A new fertilizer: a mineral to release and adsorb nitrate

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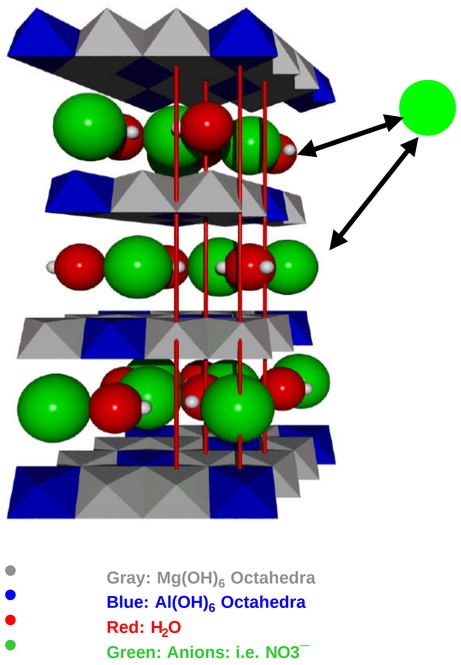
Objective

Development of a new fertilizer, which is able to regulate the nitrate concentration in the soil solution, i.e.

- ➢ to release nitrate according to plant demand, and
- ➢ to adsorb nitrate in times with no plant uptake (e.g. after harvest) to prevent leaching

Layered double hydroxide (LDH): a mineral with anion exchange capacity

Structure model
(Rennemann, 1997)



Layered Double Hydroxides (LDHs) have a positive charge due to substitution of 2 valent (e.g. Mg^{2+}) against 3 valent (e.g. Al^{3+}) cations.

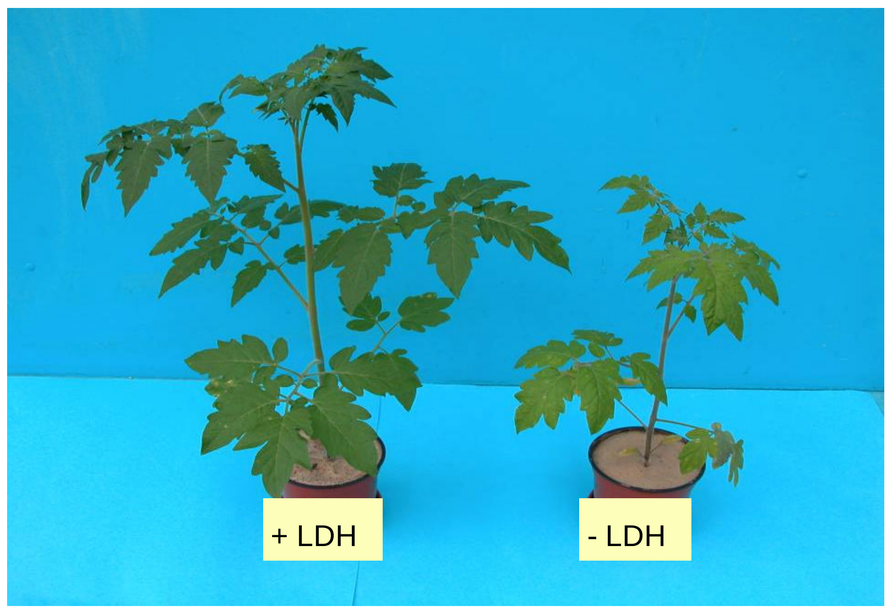
Anions (e.g. NO_3^-) can be adsorbed to the surfaces and into the interlayers, thereby compensating this surplus charge.

The exchange capacity is in the same range as the cation exchange capacity of clay minerals.

