

Lignin turnover in the plant-soil continuum: plant organ composition and isotopic differences

Abiven Samuel, Heim Alexander & Schmidt Michael W.I.

Soil Science and Biogeography Group, Department of Geography, University of Zurich, Switzerland

Lignin residues are considered an important contributor to the old and slowly degradable soil organic matter. The turnover of this compound in the soil can be estimated from field studies where C4 plants replaced C3 plants or vice-versa. The natural stable isotopic difference between biomass synthesized by these two photosynthetic pathways has allowed the calculation of the average residence time of the intact lignin monomers in soil. In these calculations, organic input from plants is usually considered to be homogeneous. However, the microbial degradation of plant parts could vary in intensity and in dynamics, i.e. the roots would decompose slower and less than the above-ground plant parts (Abiven et al., 2005). The present study aims to link the composition of individual lignin monomers and their isotopic signature in the roots, stems and leaves to the turnover of lignin monomers in the soil. Soils and plants (wheat and maize) were sampled on a field experimentation site (Rotthalmünster, Germany), where crops replaced C3-grassland plants 23 years ago. Lignin composition was determined using the CuO oxidation method and quantification by GC-FID. For the last sampling date representing the growth stage just before harvest, ¹³C signature of individual monomers was determined with GC-IRMS, as proposed by Dignac et al. (2005) and Heim & Schmidt (2006).

Results show that the plant organs do not only differ in their final lignin concentration at harvest but that they also differ in their pattern of lignin build-up during plant growth. In leaves, lignin concentrations increase regularly, while in stems, a significant increase in lignin concentrations is only observed during the last two months (figure 1). This is in accordance with the mechanisms of lignin deposition in the cell walls. The difference between the phenols type is mainly developing during the last part of the growth. This suggests that this last part of the growth period is mainly responsible for the quality and quantity of lignin monomers.

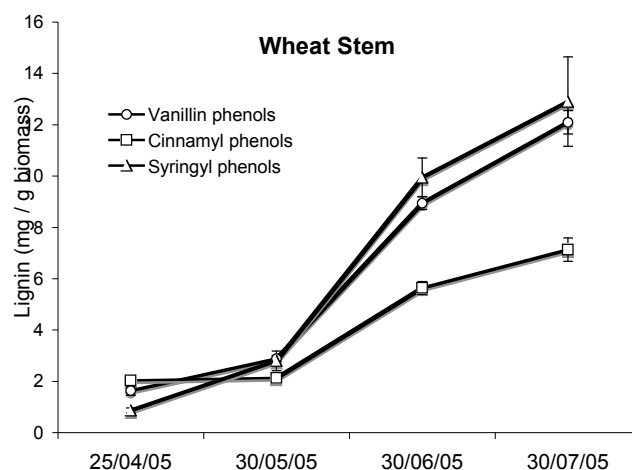


Figure 1: Evolution of lignin concentration during wheat stem growth

At the last sampling date, the lignin concentration is higher in the roots than in stems or leaves, and higher in maize than in wheat (figure 2). The distribution of the individual monomers in the plant seems to be related to the plant species: higher cinnamyl phenols in the maize and higher syringyl phenols in the wheat. This confirms preliminary results obtained on the same site and for another year of growth for wheat straw and maize stems and roots (Heim, unpublished), but are not completely in accordance with results from another site (Dignac et al., 2005).

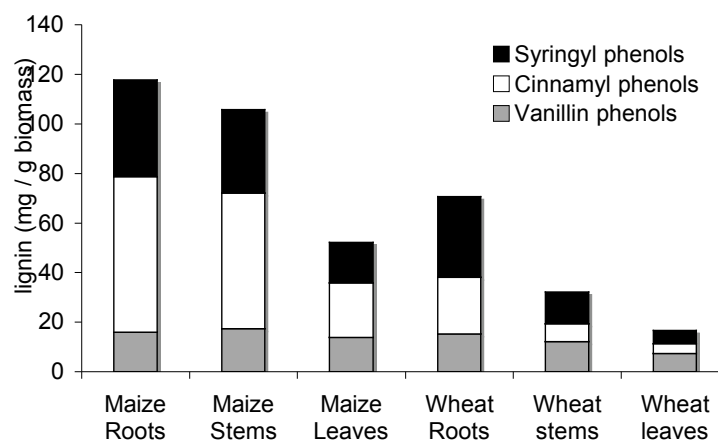


Figure 2: Lignin content in plants parts at the final date of sampling

At this last date of sampling, the $\delta^{13}\text{C}$ of the lignin monomers is slightly more negative for leaves than for stems and roots, respectively. This might indicate either differences in the biochemical pathway of lignin formation in different plant organs, or more likely, discrimination during transport of the lignin precursors within the plant. Further data will, however, be necessary to support this preliminary observation. The prospective developments will be to compare these plant data and the lignin monomers concentrations in the soil.

REFERENCES

- Abiven, S., Recous, S., Reyes, V. & Oliver, R. (2005): Mineralisation of C and N from root, stem and leaf residues in soil and role of their biochemical quality. *Biology and fertility of soils* 42 (2): 119-128.
- Dignac, M.-F., Bahri, H., Rumpel, C., Rasse, D.P., Bardoux, G., Balesdent, J., Girardin, C., Chenu, C., Mariotti, A. (2005): Carbon-13 natural abundance as a tool to study the dynamics of lignin monomers in soil: an appraisal at the Closeaux experimental field (France). *Geoderma* 128: 3-17.
- Heim, A., Schmidt, M.W.I. (2006): Lignin turnover in arable soil and grassland analysed with two different labelling approaches. *European Journal of soil science*. doi:10.1111/j.1365-2389.2006.00848.x