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Plant diversity effects on root decomposition in grasslands

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Loss of plant diversity impairs ecosystem functioning. Compared to other well-studied processes, we know little about whether and how plant diversity affects root decomposition, which is limiting our knowledge on biodiversity-carbon cycling relationships in the soil. Plant diversity potentially affects root decomposition via two non-exclusive mechanisms: by providing roots of different substrate quality and/or by altering the soil decomposition environment. To disentangle these two mechanisms, three decomposition experiments using a litter-bag approach were conducted on experimental grassland plots differing in plant species richness, functional group richness and functional group composition (e.g. presence/absence of grasses, legumes, small herbs and tall herbs, the Jena Experiment). We studied: 1) root substrate quality effects by decomposing roots collected from the different experimental plant communities in one common plot; 2) soil decomposition environment effects by decomposing standard roots in all experimental plots; and 3) the overall plant diversity effects by decomposing community roots in their 'home' plots. Litter bags were installed in April 2014 and retrieved after 1, 2 and 4 months to determine the mass loss.

We found that mass loss decreased with increasing plant species richness, but not with functional group richness in the three experiments. However, functional group presence significantly affected mass loss with primarily negative effects of the presence of grasses and positive effects of the presence of legumes and small herbs. Our results thus provide clear evidence that species richness has a strong negative effect on root decomposition via effects on both root substrate quality and soil decomposition environment. This negative plant diversity-root decomposition relationship may partly account for the positive effect of plant diversity on soil C stocks by reducing C loss in addition to increasing primary root productivity.

However, to fully understand the negative diversity-root decomposition relationship we additionally aim to unravel the true predictors of the diversity effect. We use morphological and chemical traits of community bulk roots to specify the root substrate quality effect. We use soil physical and chemical conditions as well as diversity and abundance of soil decomposers to describe the effect of the soil decomposition environment. Moreover, plant diversity is included as species richness, functional group richness and measures of functional diversity calculated with a large set of traits for all 60 species of the Jena Experiment. Using structural equation modeling (SEM) we integrate all this information to assess the individual pathways controlling the negative diversity-root decomposition relationship to promote our mechanistic understanding of increased soil C accumulation in more diverse grassland plant communities.