Sucrose is a signal molecule in a new signal-transduction pathway that modulates sucrose transport activity and assimilate partitioning.

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ABSTRACT

One of the defining features of multicellular growth is the need to partition resources and information between organ systems that specialize in divergent biological processes. The leaf is the principle site of energy and material acquisition while other organs specialize in additional requisite activities, such as water and ion uptake (root) or reproduction (flowers and seeds). Assimilate partitioning is the physiological process in higher plants that mediates the transport and allocation of organic nutrients via the phloem cells of the plant's vascular system. The proton-coupled sucrose symporter transports sucrose into the leaf's phloem against a large concentration gradient. This occurs in apoplastic phloem loading and it is the key transport step in assimilate partitioning for many plants.

In spite of many recent advances in defining the mechanisms of assimilate partitioning, vanishing little is known about the control pathways that regulate resource allocation. Yet, innumerable studies have shown that this is a regulated process and that plants have the ability to redirect resources in response to environmental and/or developmental changes. In the results reported here, we identify sucrose as a signaling molecule in a new signal-transduction pathway that regulates the sucrose symporter. Symporter activity declined in plasma membrane vesicles isolated from leaves fed exogenous sucrose via the xylem transpiration stream. Sucrose transporter activity dropped to 35-50% of water controls when fed 100 mM sucrose and to 20-25% of controls in 250 mM sucrose. In contrast, alanine and glucose transporter activities did not change in response to sucrose treatments. Decreased sucrose symporter activity was detectable after 8 h and reached a maximum by 24 h. Kinetic analysis of transport activity showed a decrease in Vmax. RNA gel blot analysis revealed a decrease in symporter message levels, suggesting a drop in transcriptional activity or a decrease in mRNA stability. Likewise, cycloheximide decreased transport activity by 60% within 4 h. Taken together, these results suggests a complex interplay between symporter gene expression and protein turnover regulates sucrose transport. Control experiments showed that these responses were not the result of changing osmotic conditions. Equal molar concentrations of hexoses did not elicit the response and mannoheptulose, a hexokinase inhibitor, did not block the sucrose effect. These data are consistent with a sucrose-specific response pathway that is not mediated by hexokinase as the sugar sensor. Sucrose-dependent changes in the sucrose symporter were reversible, suggesting this sucrose-sensing pathway can modulate transport activity as a function of changing sucrose concentrations in the leaf. This is the first report of a signaling pathway that can control sucrose partitioning at the level of phloem translocation.