Mineral	Exchange capacity [mval/100 g]
Illite	10 - 40
Kaolinite	5 - 100
Montmorillonite	80 - 150
Vermiculite	100 - 200
LDH	**180 - 200**

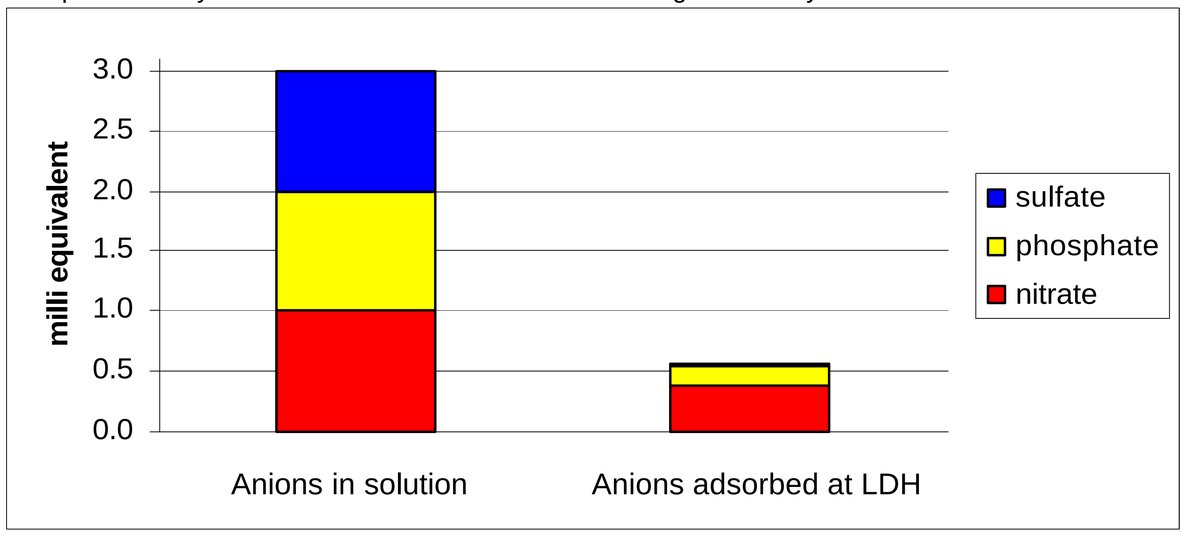
Soil applied LDH is able to adsorb nitrate and ensure plant N availabilty

In a pot trial tomatoes were grown on a sandy soil with and without LDH. Nitrate was applied at a rate sufficient for optimal growth. Thereafter a heavy rainfall was simulated. Due to leaching N availability was clearly below the plant demand in the non-LDH-treated soil .



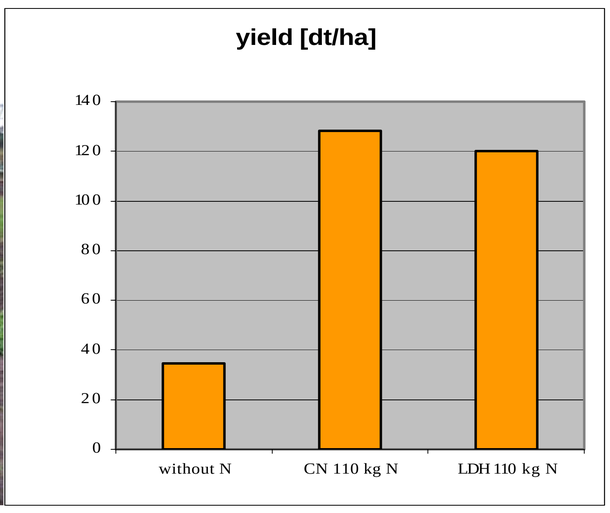
Nitrate is preferentially adsorped at the LDH

Depending on the conditions during synthesis, the LDH mineral will have a certain crystallinity. The distance between two layers (i.e. the interlayer space) restricts the access of the anions to be adsorbed. In a solution containing 3 anions (I.e. nitrate, phosphate and sulfate) at the same concentration, nitrate was preferentially adsorbed at the LDH. This shows the high selectivity of the LDH for nitrate.



