Commentary on Abscisic Acid Antagonist

The First Broad-Spectrum Abscisic Acid Antagonist

Changing from unsustainable to renewable agriculture requires boosting water-use efficiency in crops. Because abscisic acid (ABA) reinforces a plant’s capacity to withstand drought, the mode of action of this hormone has thus long attracted biophysicists, ecophysiologists, geneticists, and molecular biologists alike.

In Arabidopsis (Arabidopsis thaliana), 14 START-domain proteins compose the family of cytosolic ABA receptors (Ma et al., 2009; Park et al., 2009). One founding mutant, PYRABACTIN RESISTANCE1 (PYR1), is in fact a namesake based on a genetic screen for seeds that can germinate in the synthetic ABA agonist pyrabactin (Park et al., 2009). An analog, quinabactin, was later found to activate strongly four ABA receptors (PYR1, PYL1–PYL3), resulting in seed germination inhibition and stomatal closure. Several plant species treated with this compound did improve water-use efficiency (Okamoto et al., 2013), hinting at its potential in agriculture.

In this issue, Ye et al. (2017) identified and characterized in detail ABA ANTAGONIST1 (AA1) by screening for chemicals that can reverse the inhibitory effect of ABA on Arabidopsis seed germination. AA1 can oppose all known elementary ABA responses tested, ranging from stomatal movements to expression of reporter genes. Also, among known antagonists, AA1 can block all ABA receptors, at least by bonding with some of the same amino acid residues as ABA. An interesting twist is that the authors went further to probe two little-noticed ABA functions using AA1. Higher ABA levels were known to associate with senescing vegetative tissues and ripening fruits, although the significance of these results had not been clear. Ye et al. demonstrated that AA1 can suspend, in a dose-dependent manner, the progress of senescence in leaves and ABA-induced tomato ripening.

Why is the above an important development? Permanent adaptation requires the plant to optimize the trade-off between H2O and CO2 for photosynthesis (Raschke, 1976). In simplest terms, while closed stomates help to retain H2O in plant tissues, they also tend to keep CO2 out. Many drought-hardy plant species compensate, for example, by recycling malate as the carbon source (Crassulacean acid metabolism). As this is not the case for most crops, ABA antagonists could become decisive tools to redress this trade deficit in CO2.

Pyrabactin, quinabactin, and AA1 have proven valuable in differentiating the physiological roles of certain ABA receptors and uncovering potentially novel ABA functions. Agonists and antagonists can offer advantages to exploring structure-function of ABA receptors in nonmodel plants with complicated genetics because their chemical effects should not be sensitive to large gene families or high ploidy levels. For biotechnology, many proposals to enhance crop water-use efficiency have relied on expressing candidate transgenes, including ABA receptors. Again, agonists and antagonists offer alternative choices to modulate selectively, conditionally and reversibly the ABA receptor activities, independent of whether the crop can be transformed, and by the same token, avoid potential cosuppression problems and the contentious issue of releasing transgenic crops. A bonus application with AA1, as Ye et al. suggest, could be in preserving fruits and vegetables temporarily in their most robust states suitable for long-distance transport.

Jeffrey Leung*
Institut Jean-Pierre Bourgin,
UMR1318 INRA-Agro-ParisTech,
INRA Centre de Versailles-Grignon,
78026 Versailles, France
ORCID ID: 0000-0001-8140-7440 (J.L.).

LITERATURE CITED


* Address correspondence to jeffrey.leung@inra.fr.

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