A plant's nutrient-sensing abilities can modulate its response to environmental stress

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Understanding how plants respond to stressful environmental conditions is crucial to developing effective strategies for protecting important agricultural crops from a changing climate. New research led by

Carnegie's Zhiyong Wang, Shouling, Xu, and Yang Bi reveals an important process by which plants switch between amplified and dampened stress responses. Their work is published by *Nature Communications*.

To survive in a changing environment, plants must choose between different response strategies, which are based on both external environmental factors and internal nutritional and energy demands. For example, a plant might either delay or accelerate its lifecycle, depending on the availability of the stored sugars that make up its energy supply.

"We know plants are able to modulate their response to environmental stresses based on whether or not nutrients are available," Wang explained. "But the molecular mechanisms by which they accomplish this fine tuning are poorly understood."

For years, Carnegie plant biologists have been building a treasure trove of research on a system by which plants sense available nutrients. It is a sugar molecule that gets tacked onto proteins and alters their activities. Called O-linked N-Acetylglucosamine, or O-GlcNAc, this sugar tag is associated with changes in gene expression, cellular growth, and cell differentiation in both animals and plants.

The functions of O-GlcNAc are well studied in the context of human diseases, such as obesity, cancer, and neurodegeneration, but are much less understood in plants. In 2017, the Carnegie-led team identified for the first time hundreds of plant proteins modified by O-GlcNAc, providing a framework for fully parsing the nutrient-sensing network it controls.

In this most recent report, researchers from Wang's lab—lead author Bi, Zhiping Deng, Dasha Savage, Thomas Hartwig, and Sunita Patil—and Xu's lab—Ruben Shrestha and Su Hyun Hong—revealed that one of the

proteins modified by an O-GlcNAc tag provides a cellular physiological link between sugar availability and stress response. It is an evolutionarily conserved protein named Apoptotic Chromatin Condensation Inducer in the Nucleus, or Acinus, which is known in mammals to play numerous roles in the storage and processing of a cell's genetic material.

Through a comprehensive set of genetic, genomic, and proteomic experiments, the Carnegie team demonstrated that in plants Acinus forms a similar protein complex as its mammalian counterpart and plays a unique role in regulating stress responses and key developmental transitions, such as seed germination and flowering. The work further demonstrates that sugar modification of the Acinus protein allows nutrient availability to modulate a plant's sensitivity to environmental stresses and to control seed germination and flowering time.

"Our research illustrates how plants use the sugar sensing mechanisms to fine tune stress responses," Xu explained. "Our findings suggest that plants choose different stress response strategies based on nutrient availability to maximize their survival in different stress conditions."

Looking forward, the researchers want to study more proteins that are tagged by O-GlcNAc and better understand how this important system could be harnessed to fight hunger.

"Understanding how plants make cellular decisions by integrating environmental and internal information is important for improving plant resilience and productivity in a changing climate," Wang concluded. "Considering that many parts of the molecular circuit are conserved in plant and human cells, our research findings can lead to improvement of not only agriculture and ecosystems, but also of human health."

More information: Yang Bi et al, Arabidopsis ACINUS is O-glycosylated and regulates transcription and alternative splicing of

regulators of reproductive transitions, *Nature Communications* (2021). DOI: 10.1038/s41467-021-20929-7