How steroid hormones enable plants to grow

August 19 2014

The photo shows just how important brassinosteroids are for the development of plants. A deficit of the plant hormone has disrupted growth in the cucumber plant on the right. Credit: Wilfried Rozhon / TUM

Plants can adapt extremely quickly to changes in their environment. Hormones, chemical messengers that are activated in direct response to light and temperature stimuli help them achieve this. Plant steroid hormones similar to human sex hormones play a key role here. In the current edition of *Nature Communications*, scientists describe a new signaling mode for the brassinosteroid class of hormones.

Plants are superior to humans and animals in a number of ways. They have an impressive ability to regenerate, which enables them to regrow entire organs. After being struck by lightning, for example, a tree can grow back its entire crown. But there is one major downside to life as a plant: They are quite literally rooted to the habitats in which they live and therefore completely at the mercy of the elements. In response to this dilemma, plants have developed mechanisms that enable them to rapidly adapt their growth and development to changes.

Plant hormones are important enablers of this flexibility. Brassinosteroids play a key role here. These hormones have an effect at the lowest concentrations; they regulate cell elongation and division and are active throughout the entire lifecycle of a plant. A team of researchers from Technische Universität München (TUM) and the University of Vienna have now mapped a new signaling mode for brassinosteroids.

Meeting points for DNA-binding protein

When brassinosteroids bind to a receptor on a cell wall, they trigger a multi-level cascade of reactions that regulates the activity of the CESTA (CES) transcription factor. Transcription factors bind to the DNA in a cell's nucleus and are capable of activating genes that change the protein composition in the cell.

A team of scientists – headed by Prof. Brigitte Poppenberger at TUM's Institute of Biotechnology of Horticultural Crops – has been able to show for the first time that the concentration of CES protein increases in certain nuclear regions following brassinosteroid activation.

These structures occur as nuclear bodies in the cell nucleus. The scientists believe that the CES transcription factor collects in specific regions of the DNA in order to effectively control gene function. "The cell seems to bundle key resources to rapidly trigger the production of certain proteins. We can compare this to a construction site, for example, where workers temporarily gather at a certain location to unload building material," explains Poppenberger.

Brassinosteroids are growth hormones found in all plants. The steroid hormones were first isolated in rapeseed (*Brassica napus*) in 1979 and were subsequently named after this plant. Credit: A. Heddergott / TUM

New signal pathway

The scientists also mapped the mechanism that gives the CES molecules the signal to gather. The molecules have a binding site for SUMO protein. As soon as this attaches, CES moves to nuclear bodies. While this is happening, it is protected from being broken down by enzymes. "What is interesting here is that the SUMO marker seems to strengthen the effect of CES," continues Poppenberger. "This is the opposite of what happens in the animal world, where the SUMO protein is known to repress effects conferred by transcription factors."

The research findings are an important step towards understanding more about the functions of brassinosteroids. "We have been using other kinds of hormones to promote growth and increase crop yields in horticulture and agriculture for decades now," says Poppenberger. "But we have never leveraged the potential of brassinosteroids. Understanding how they work will help us utilize them for plant production. This is what we are aiming for in our work."

More information: Interplay between phosphorylation and SUMOylation events determines CESTA protein fate in brassinosteroid signaling; Mamoona Khan, Wilfried Rozhon, Simon Josef Unterholzner, Tingting Chen, Marina Eremina, Bernhard Wurzinger, Andreas Bachmair, Markus Teige, Tobias Sieberer, Erika Isono, and Brigitte Poppenberger, *Nature Communications*; DOI: 10.1038/ncomms5687

Provided by Technical University Munich