EGU General Assembly 2025

EGU25-4478, updated on 22 Jan 2026
https://doi.org/10.5194/egusphere-egu25-4478
EGU General Assembly 2025

Detection of the effects of hydraulic activation of stomata (HAS) on the water use efficiency of crops

Shuaishuai Deng[1], Jürgen Burkhardt[2], Ronny Lauerwald[1], Christophe Flechard[3], Jürgen Knauer[4], Carmen Kalalian[1], Benjamin Dumont[5], Nicolas Viovy[6], and Benjamin Loubet[1]

[1]UMR ECOSYS, INRAE AgroParisTech, Université Paris-Saclay, 91120 Palaiseau, France.
[2]Institute of Crop Science and Resource Conservation, University of Bonn, Bonn, Germany.
[3]Institut National de la Recherche en Agriculture, Alimentation et Environnement (INRAE), UMR 1069 SAS, 35042 Rennes, France.
[4]Hawkesbury Institute for the Environment, Western Sydney University, Penrith, NSW, Australia.
[5]ULiege-Gembloux AgroBio-Tech, Plant Sciences Axis, Crop Science Lab., B-5030 Gembloux, Belgium.
[6]Laboratoire des Sciences du Climat et de l'Environnement, IPSL, CEA-CNRS-UVSQ, Université Paris-Saclay, Gif Sur Yvette, France.

Hydraulic activation of stomata (HAS) is the process of wicking water from the leaf interior to the surface, promoted by deliquescent salt on the leaf surface, serving as a critical physiological mechanism that affects stomatal behavior, water fluxes, and ultimately water use efficiency (WUE) in vegetation. This study is the first to evaluate the HAS effect under field conditions, investigating the potential role of hygroscopic urea ammonium nitrate (UAN) foliar application promoting HAS and detecting its effects through changes in transpiration, stomatal slope (g_1), carbon-water exchange rate (λ), and inherent water use efficiency (IWUE) at the ecosystem scale.

Using eddy covariance (EC) observations across four ICOS European cropland sites (FR-Gri, BE-Lon, DE-Kli, DE-Geb) from 2005 to 2020, our findings revealed distinct crop-specific responses, with HAS influencing transpiration dynamics after foliar UAN application. Barley, maize, and winter wheat exhibited significantly increased transpiration, as evidenced by substantial increases in g_1 and λ ($p < 0.05$). These changes were accompanied by reductions in IWUE, reflecting enhanced stomatal conductance and more water loss under the HAS effect. In contrast, rapeseed showed reductions in transpiration, g_1, and λ, but an increase in IWUE, suggesting improved water use efficiency through distinct physiological response. Except for rapeseed, foliar UAN application enhanced CO_2 assimilation, leading to a larger difference in CO_2 concentrations ($C_a - C_s$) and decreased temperature gradient ($T_a - T_s$) between air and surface, which was attributed to cooling effects induced by elevated transpiration across sites. Notably, g_1 remained stable over a one-month period in the absence of foliar UAN application, indicating that observed changes in WUE are primarily driven by the effects of UAN rather than intrinsic stomatal regulation under natural growth conditions.

These findings highlight HAS's distinct impacts on transpiration, surface energy fluxes, and WUE under field conditions, underscoring the need to incorporate HAS into ecosystem models. The

neglect of HAS in current models results in an overestimation of WUE following foliar fertilization in cereals. This limitation may also extend to other vegetation types due to hygroscopic deposition of aerosols, emphasizing the broader significance of integrating HAS into models to improve WUE predictions and support sustainable ecosystem management practices.