Importance of Heterocyclic Nitrogen (N) Containing Compounds for the N Cycling in Soil and N Plant Nutrition

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Introduction

Heterocyclic nitrogen (N) compounds form a significant organic N pool in soils but its fate is completely unknown. One reason for this gap in knowledge is the difficulty in the identification and quantification of these compounds in complex environmental matrices. Synchrotron-based X-ray absorption near-edge spectroscopy (XANES) at the nitrogen (N) *K*-edge was found as useful tool for the unequivocal detection of heterocyclic N in soils [1], and first attempts to develop quantitative evaluation methods of N-XANES spectra have been made (see previous article).

Science

Our long-term objective is to disclose the fate of heterocyclic N in the soil-plant system. Recent investigations were aimed at answering two questions:

1. To what extent is the heterocyclic N pool affected by soil management?

2. Can this pool be utilized by soil microorganisms?

Materials and Methods

We investigated pairs of soil samples from long-term experiments that were (1) N-depleted due to a history of long-term pasture management or cropping without sufficient N-supply; and (2) N-enriched with either native vegetation or cropping with sufficient N-supply by fertilizer and manure. Furthermore, we spiked some of these samples with reference compounds for important heterocyclic N-functions in soil and traced the microbial utilization of the added heterocyclic N. All samples to be compared were investigated by pyrolysis-field ionization mass spectrometry (Py-FIMS) and by N-XANES. The XANES spectra were recorded on the 11ID-1 Spherical Grating Monochromator beamline. Interpretations of spectra were based on measurements of reference compounds [1].

Discussion

Sample pairs from N-depleted and N-enriched soils showed rather similar features (peak a). Relative enrichments were observed for heterocyclic and nitrile-N [(Lethbridge, cultivated, peak b), less pronounced at Bad Lauchstädt] at the expense of amino- and amide N [(peak c), reduced in cultivated and unfertilized] (Figure 1). Heter-ocyclic N in pyrroles (peak d) was also abundant and slightly enriched in N-depleted soils. This was also found for other similarly managed soils. The first experiments with spiked and incubated samples revealed that added heterocyclic N was used by soil microbes as reflected by reductions in the corresponding N-XANES peaks and confirmed by Py-FIMS.

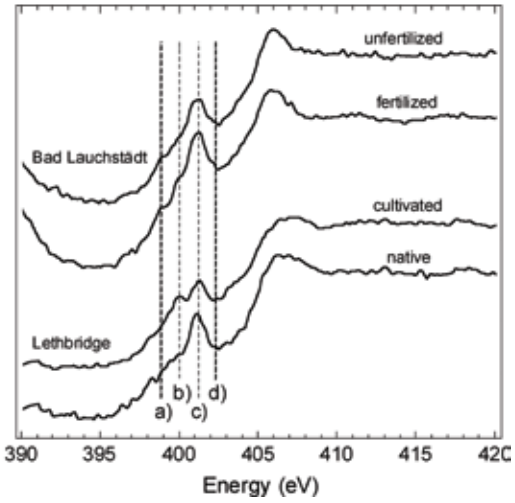

Figure 1. N *K*-edge XANES of long-term differently managed soils.

Conclusion

The present N-XANES data indicate that heterocyclic N is relatively enriched in soils that have lost native labile N-compounds. Therefore, microbial transformations of heterocyclic N may be significant for plant nutrition in modern agricultural systems.

References

1. Leinweber, P., Kruse, J., Walley, F.L., Gillespie, A., Blyth, R.I.R., Regier. T. 2007. N K-edge XANES – An overview of reference compounds used to identify 'unknown' organic nitrogen in environmental samples. Journal of Synchrotron Radiation. 14, 500-511.

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