Understanding carbon metabolism in sugarcane to improve bioethanol production

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Sugarcane is one of the most important bioenergy crops extant and any improvement in bioethanol production requires better understanding of its biochemistry, physiology and molecular biology. Some points are particularly important such as photosynthesis, sucrose metabolism and cell wall biochemistry. Sucrose metabolism has been deeply studied in varieties of sugarcane from other countries, but Brazilian varieties lack such studies. Although C4 photosynthesis has been discovered in leaves of sugarcane in the 1960s, little is known about its biochemical and genetic controls. In the case of cell walls, even less is known. Due to the great interest in the production of second-generation bioethanol, understanding its cell wall structure and metabolism will be key to guide future agricultural and industrial process development. In this presentation I will report recent discoveries from my lab regarding photosynthesis and carbon metabolism associated to source-sink relationship in sugarcane, including work on the structure and architecture of its cell walls. Proteomics analyses of mature leaves from 45 days old plant revealed that activation of photosynthesis is followed by an increase in malate metabolism, which is one of the driving forces of the elevated CO2 effects through the sink of reducing power (NADPH and ATP) from the light reactions. As a result, electron transport increases and with that, a better use of water has been observed. Carbohydrate analyses of the diurnal variation of metabolism (including he use of metabolomics of 60 days old plants) of sugarcane revealed that leaves make starch and sucrose and export the latter to the culms, which accumulate very little starch and a large proportion of sucrose. We followed the diurnal variations of 91 substances and found that most of them vary with light-dark cycle. Starch, sucrose, raffinose, glucose and fructose (the non-structural carbohydrates) increase during the day and decrease during the night. Our results indicate that cell wall polysaccharides are synthesised during the day and wall extension occurs in the night. In 2001, we reported the discovery of 469 genes related to cell wall metabolism in sugarcane (Lima et al. Gen.Mol.Biol. 24:191). Since then, we have determined the chemical structure of sugarcane cell wall. We found that Beta-glucan, arabinoxylan and xyloglucan are the main hemicelluloses in sugarcane walls. Their fine structures and architecture are starting to be revealed, which are leading to a better understanding of wall architecture and making possible to design strategies for its degradation in order to accomplish processes for 2nd generation biothanol. We have characterised a process in sugarcane roots (aerenchyma formation) in which walls are degraded within the context of plant metabolism. By studying the biochemistry and molecular biology of this process, we expect to understand sugarcane systems biology connections that link photosynthesis and growth through cell wall production and modifications. We expect this to make possible future genetic transformations that could lead to changes in carbon metabolism and a possible increase influence bioethanol production.

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