The Scent of Senescence: Cell wall ester modifications and volatile emission signatures of plant responses to abiotic stress

Kolby Jardine¹, Rebecca Dewhirst¹, Joseph Lei¹, Eliana Tucker¹, Robert Young P², Miguel Portillo-Estrada³, Yu Gao⁴, Luping Su⁵, Silvano Fares⁶, Cristina Castanha¹, and Jenny Mortimer⁴

¹E O Lawrence Berkeley National Laboratory
²Pacific Northwest National Laboratory
³Research group PLECO (Plants and Ecosystems) Department of Biology University of Antwerp Wilrijk Belgium
⁴Joint BioEnergy Institute
⁵Tofwerk USA Boulder CO USA
⁶Consiglio Nazionale delle Ricerche

January 31, 2022

Abstract

Growth suppression and defense signaling are simultaneous strategies that plants invoke to respond to abiotic stress. Here, we show that the drought stress response of poplar trees (Populus trichocarpa) is initiated by a suppression in cell wall derived methanol (meOH) emissions and activation of acetic acid (AA) fermentation defenses. Temperature sensitive emissions dominated by meOH (AA/meOH < 30%) were observed from physiologically active branches, detached stems, leaf cell wall isolations, and whole ecosystems. In contrast, drought treatment resulted in a suppression of meOH emissions and strong enhancement in AA emissions together with fermentation volatiles acetaldehyde, ethanol, and acetone. These drought-induced changes coincided with a reduction in stomatal conductance, photosynthesis, transpiration, and leaf water potential. The strong enhancement in AA/meOH emission ratios during drought (400-3,500%) was associated with an increase in acetate content of whole leaf cell walls, which became significantly ¹³C ₁,₂-labeled following the delivery of ¹³C ₁,₂-acetate via the transpiration stream. The results are consistent with central roles of acetate fermentation in regulating plant defense and metabolic responses to drought, and suggest that cell wall O-acetylation may be reversible allowing plants to rapidly respond to drought stresses by down-regulating methyl ester hydrolysis and growth processes while enhancing O-acetylation. We suggest that AA/meOH emission ratios could be used as a highly sensitive non-destructive sensor to discriminate between thresholds of rapid plant growth and drought stress responses.

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