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Transgenic plants' 'die and let live' strategy dramatically increases drought resistance

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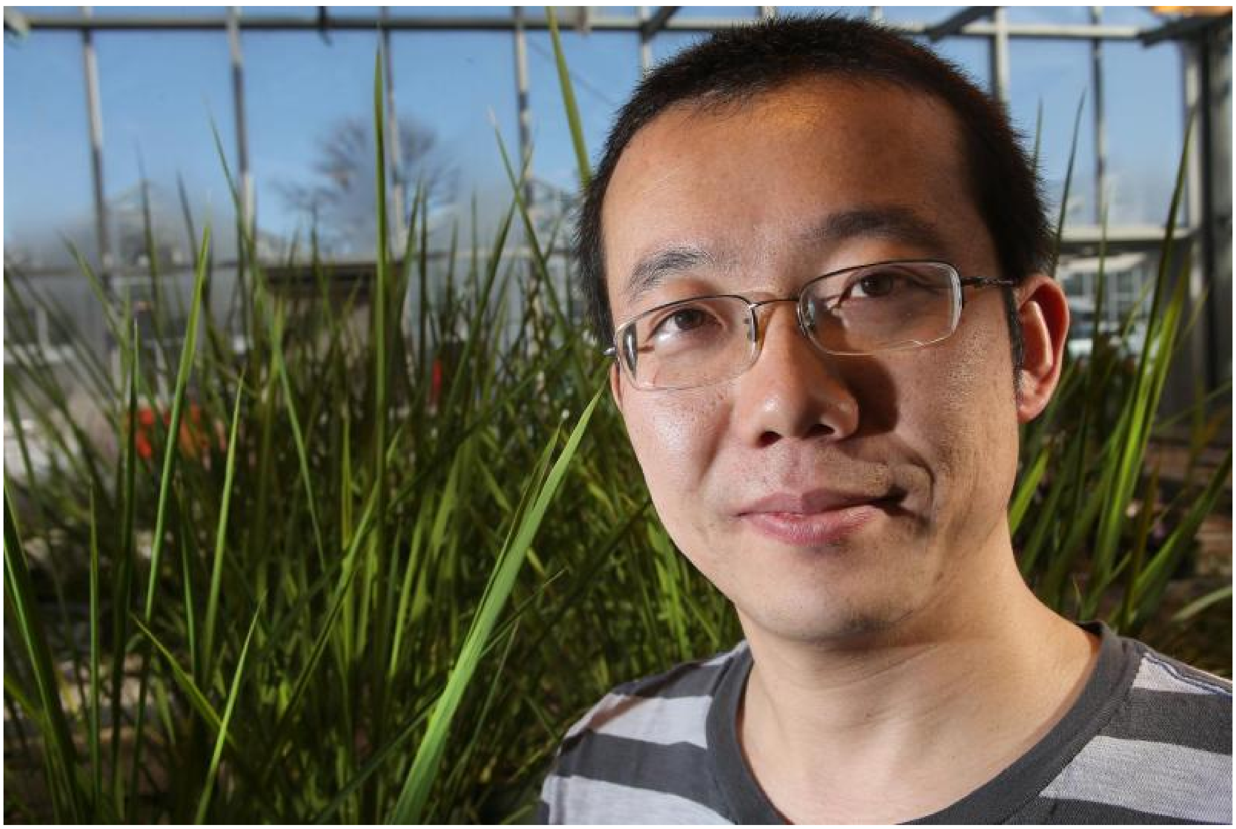

Yang Zhao, Purdue University horticultural researcher, found that engineering rice to produce high levels of the protein PYL9 can improve the crop's drought survival rate by 40 percent. Credit: Purdue University/Tom Campbell

Purdue University researchers found that engineering plants to produce high levels of a protein known as PYL9 dramatically boosted drought tolerance in rice and the model plant *Arabidopsis*.

Under severe drought conditions, the transgenic plants triggered the death of their old leaves—a process known as senescence—to conserve resources for seeds and buds, a survival strategy some plant scientists refer to as "die and let live."

The study offers insights into the drought survival mechanisms of plants and presents a possible means of protecting crops from severe drought stress.

"This study shows that controlled senescence is good for plants under drought conditions," said Yang Zhao, first author of the study and research assistant in the Jian-Kang Zhu lab in the Department of Horticulture. "This combination of death and life is similar to a triage strategy. If old leaves die, then the buds and small leaves might gain life."

Because plants can't flee drought, they deploy an array of survival strategies while awaiting better growing conditions. Their drought responses are controlled by a hormone known as abscisic acid (ABA), which regulates growth and development and directs plants' reaction to stress.

Plants' short-term drought responses include closing their stomata—holes that "exhale" water—and creating extra wax to seal moisture within leaves. Long-term drought conditions cause plants to go into dormancy and redirect water and nutritional resources away from leaves to sink tissues such as seeds and buds, reservoirs for new growth. A shriveled, leafless plant might appear dead but is often executing a line of defense.

Zhao and his fellow researchers found that altering plants to overexpress PYL9 made them highly sensitive to ABA. A stress-responsive promoter protein controlled the level of PYL9 expression in the plants.

The gene alterations enabled Arabidopsis and rice to better withstand severe drought stress and caused older leaves to yellow sooner compared with the plants' wild type counterparts.

PYL9 transgenic rice had a 50 percent survival rate after a two-week drought compared with 10 percent survival in wild type rice.Zhao cautioned, however, that the spike in survival rate does not mean that the yield of the transgenic plants under drought conditions would equal that of conventional rice varieties under good growing conditions. The study did not test for yield.

"We still can't really solve the problem of drought," he said. "But we can make it better. In extreme drought conditions, even a bad yield would be better than nothing in terms of preserving human life."

The transgenes did not affect plant growth and development under normal conditions, which suggests that they could be used to improve crop drought tolerance.

"It is challenging to figure out the specific function of individual PYL proteins," said Jian-Kang Zhu, distinguished professor of plant biology and the study's principal investigator. "This study not only illuminates the function of PYL9 in stress-induced leaf senescence but also demonstrates a great potential for using PYL9 to improve plant drought resistance."

Unexpectedly, when transgenic plants were treated with ABA under normal conditions, the old leaves started to wilt, even though the plants received enough water. This suggests that the plants had blocked their old leaves' access to water, preferentially driving water to developing tissues instead.

The research team concluded that during severe drought conditions, hypersensitivity to ABA leads to increased senescence and death of old leaves but protects young tissues by sending them into dormancy. The study also suggests that the ABA core signaling pathway plays a crucial role in plant survival during extreme drought and that senescence is a beneficial drought defense strategy, previously points of contention among plant scientists.

"This common connection finally uncovers the underlying molecular mechanism of drought-and ABA-induced leaf senescence and its association with the ability to survive extreme drought," Zhao said.

The study was published in *Proceedings of the National Academy of Sciences* on Monday, Feb. 1, 2016.

More information: ABA receptor PYL9 promotes drought resistance and leaf senescence, *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1522840113

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