New insights in below ground nitrogen of clover-grass mixtures

Andreas Hammelehle[a, b], A. Oberson[c], A. Lüscher[d], P. Mäder[e] and J. Mayer[a]

[a] *Agroscope, Agroecology and Environment, Zurich, Switzerland*
[b] *Landesbetrieb Landwirtschaft Hessen, Germany*
[c] *Institute of Agricultural Sciences, ETH Zurich, Switzerland*
[d] *Agroscope, Animal Production Systems and Animal Health, Zurich, Switzerland*
[e] *Research Institute of Organic Agriculture (FiBL), Frick, Switzerland*

Estimates of symbiotic nitrogen fixation (SNF) of clover in mixtures usually consider only aboveground clover nitrogen (N). However, belowground inputs of clover N derived from SNF via roots and rhizodeposition and its transfer to associated grass may contribute significantly to the amount of symbiotically fixed clover N. A microplot study with a red clover (L.)-perennial ryegrass (L.) model mixture was conducted within zero fertilised, bio-organic and conventional field plots of the DOK (bio-Dynamic, bio-Organic, Konventionell) long-term experiment during two consecutive years. The DOK experiment has been performed since 1978 in Therwil near Basel (CH). Examined cropping systems were fertilised at the typical level according to the respective regulations and, in addition, at the half level (bio-organic). Fertilisation strategies resulted in a gradient of mineral N input increasing from the zero fertilised control (0 g m^{-2} a^{-1}) to the bio-organic cropping system at half dose (2 g m^{-2} a^{-1}), at full dose (4 g m^{-2} a^{-1}) and to the conventional cropping system (12 g m^{-2} a^{-1}). Clover was multiple ^{15}N urea leaf labelled during two cultivation years. Symbiotic N_2 fixation and the fate of symbiotically fixed N in the soil plant system were examined using a combination of ^{15}N enrichment and natural abundance approaches. Results of the microplot study were scaled up using yield data compiled from field plots of the DOK experiment. The ratio of red clover belowground N to aboveground N was constantly 0.4 to 1 irrespective of the cropping system and the time of cultivation. Forty percent of perennial ryegrass N were transferred from red clover in zero and low N (< 5 g m^{-2} a^{-1}) fertilised cropping systems. Total SFN over the two years period was on average 37 g m^{-2}, with a contribution of 90% to red clover N (conventional system > 80%). On average 19 g m^{-2} clover N and 29 g m^{-2} grass N were harvested during the 2 years of cultivation. At the end of the second year, about 5 % of total SNF were stored in clover roots. During the two years, 50% of total SNF was deposited into the soil and further distributed to soil organic matter pools, microbial and soluble N (15% of total SNF) and to the grass partner (35% of total SNF). At the end of the two years, a residual N potential of SNF of 10 g m^{-2} remained in the field. Residual N consisted of N in clover roots (5% of total SNF), clover stubbles (1% of total SNF), grass stubble and roots (8% of total SNF) and soil N pools (15% of total SNF). Thus, a realistic estimation of SNF of red clover in mixtures should take into account belowground N pools and N transfer.