive root growth stimulated by the higher nutrient availability in soil.

The specific root length (SRL, m/g) increased in Fb SC in response to NP supply, demonstrating an energy investment in root elongation instead in feeding N_2-fixing bacteria when mineral N was available, which is confirmed by the lower nodule density. The opposite occurred in the B SC,

where SRL was reduced by mineral supply. In the IC, NP input increased the SRL of both species, demonstrating strong interspecific competition for nutrient acquisition and not complementarity, as it is generally supposed for cereal/legume intercrops. As a result of the higher investment of resources in root elongation, in Fb, nodule density decreased dramatically. In the fertilized IC soil also the GMea was higher, suggesting a major production of exudates from roots.