

Defying frost and the cold with hormones

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Pictured are frozen flowers of an apple tree in South Tyrol, Italy that have been protected from damage by late frost with frost-protection sprinkling. Eremina et al show that in the freezing tolerance of plants steroid hormones take part, and elucidate molecular pathways, which contribute to this activity. Credit: D. Mitterer-Zublasing

Plants cannot simply relocate to better surroundings when their

environmental conditions are no longer suitable. Instead, they have developed sophisticated molecular adaptation mechanisms. Scientists at the Technical University Munich (TUM) in cooperation with the Helmholtz Center Munich and the University of Nottingham have been able to demonstrate that brassinosteroids, which until now have mainly been regarded as growth hormones, increase the resistance of plants against frost.

"Stress caused by cold is an environmental influence which has a direct effect on the growth and yield of plants", says plant molecular biologist Professor Brigitte Poppenberger. With her research group at the Biotechnology of Horticultural Crops institute at the TUM, she investigates the mechanisms used by plants to adapt to external influences. Her research activities have centered on brassinosteroids for quite some time.

In earlier work, her group already used common thale cress (*Arabidopsis thaliana*) as a model plant to demonstrate exactly how this plant hormone, which was identified for the first time in rapeseed in 1979, promotes plant growth. In fact, it had been known for a long time that this hormone plays a role in plant development. However, the exact mechanism of action was unknown. It was the work of the biotechnology experts at the TUM School for Life Sciences in Weihenstephan that first made it possible to gain a precise understanding of this phenomenon.

It's no coincidence that Brigitte Poppenbergers team once again picked *Arabidopsis* for the current study. Due to its relatively undemanding nature, simple structure, and its compact size, it isn't simply a favorite among geneticists in general—the tiny herb also provides optimal conditions under which to search for cold protection mechanisms in plants, as it's able to survive low temperatures and increase its tolerance to frost by adapting to the cold. In the current issue of the specialist journal "*Proceedings of the National Academy of Sciences*" (*PNAS*), the

scientists describe the hitherto unknown side of brassinosteroids, which up until now have been known as [growth hormones](#).

In order to gain a detailed understanding of their mechanisms, the researchers carried out experiments in which they exposed Arabidopsis plants to slowly decreasing temperatures. Experiments with wild-type varieties in the laboratory showed that as the temperature decreases, the plant reacts by beginning to modify the expression of genes for which DNA is transcribed to RNA within its cells. "This reduces its growth, which increases its chances of survival", Poppenberger explains, describing the natural protective mechanism of the normal plants.

A molecular path to 'winter fat'

The researchers obtained a different result with their experiments involving genetically modified model plants, which are no longer able to synthesize brassinosteroids themselves or recognize them as a signal. While wild-type varieties often still managed to survive temperatures of six degrees below zero, most of the mutants already displayed clear signs of damage at this point, which demonstrates the essential role steroid hormones play in this process. By analyzing the process, the researchers found that brassinosteroids increase frost resistance by regulating a protein called CESTA. This protein uses a signal cascade to control gene expression. In this manner, it in turn influences the protein composition of the cells, which among other things appears to lead to a change in the fatty acid composition. This ensures that the plant stocks up on a type of 'winter fat' on a molecular level, thereby protecting it from potential cold damage.

Spray-on steroids for plants

These exact findings regarding the order and type of chemical processes

for the effects of [steroid hormones](#) in plants are not only an important step forward for basic research into the adaptation strategies of plants. More importantly, according to the researchers, they may also provide solutions to problems, which have occurred in agriculture as a result of climate change. Although people generally only associate global warming with an increased occurrence of hot periods, it also causes an increase in the number of frost events, such as early and late frosts, which can lead to devastating harvest shortfalls. "The conventional method of breeding more resistant plants has not been very successful so far, as resistance to cold and reduced growth are difficult to separate", says Brigitte Poppenberger. But she's convinced that "our discovery that brassinosteroids boost both growth and cold resistance will open up new possibilities for bringing out both characteristics in plants." She asserts that it's also possible to spray crop [plants](#) with brassinosteroids to achieve both effects. "That may be a viable method—at least, that's what the findings suggest."

More information: Marina Eremina et al, Brassinosteroids participate in the control of basal and acquired freezing tolerance of plants, *Proceedings of the National Academy of Sciences* (2016). [DOI: 10.1073/pnas.1611477113](#)

Provided by Technical University Munich

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