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Guard cell photosynthesis is critical for stomatal turgor production, yet does not directly mediate CO_2 - and ABA-induced stomatal closing.

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Plant J. 2015 Aug; 83(4):567-81

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Good 01 Sep 2015

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NEW FINDING

DOI: 10.3410/f.725579985.793509283

The basic function of mesophyll chloroplasts is clear, as they serve as the CO_2 assimilation power house in plant cells. However, the presence of chloroplasts in plants is not limited to leaf-mesophyll cells, since we find these organelles also in some fruit tissues, specifically stem cells and in guard cells. The latter cells form the basis for stomata, which are required for controlled release of O_2 and water vapor, and influx of CO_2 into photosynthesizing leaves. Interestingly, the physiological impact of chloroplasts in guard cells is still under debate.

Tamar Azoulay-Shemer of the Julian Schroeder group and coworkers developed a novel elaborate strategy to specifically decrease the chlorophyll content in guard cell chloroplasts, without affecting chloroplasts in other cell types. They discovered that although 90% of all guard cells were chlorophyll-deficient, several photosynthetic parameters of mutant leaves resembled those of the wild types (WTs). However, about half of the mutant stomata exhibited an unusual morphology as they are thin, and not kidney-shaped. The responses of chlorophyll-less stomata to CO_2 or the phytohormone ABA were similar to those observed on WT stomata, giving rise to the conclusion that the latter responses do not depend upon intact photosynthesis. Instead, impaired stomatal conductance and CO_2-assimilation rates, as well as impaired stomatal morphology in mutants indicate that photosynthesis of guard cell chloroplasts contributes to the synthesis of osmotically active solutes, e.g. sugars and malate, and that solute synthesis is the major function of these interesting organelles. With this paper, the Schroeder group fill a long-lasting gap in our knowledge on the regulation of plant gas exchange and contribute important findings on plant cell physiology.

Disclosures
None declared

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Abstract:

ABSTRACT

Stomata mediate gas exchange between the inter-cellular spaces of leaves and the atmosphere. CO_2 levels in leaves (Ci) are determined by respiration, photosynthesis, stomatal conductance and atmospheric [CO_2]. [CO_2] in leaves mediates stomatal movements. The role of guard cell photosynthesis in stomatal conductance responses is a matter of debate, and genetic approaches are needed. We have generated transgenic Arabidopsis plants that are chlorophyll-deficient in guard cells only, expressing a constitutively active chlorophyllase in a guard
cell specific enhancer trap line. Our data show that more than 90% of guard cells were chlorophyll-deficient. Interestingly, approximately 45% of stomata had an unusual, previously not-described, morphology of thin-shaped chlorophyll-less stomata. Nevertheless, stomatal size, stomatal index, plant morphology, and whole-leaf photosynthetic parameters (PSII, qP, qN, FV '/FM') were comparable with wild-type plants. Time-resolved intact leaf gas-exchange analyses showed a reduction in stomatal conductance and CO_2 -assimilation rates of the transgenic plants. Normalization of CO_2 responses showed that stomata of transgenic plants respond to [CO_2] shifts. Detailed stomatal aperture measurements of normal kidney-shaped stomata, which lack chlorophyll, showed stomatal closing responses to [CO_2] elevation and abscisic acid (ABA), while thin-shaped stomata were continuously closed. Our present findings show that stomatal movement responses to [CO_2] and ABA are functional in guard cells that lack chlorophyll. These data suggest that guard cell CO_2 and ABA signal transduction are not directly modulated by guard cell photosynthesis/electron transport. Moreover, the finding that chlorophyll-less stomata cause a 'deflated' thin-shaped phenotype, suggests that photosynthesis in guard cells is critical for energization and guard cell turgor production.© 2015 The Authors The Plant Journal ©

PMID: 26096271

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