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Magnesium isotope signatures in long-term liming field in Germany

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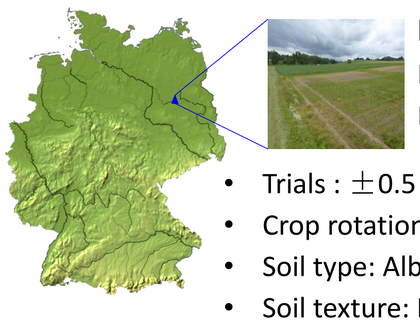
Introduction

Magnesium (Mg) is one of macro essential elements for most plants and of great importance to biological functions. Isotope fractionations in $^{26}Mg/^{24}Mg$ have been observed during biological processes, such as nutrient uptake and translocation in plants. Liming management could alleviate soil acidity and improve soil fertilities. Investigation of Mg isotopic compositions may provide an innovative tool to help estimate the effect of liming management on elemental Mg cycle in soil-plant systems.

Long-term field site



Dahlem

Long-term field experiment (established since 1923) in Berlin-Dahlem

- Trials : ±0.5 t $CaCO_3$ $ha^{-1}a^{-1}$; + 20 kg P $ha^{-1}a^{-1}$; +15 t manure $ha^{-1}a^{-1}$
- Crop rotation: winter wheat, potato
- Soil type: Albic Luvisol.
- Soil texture: Loamy sand (clay content: 3-8%)

Materials & Methods

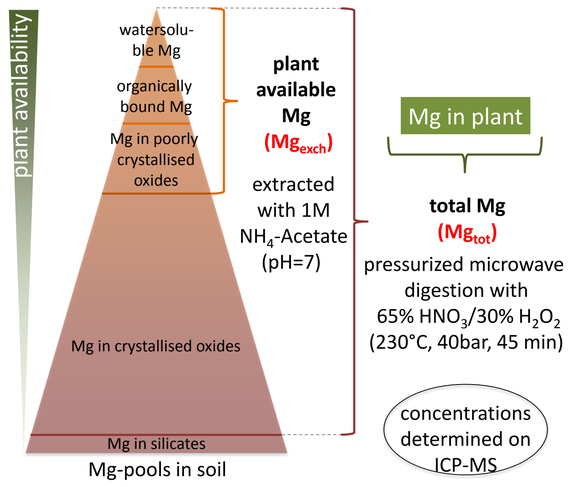
Field sampling → Sample preparation → Extraction/Digestion → Chromatography → Isotope ratio determination

Soil cores of 1 m depth (taken with a COBRA drill) were cut into minimum 4 layers (0-30 cm, 30-50 cm, 50-70 cm and 70-100 cm). If necessary additional cuts according to soil horizonation were done.

Plants were sampled with roots and separated into roots, stem, leaves and spike.

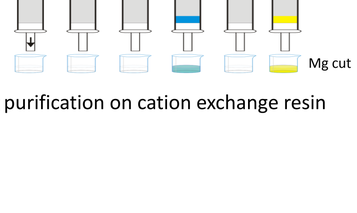
Soil samples were freeze-dried, ground if necessary and sieved to 2 mm.

Plants organs were freeze-dried and milled in PP-bottles with WC-balls.



Mg-pools in soil

Sample dry-down → Re-dissolved in 1M HNO_3 or 0.4M HCl



Mg purification on cation exchange resin

Multicollector ICP-MS (Nu Plasma II)

Mg isotopic compostions are expressed in **δ**-notion with reference to standard Dead Sea Magnesium (DSM3) using sample-standard bracketing method following:

$$\delta^{x}Mg_{sample} = 10^{3} \times \left\{ \frac{(^{x}Mg/^{24}Mg)_{sample}}{\frac{(^{x}Mg/^{24}Mg)_{standard_1} + (^{x}Mg/^{24}Mg)_{standard_{+1}}}{2}} - 1 \right\}$$

where x represents 25 or 26. The unit is permil.

Results

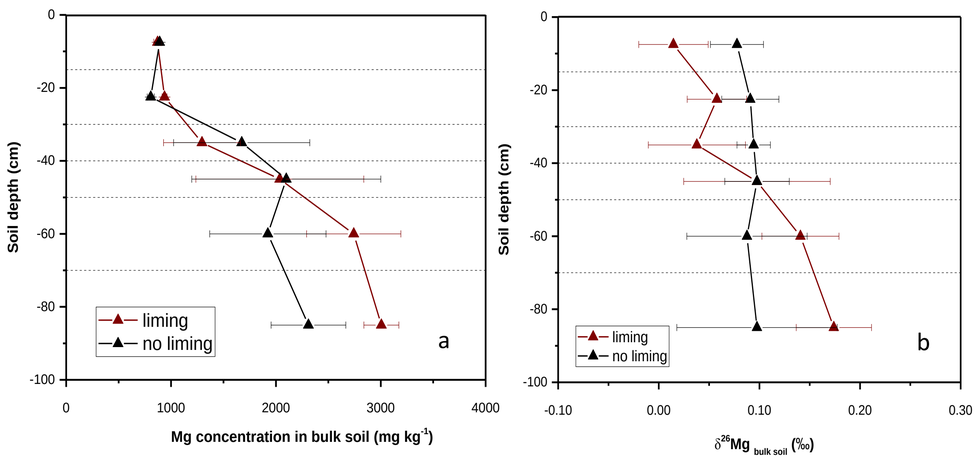


Fig. 1. Mg concentration (a) and isotopic compositions (b) in bulk soil along with the soil profile

