**Carbon and nitrogen services from cover crops are optimized by including legumes in mixtures**

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Cover crops are cultivated during unproductive periods to provide ecosystem services, such as preventing nitrogen (N) leaching, and have the potential to increase soil organic carbon (C), thus contributing to climate change mitigation. Their effect on soil C storage depends on C input, which is challenging to quantify due to belowground sampling (roots and C deposited in the soil). Leguminous cover crops (in pure stands or in mixtures) increase the productivity of following main crops due to high N input, but also the risk of N losses, compromising the mitigation effect. As C and N services vary with cover crop type, tradeoffs could be minimized by species selection. The aim of this study was to assess C input from different cover crop species and mixtures, as well as N uptake in their biomass, and their effect on soil mineral N (SMN) and yield of the following crop.

We conducted a field experiment in 2020-2021 at Foulum, Denmark (temperate oceanic climate, sandy loam soil), with seven treatments (five cover crops, control with volunteers, and bare soil) replicated four times. Cover crops undersown in spring barley (*Hordeum vulgare* L.) in May 2020 were: *Lolium perenne* L. (ryegrass, RG), *Trifolium pratense* L. (red clover, RC), *Plantago lanceolata* L. (plantain, PL) and the mixtures RG-PL and RG-PL-RC. On August 24, 2020, after barley harvest, PVC cylinders (diameter: 29.5 cm, height: 30 cm) were inserted in each plot (25 cm depth) and used for 13C-CO2 multiple-pulse isotopic labeling. Two sessions per week were conducted until cover crop sampling in November 2020, when C and N in above- and belowground biomass, as well C deposited in the soil were determined. Monthly soil sampling (20 cm depth) was performed from August 2020 until April 2021 to assess SMN. Then barley was sown to evaluate cover crops residual effect.

Aboveground biomass was lowest in RG (1.5 Mg ha-1), and highest in RG-PL-RC (5.4 Mg ha-1). Total C input (above- and belowground) ranged from 1.6 to 4.3 Mg ha-1, with RG-PL-RC (highest) being significantly higher than RG-PL and RG (lowest). The same pattern applied to total N input, ranging from 74 to 202 kg ha-1. All cover crop treatments had lower SMN than bare soil and volunteers in August 2020. SMN increased from August until April 2021 with all cover crops except RG, and decreased with bare soil and volunteers. SMN in April was 15 kg ha-1 higher with RC and RG-PL-RC than RG. Barley yield following leguminous cover crops was comparable to plots fertilized with 100 kg ha-1 of mineral N, while non-legumes to 40 kg ha-1. Overall, the mixture with RC provided the greatest C input and positive residual effect. The small change in SMN in April indicate that biomass N was converted into mineral N and taken up by barley during the growing season, thus not increasing the risk of N losses.