**Soil P and K availability defines below-ground biomass allocation of grass-legume leys**

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**Abstract**

Exploring the response of above- and below-ground biomass allocation to soil nutrient availability is crucial to reliably estimating root carbon (C) input and predicting long-term soil C dynamics. Despite this, belowground C input is often estimated by using yield-based allometric equations without considering the impacts of environmental factors or management practices such as fertiliser levels, which could lead to erroneous and uncertain estimates.

Based on a 120-year-old fertiliser experiment (Askov LTE) varying in four nutrient levels (deficient, sub-optimal, optimal and over-optimal) and two nutrient sources (animal manure and mineral fertiliser), we examined the effects of nutrient level and source on herbage yield and composition, root biomass and root-to-shoot (R/S) ratio of unfertilised grass-legume multi-species leys.

Results showed that R/S ratio decreased linearly at low level (from deficient to optimal) of plant-available phosphorus (P) and potassium (K), but remained constant at high level (from optimal to over-optimal). The threshold values were 9 mg Olsen-P kg-1 soil and 49 mg acetate-extracted K kg-1 soil, respectively. Nutrient source (organic vs. inorganic) had no influence on root biomass and R/S ratio, although it differentially affected herbage yield of grass and legume species. R/S ratio linearly decreased with herbage yield, but did not respond to changes in grass or legume proportion of plant community.

We conclude that above- and below-ground biomass allocation in temperate grassland leys is mainly determined by nutrient level and plant community productivity. These findings provide a benchmark for reliably estimating root C inputs to soil in temperate grassland leys.