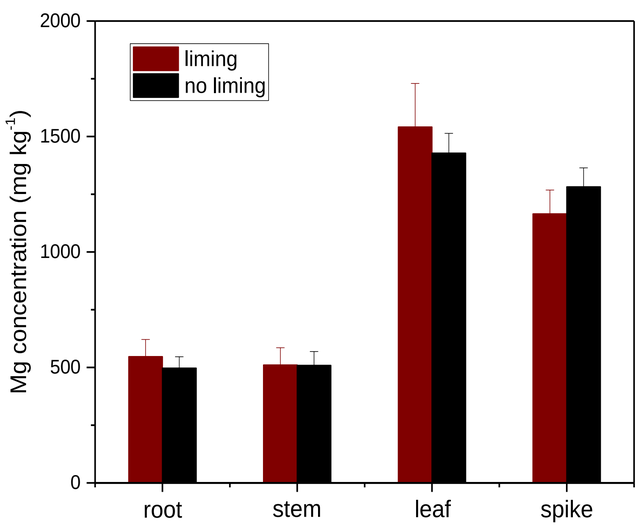


Fig. 2. Comparisons of Mg concentration in each crop tissue in liming and no-liming field

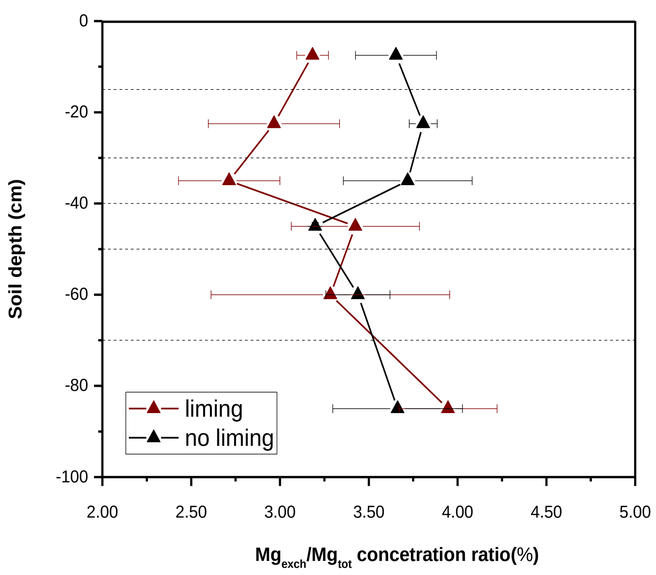


Fig. 3. Mg_{exch}/Mg_{bulk} concentration ratio with soil profile in liming and no-liming fields

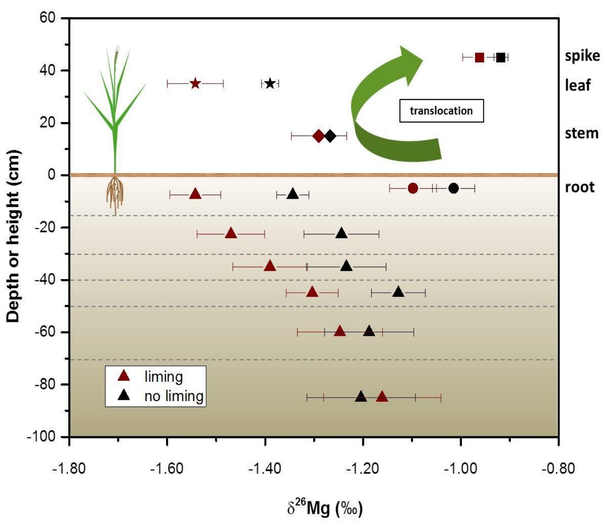


Fig. 4. Variation of Mg isotopic ratios in soil exchangeable pool with depth and during internal translocation from roots to shoots.

- Mg concentrations in bulk soil increased with depth while $\delta^{26}Mg$ values kept unchanged around 0.10 in *Albic Luvisol*.
- No significant variance of Mg concentration in crop tissues was found between field trials.
- Mg_{exch}/Mg_{bulk} concentration ratios, as well as the exchangeable pool $^{26}Mg/^{24}Mg$ isotopic ratios, in liming field were lower than that in no-liming field in soil down to 50cm depth.
- Liming enhanced depletion of ^{26}Mg from soil by roots with $\Delta^{26}Mg_{root\text{-}soil}$ from 0.33 to 0.48 ‰ in top soil.
- Internal plant translocation induced Mg isotope fractionation by enriching heavier Mg in spikes.

Conclusions

- Mg concentration and isotope composition in bulk soil is mainly affected by the soil pedogenesis with $\delta^{26}Mg$ in *Albic Luvisol* ranging from 0.01 to 0.17.
- Liming could enhance nutrient uptake in the soil down to 50 cm related to root density.
- Soil-root interface transport and plant internal translocation could induce Mg isotope fractionation with heavier Mg preferentially absorbed and transferred to productive tissues.

Acknowledgement

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