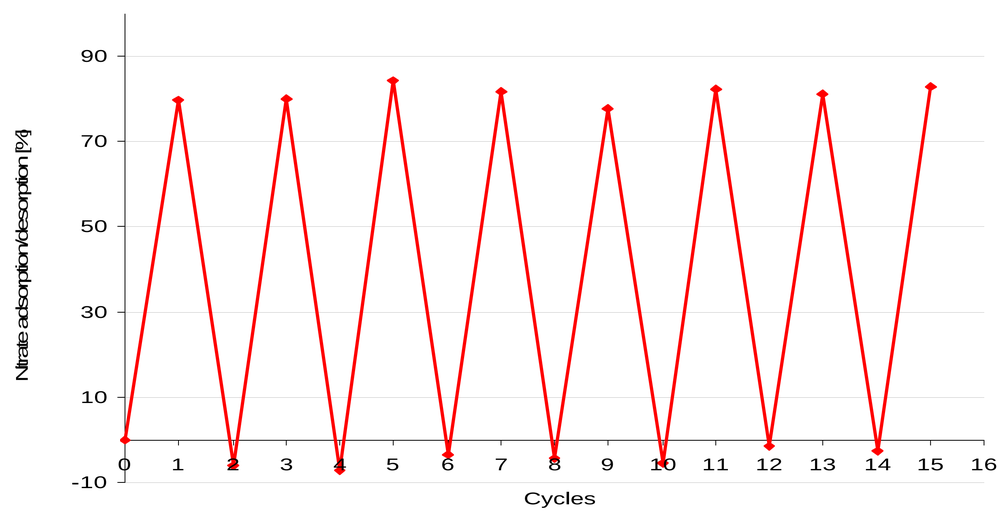
Nitrate applied as NO_3^--LDH is plant available

In field trials with spinach nitrate release from a NO_3^--loaded LDH was adequate to ensure optimal plant growth: no differences in yield could be found between Calciumnitrate (CN) and LDH at a N application rate of 110 kg N/ha.



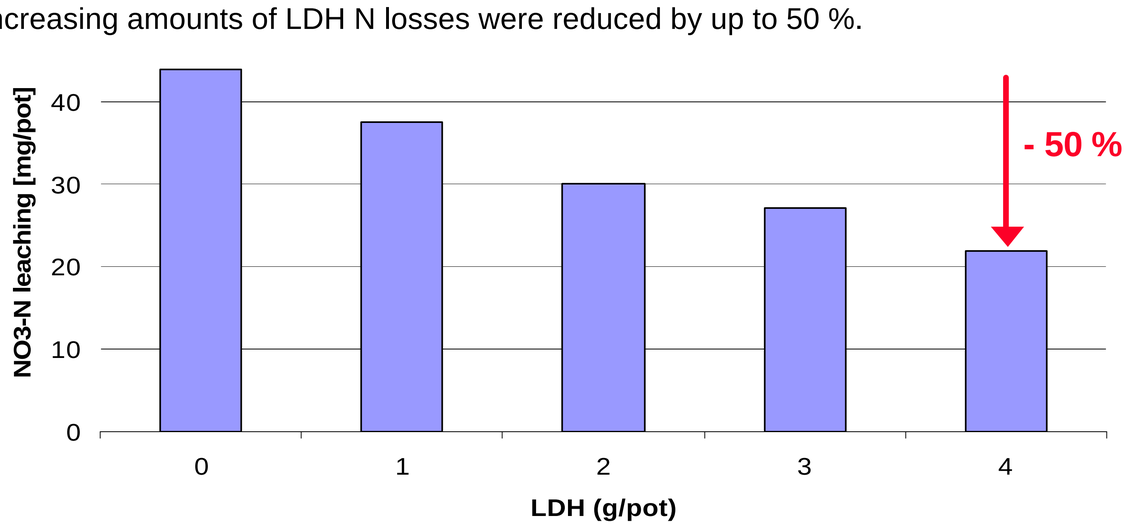
Adsorption of nitrate at the LDH is reversible

Loading – deloading experiments were conducted based on a spezial filter funnel technique revealing that the nitrate exchange capacity of the LDH can be used repetitively.



N leaching is efficiently reduced due to LDH application

Increasing amounts of LDH were applied to a sandy soil. After 2 weeks water was applied equivalent to the water holding capacity of the soil and nitrate leaching was measured: with increasing amounts of LDH N losses were reduced by up to 50 %.



Conclusions

Mg/Al-layered double hydroxide (LDH), a mineral which has a positive charge due to substitution of Mg^{2+} against AL^{3+}, can release and adsorb nitrate depending on the concentration in the surrounding solution. Nitrate adsorbed at the LDH is plant available and LDH reduces N leaching. Evaluation of the agronomic performance will be in focus of the on-going research activities.

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