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

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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 $^{13}C_{1,2}$-labeled following the delivery of $^{13}C_{1,2}$-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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