How plants respond to environmental threats with the proper defense

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Credit: Michigan State University

In plants, the jasmonate, or JA, signaling pathway helps plants control their defense responses to environmental stresses. Like the human body, plants respond differently to individual threats. Just as people wouldn't get a fever due to a sprained ankle, plants deal with harmful elements in particular ways.

A study from the MSU-DOE Plant Research Laboratory (PRL) Howe lab looks at how plants respond to environmental threats in the correct way. This study was published in *New Phytologist*.

"Plants encounter so many environmental stressors, including biotic stressors like pathogens or insects," said Leah Johnson, co-first author on the study and former graduate student in the Howe lab. "It can be really energy intensive for them to produce all these defense responses."

Researchers have known that the JA signaling pathway controls defense responses for some time, but they were still seeking to understand how appropriate plant responses to different threats can be turned on or off as needed. JAZ and MYC proteins were known to have opposing effects on this pathway: JAZs keep the pathway off and the MYCs can turn the pathway on. Most plants have several copies of the JAZs and the MYCs and one common idea is that those multiple copies help plants fine-tune their responses.

"The real breakthrough of the paper is showing that different JAZ subsets control different responses," said Ian Major, co-first author on the study and former postdoctoral researcher in the Howe lab.

The researchers grew mutant Arabidopsis thaliana plants which were missing most of their JAZs. As JAZs keep the defense responses under control, their removal results in an uncontrolled defense response, somewhat analogous to autoimmunity. Because the mutant plant was spending so much energy on defending itself from all threats, even if those threats were not present, it had less energy to grow. The plants were smaller and produced fewer seeds than their counterpart found in the wild.

This mutant was cross bred with wild-type Arabidopsis plants to generate offspring with different sets of missing JAZs. Some of those offspring

showed increased levels of defense involved in protection against necrotrophic pathogens, which feed on dead tissue. By examining which JAZs were missing in those plants, the researchers were able to identify what part of the JA pathway allows for this defense to be turned on and off.

"We were able to show that with JAZ regulators, a certain set controls insect defense, and a completely separate set seems to control resistance to necrotrophic pathogens," Major said.

Johnson continued, "We found that subsets of these families [JAZ and MYC] differentially regulate responses to insects versus necrotrophic pathogens. This suggests that these families obtained distinct regulatory functions at some point in plant evolutionary history and suggests a mechanism for how plants can respond correctly to different stressors."

In the future, this work has potential to be applied to crop plants, activating defenses to insects or pathogens, without expending too much energy, to help them fight off these threats.

"The identification of plant regulatory genes that specifically control the partitioning of photosynthetic products creates new opportunities to engineer plants for enhanced yield and stress resistance," said Gregg Howe, the primary investigator on this paper and MSU Foundation Professor in the PRL and the Department of Biochemistry & Molecular Biology.

More information: Leah Y. D. Johnson et al, Diversification of JAZ-MYC signaling function in immune metabolism, *New Phytologist* (2023). DOI: 10.1111/nph.19114

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