Plant research on photoprotective mechanisms and magnesium nutrition at IAPN

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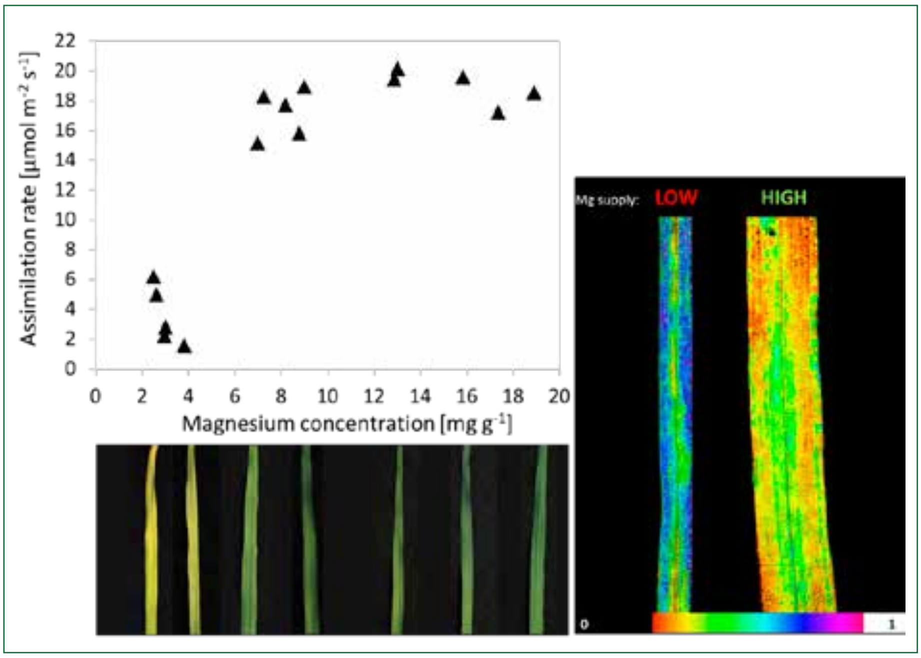
The nutrient magnesium is essential for plants and plays a dominant role in photosynthesis and photosynthesis related processes. Photosynthesis takes place in the chloroplasts, where 35% of the magnesium in cells is allocated. This high percentage illustrates the dependence of photosynthetic processes on the presence of magnesium. For instance, the enzyme Rubisco which is responsible for fixation of atmospheric CO_2, is activated by magnesium. Moreover, the leaf pigment chlorophyll, which absorbs light energy, requires magnesium for its molecular structure. If magnesium concentrations within the plant become deficient, photosynthetic performance is decreased and only a small portion of light energy is converted to biochemical energy (see figure). Hence, excessive energy is formed which in turn produces reactive oxygen species. Reactive oxygen species are toxic to the plant and can cause damage to DNA, proteins, cell walls etc. if they occur in too high concentrations. To protect itself from damage, the plant uses the so called "photoprotective mechanisms". Hereby, part of the excessive energy is converted into harmless heat, a process known as "non-photochemical quenching" (NPQ). The proportion of energy used in photosynthetic processes and the proportion of energy converted into heat can be determined by chlorophyll fluorescence where the leaf is illuminated with light of a certain wavelength. While part of the light is absorbed by the leaf pigments, a small portion of light, approximately 1-2%, is remitted in a longer wavelength and can be detected as fluorescence. This methodology allows indication on the photochemical efficiency of the plant. Our results show that plants which suffer magnesium deficiency reduce the photochemical efficiency and dependent on the severity of deficiency, increase the dissipation of energy as heat.



Left: Decreasing leaf magnesium concentrations lead to reduced assimilation rates and reduction of chlorophyll concentration as visible by yellowing of leaves.
Right: Due to reduced assimilation capacity, light energy is in excess to what can be used in photosynthesis and can damage the plant. To protect leaves from damage, the excess light energy is converted to thermal energy, which is assessed as non-photochemical quenching (NPQ). The leaf on the left suffers Mg deficiency and has higher NPQ, indicated by more blue and purple colours. The false colour scale at the bottom depicts values from 0 to 1.

Recent publication on the topic:

Tränkner, M.; Tavakol, E. & Jákli, B. (2018): Functioning of potassium and magnesium in photosynthesis, photosynthate translocation and photoprotection. Physiol. Plantarum, 163, 414-431.