"Soil control on tradeoffs between silica and cellulose as structural component in sugarcane leaf (Saccharum officinarum)"

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Abstract

Soil processes partly govern the terrestrial cycle of silicon (Si). The biological and physiological functions related to Si deposits in plants are increasingly studied. The understanding of tradeoffs between silicon and cellulose in leaf structure remains unclear and available studies are restricted to rice plants, mainly under controlled conditions. The soil processes underlying this tradeoff are, moreover, not inferred despite the well-known impact on Si bioavailability and soil-to-plant transfer. Here, we study the tradeoff between silica and cellulose in leaves of sugarcane (Saccharum officinarum L.) cropped on three different soils (Nitisol, Andosol, Vertisol). The soil CaCl2 extractable Si concentration, so-called bioavailable Si, was measured after extraction using CaCl2 solution (0.01M) for 6h. The total leaf Si concentration was determined after drying, calcination and further alkaline fusion followed by ash dissolution using concentrated HNO3. Plant silica bodies were phys...

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Soil control on tradeoffs between silica and cellulose as structural component in sugarcane leaf (Saccharum officinarum)

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Soil processes partly govern the terrestrial cycle of silicon (Si). The biological and physiological functions related to Si deposits in plants are increasingly studied. The understanding of tradeoffs between silicon and cellulose in leaf structure remains unclear and available studies are restricted to rice plants, mainly under controlled conditions. The soil processes underlying this tradeoff are, moreover, not inferred despite the well-known impact on Si bioavailability and soil-to-plant transfer. Here, we study the tradeoff between silica and cellulose in leaves of sugarcane (Saccharum officinarum L.) cropped on three different soils (Nitisol, Andosol, Vertisol). The soil CaCl2 extractable Si concentration, so-called bioavailable Si, was measured after extraction using CaCl2 solution (0.01M) for 6h. The total leaf Si concentration was determined after drying, calcination and further alkaline fusion followed by ash dissolution using concentrated HNO_3. Plant silica bodies were physically extracted from sugarcane leaves through wet digestion. The leaves were observed and mapped for Si by ESEM-EDX. Leaf cellulose, hemicellulose and lignin concentrations were determined according to the Van Soest method. As expected, total leaf Si concentration increases with increasing soil CaCl2-extractable Si following the sequence Nitisol<Andosol<Vertisol. We further show that silica is more evenly distributed in large veins and long cells at largest leaf Si concentration whereas silica deposits are mainly restricted to silica cells and stomata at smallest leaf Si. At largest leaf Si, silica bodies exhibit much larger structures (up to 0.5 mm), filling cell lumen and molding cell walls. Leaf C concentration decreases with increasing Si, due to a ‘dilution effect’. Cellulose concentration significantly decrease with increasing Si concentration. This inverse relationship persists after ash correction. The silica leaf deposits thus significantly contribute to counterbalancing cellulose as a leaf structural component. This process is soil and climate dependent. Indeed, soil weatherable silicate minerals release bioavailable Si whereas Si root uptake and further transport and accumulation to plant transpiration termini are strongly climate dependent. We hypothesize a soil control on silica-cellulose tradeoff given the fact that the three soils markedly differ in their reserve of weatherable silicates (Vertisol>Andosol>Nitisol). The occurrence of these soils is, however, intimately linked to largely distinct climatic conditions.