INTEGRATING PHYSIOLOGICAL, MORPHOLOGICAL AND ANATOMICAL TRAITS TO UNDERSTAND THE DIFFERENTIAL SUCROSE YIELD IN SUGARCANE GENOTYPES

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Our purpose was to understand some aspects of sucrose yield by addressing physiological, morphological and anatomical traits. This strategy will increase the subjacent knowledge about sucrose yield and let us to a more complex scenario about this important agricultural theme. In fact, improvement in the understanding of ecophysiological aspects related to phytomass production and sucrose yield of sugarcane is an essential condition to the development of the Brazilian sugar-ethanol sector. However, little is known about the relationship between plant traits and sucrose yield in the Brazilian sugarcane genotypes, an important issue for sugarcane breeding programs and modeling. Considering that sugarcane breeding programs have periodically launched many productive cultivars, the following questions are relevant for the Brazilian agriculture: why do sugarcane genotypes accumulate differential sucrose amount in stalks? Is it a physiological and/or morphological and/or anatomical matter? Is it related to the source, sink or source-sink characteristics? Is the high sucrose yield related to differential sensitivity of sugarcane genotypes to stressful conditions found during the winter season? Is the differential sensitivity found in a specific phenological stage or in entire crop cycle? About those questions, an integrated approach for studying sugarcane plants is essential to study plant growth and sucrose accumulation. This challenge was addressed in sugarcane genotypes with differential sucrose yield and canopy architecture growing under field and controlled (greenhouse and growth chamber) conditions. Several physiological, morphological and anatomical traits related to photosynthesis and sugar metabolism were evaluated, with this project being the first step towards an integrative and interdisciplinary approach to understand the ecophysiology of Brazilian sugarcane genotypes.

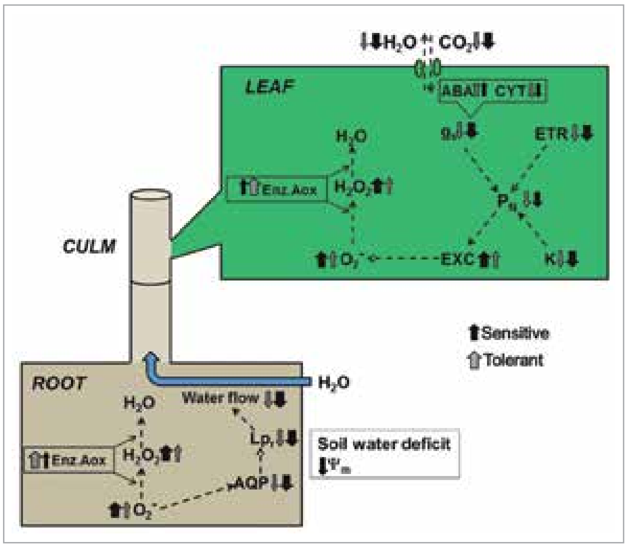

Figure 1. Physiological responses of sugarcane genotypes with differential sensitivity to water deficit. ABA = abscisic acid; CYT = cytokinin; g_s = stomatal conductance; ETR = apparent electron transport rate; P_N = net CO_2 assimilation; K = apparent carboxylation efficiency; EXC= relative excess of light energy; O_2^-= superoxide; H_2O_2 = hydrogen peroxide; Enz.Aox = antioxidant enzymes; AQP = aquaporins; Lpr = root hydraulic conductance; Ψm, soil matric potential. Filled arrows indicate increase or decrease in activity or concentration in drought-tolerant (gray) and -sensitive (black) genotypes

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

The water deficit is one of the main environmental constrains causing significant reduction of sugarcane yield. In such scenario, drought-tolerant genotypes are fundamental for maintaining sucrose yield and improving resource use efficiency. Herein, we present a comparative analysis of the physiological responses found in sugarcane genotypes that are tolerant or sensitive to water deficit through a general model of reaction to water deficit (*Figure 1*), linking the functioning of roots and shoots. Low soil water availability reduces the soil water potential (Ψm) and then limits water uptake and decreases root water content. Signals of oxidative damage in roots are detected either in tolerant or sensitive genotypes, being more intense in the sensitive ones. Reactive oxygen species (ROS) reduce the aquaporin (AQPs) activity, causing reduction in root hydraulic conductance (Lpr). Such negative impact of water deficit is also higher in the sensitive genotypes (*Figure 1*), which also present low activity of antioxidant enzymes (Enz.Aox) such as superoxide dismutase, catalase and ascorbate peroxidase in roots. As consequence, water flow to shoots is more affected in the sensitive genotypes, with plants presenting reductions in leaf relative water content. Other important responses associated to water deficit were building up of abscisic acid (ABA) concentration and decreases in cytokinin (CYT) concentration in leaves with consequent reduction of stomatal aperture (g_s). Water deficit also affects chloroplasts and the photosynthetic apparatus, with plants showing reduction in the apparent carboxylation efficiency (K). Decreases in g_s and K lead to low net CO_2 assimilation (P_N), being such responses more intense in the drought-sensitive genotypes (*Figure 1*). Low P_N associated with the continuous exposure to solar radiation increases the relative excess of energy at the photosystems II (EXC), increasing the energetic pressure on the photochemical apparatus. Leaf ROS production is then increased, which is accompanied by increases in the activity of antioxidant enzymes and thermal dissipation of energy. Although both processes are present either in sensitive or tolerant genotypes, they are more enhanced in the latter ones (*Figure 1*). As a conclusion about the physiological responses to water deficit, tolerant genotypes present higher water transport than the sensitive ones due to the root ROS detoxifying mechanism. These responses associated with the lower sensitivity of photosynthesis to drought are the physiological bases for maintaining sugarcane growth under low water availability.

MAIN PUBLICATIONS

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