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The role and function of calcium (Ca) in agricultural soil and plants

The total Ca^{2+} in the earth's crust is approximately 3.5%. Anorthite is a primary mineral and the most important natural source of Ca^{2+} in soil.

In humid regions with non-calcareous soils, the levels of calcium in soil may vary between 0.5 and 0.7%. In tropical soils that are eroded the calcium would be between 0.1 and 0.3%. The dryer, arid areas would have calcium levels between 1-30% due to less leaching of calcium and more calcium precipitations within the soil.

The trend is that courser (sandy) soils in humid regions have lower exchangeable calcium, and therefore lower plant available calcium. Soils in humid regions with a more clayey texture and higher Ca levels will therefore have more exchangeable plant available calciums, but in acidic clayey soils these calciums would not be available for plant uptake.

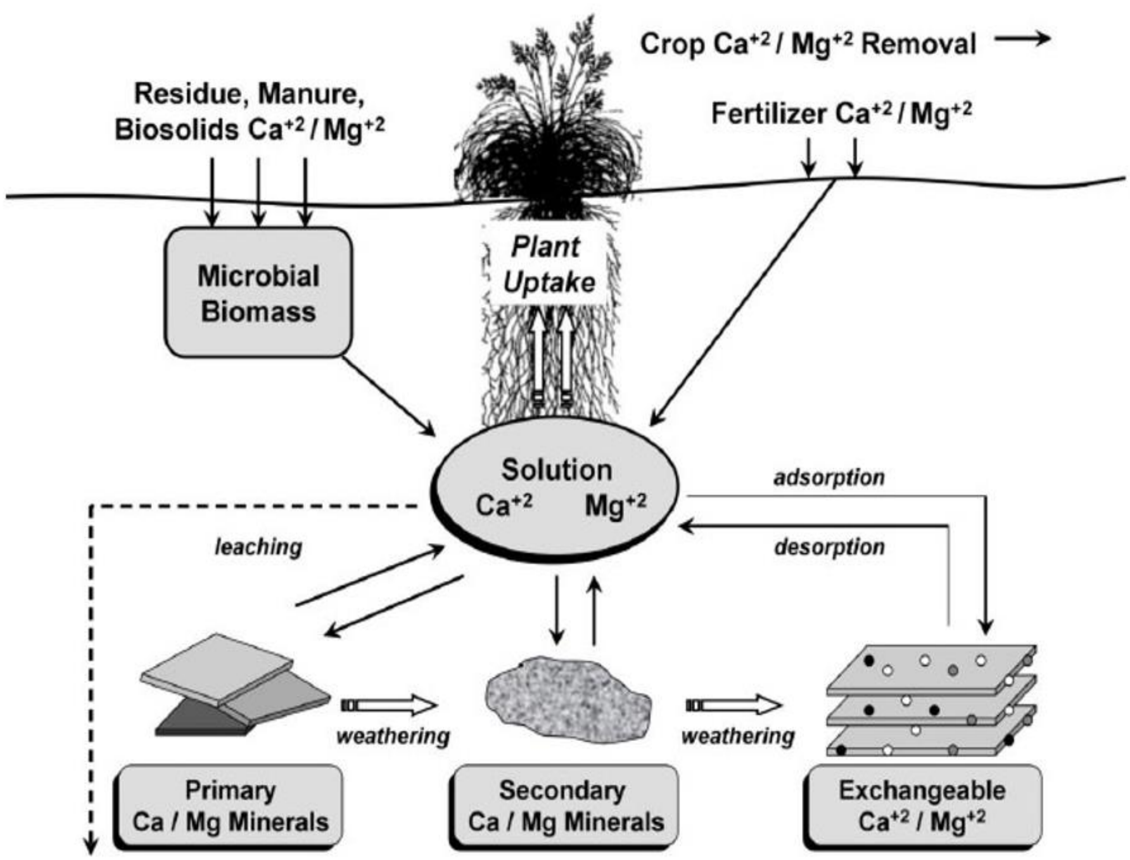

Figure 1 Calcium cycle in soils

The calcium cycle in Figure 1 depicts how the plant uptake and movement of calcium takes place within the soil medium. Natural minerals within the soil slowly weathers and releases some calcium into the soil solution. These calciums within the soil solution will then be able to move by means of mass flow towards plants roots for uptake as well as start to leach through your soil profile. Plant residue and alternative Ca^{2+} resources from fertilizers and lime will also end up in the soil solution that would also be prone to leaching, binding onto clay particles and taken up by plants. Calcium in the soil solution could also precipitate as primary and secondary minerals. The largest loss of calcium is by leaching, which can account to a loss of 400kg Ca per hectare per year.

The most economical yield is achieved when the Ca dominates the TEC (total exchangeable cations) in the soil. Magnesium will suppress calcium if the magnesium levels are high, emphasizing the importance to achieve and maintain the correct balance between these two elements. Ca^{2+} is also important to control the Na levels, as a 5-15% exchangeable sodium percentage would affect the water penetration of the soil. Ca^{2+} would displace the sodium from the exchangeable complex, creating Na^{+} salts, resulting in the leaching of these salts. Calcium is also important for the soil structure as calcium causes soil particles to flocculate and form soil aggregates (structure).

The necessary Ca^{2+} corrections will result in better long term yields (2 - 3 years), but it is regarded as a relative expensive correction as producers are more concerned with short-term seasonal results.

The plant uptake of calcium has a relative low potential as calcium is only absorbed by the unsuberized root tips of plants (young “white” non corky root tips). Furthermore, potassium (K^{+}) and ammonium ($NH4^{+}$) suppress calcium and are favourably absorbed by the roots. The translocation of calcium in the plant is upwards in the transpiration system therefore, calcium translocation is determined largely by the intensity of transpiration. If calcium is deposited in older leaves, mobilization will not be possible and translocation of calcium to younger plant parts would be difficult.

Calcium plays an important role in plant cell elongation and division in plants. It is also needed for the stabilization of new cell membranes. It creates a steep gradient of K^+ between the apoplast and cytoplasm. Calcium enhances the permeability of the cell membrane, allowing inorganic and organic compounds to enter and move through cell walls via diffusion (movement of an ion from high concentration towards a lower concentration).

Calcium-phosphate precipitations will form when the calcium concentrations are too high, resulting in a shortage of both calcium and phosphate, these high calcium concentrations will also suppress the magnesium uptake, resulting in a magnesium deficiency. Therefore, it is critical to measure and correct calcium concentrations within the plants at the **correct time, correct place** as well as through the **correct method.**

Most common calcium corrections could be obtained through:

Lime sources

- Calcitic lime
- Dolomitic limestone
- Slaked lime

Fertilizer

- CAN – 10%
- Triple superphosphate – 10 – 14% Ca
- Calcium nitrate – 19% Ca
- Polysulphate – 17% CaO as calcium sulphate

[1] Principles of plant nutrition - Mengel, Kirkby, Kosegarten & Appel
Soil Chemistry – Bohn, McNeal & O'Connor
SOIL 3714 class notes – UFS Department of Agriculture
The influence of lime application depth on soil pH and maize – JG Benade