Lignin degradation in arable soils: a 15-year time series

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Our objective is to estimate the impact of soil texture and organic matter input on lignin decomposition in arable soils. Lignin is a major cell wall component of vascular plants and, via plant litter, a contributor to soil organic matter. To track the decomposition of lignin in soil over time we used compound specific isotope analysis and soil samples from 15 years of continuous maize cultivation on former C3 soils (experiment initiated by Bent Christensen, described in Kristiansen et al. 2005).

Lignin monomers, as biomarkers of the complex biopolymer lignin, were extracted from soil by CuO oxidation (Goñi & Montgomery 2000). Subsequent GC-FID (gas chromatography-flame ionization detector) measurements yielded quantities of lignin monomers in soil. GC-C-IRMS (gas chromatography-combustion-isotope ratio mass spectrometry) analyses provided $\partial^{13}C$ values of the lignin monomers. These results allow calculating the proportion of C3- and C4-plant-derived lignin in the sample. Thus, the degradation of the C3-derived lignin can be monitored in the presence of new C4-lignin input. In our study we examined two factors on lignin degradation: (i) soil texture (sandy loam, sand) and (ii) harvest residue incorporation (input of 0.8 kg dry matter of chopped maize shoots m^{-2} or no input).

Sandy loam soil and sand soil gave similar trends of slow lignin degradation (Figure 1): About 2/3 of lignin seemed to be protected from degradation for at least 15 years, supporting the calculated turnover times of 10 to 40 years from a previous study (Heim & Schmidt 2006). Harvest residue management practices did not result in significantly different patterns of lignin degradation. However, there was a trend of less degradation when soil was amended with harvest residues (Figure 1). This was especially noticed in sandy soil and could be due to improved aggregation. Lignin decomposition most likely followed biexponential kinetics for both textures with the no-input treatment, suggesting a fast and a slowly degrading lignin pool. With harvest residue input the kinetics are not as clear yet, additional samples will be analyzed.

The results suggest that soil texture or harvest residue management practices as individual factors have no significant direct influence on lignin degradation. Instead, the results point to a more complex system, where protection mechanisms, e.g. stabilization in soil aggregates, play a major role. Upcoming steps in the project will therefore include examination of possible sites for lignin protection in soil.

REFERENCES

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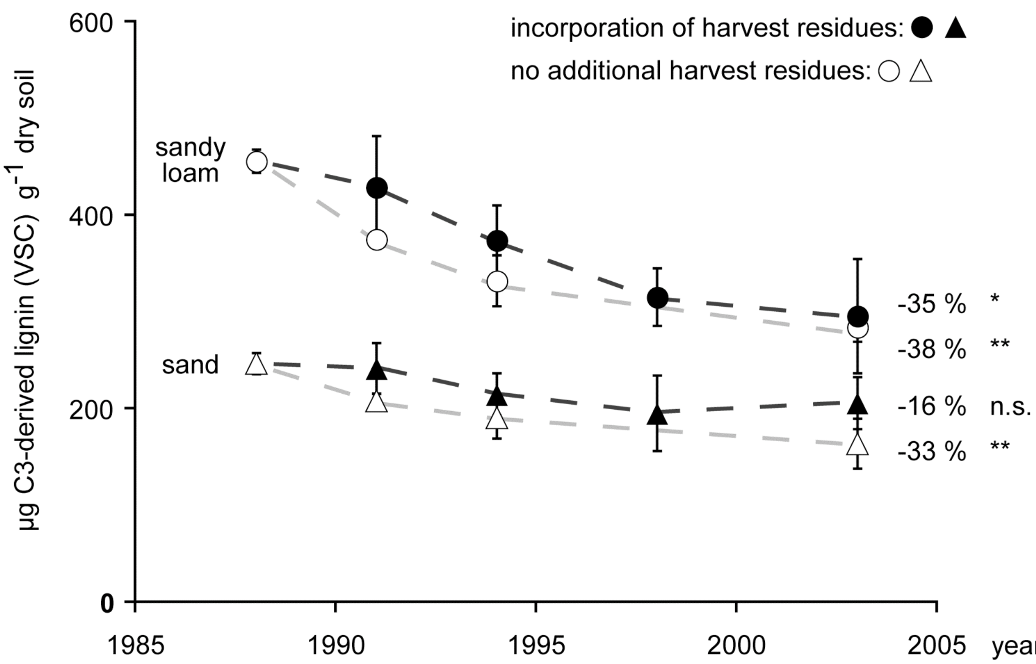

Figure 1. The graphs show the decrease of C3-plant derived lignin over 15 years for two differently textured soils (sandy loam: circle symbols and sand: triangle symbols) treated with two harvest residue management practices (incorporation of 0.8 kg dry matter of chopped maize shoots m^{-2}: black symbols or no additional input: white symbols). Decrease of initial C3-lignin is given in % (m/m). Differences between initial (1988) and end (2003) values: * significant ($p<0.05$), ** very significant ($p<0.01$), n.s. not significant ($p>0.05$), p probability of error.