Scientists demonstrate plant stress memory and adaptation capabilities

May 31 2019

Photos from the expeditions are from the private collection of Victor Bulgakov.
Credit: Victor Bulgakov

Russian and Taiwanese scientists have discovered a connection between the two signaling systems that help plants survive stress situations, demonstrating that they can remember dangerous conditions that they have experienced and adapt to them. This memory mechanism will help improve agricultural plants, making them more resistant to drought, flooding, high humidity and extreme temperatures.

Plants are stressed when exposed to extreme temperatures or a lack or overabundance of water. This negatively affects the growth of the plant, which leads to losses of up to one-half of crops worldwide. As a means of self-protection, plants use the stress hormone abscisic acid (ABA) mediated signaling, which produces stress resistance to extreme situations. Such signaling systems play an important role in organisms, acquiring information from the environment and adjusting internal processes to external conditions.

Scientists suggest that the ABA system is linked with the heat shock protein/chaperone system, and these two systems work together in different stressful situations.

Biologists still do not fully understand the coordination and sequence of events in these signaling systems. There have been no studies that would connect these two defence mechanisms, although it is clear that they must work in a coordinated manner in nature. It is believed that these discoveries will lead to breakthrough technologies in crop bioengineering. More specifically, they may help overcome the main problem of agriculture—growth retardation and development anomalies in stress-resistant crops.

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The study was carried out by researchers from the Federal Scientific Center of the East Asia Terrestrial Biodiversity of the Far Eastern Branch of the Russian Academy of Sciences in collaboration with colleagues from Taiwan. The research team set out to identify the relationship between ABA and heat-shock protein signaling. The researchers used popular model plant Arabidopsis, as it goes through the full development cycle in six weeks, which made it possible to speed up the experiments.

"In our earlier work, we obtained a map of protein-protein interactions in Arabidopsis. Now, we have analyzed this map and discovered that the only factors linking the two systems are the SWI/SNF chromatin-remodelling proteins, which are involved in the formation of the 'stress memory' effect," explained the project leader, Dr. Victor Bulgakov, a Head of Bioengineering Laboratory at the Federal Scientific Center of the East Asia Terrestrial Biodiversity of the Far Eastern Branch of the Russian Academy of Sciences and one of the authors of the article.

The stress memory effect is one of the main mechanisms of plant defence: the plant "remembers" extreme conditions they have experienced. Stress signals sensed through the ABA and heat-shock protein signaling systems are perceived and then stored via the SWI/SNF chromatin-remodeling proteins, changing the structure of the chromatin (the DNA-protein complex). As a result, plants acquire a stress resistance to conditions that they have already experienced. The mechanism studied has become a reference point for new bioengineering technologies that the researchers have termed "bioengineering memory.""

In the course of the study, the researchers also systemized a large array of information and found that when correcting the ABA and heat-shock protein/chaperone pathways, the state and changes of the plants' memory to the previous stress must be taken into account.

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In the future, the researchers plan to move away from Arabidopsis to agricultural crops. They note that the work on improving plants will be different for each country.

"The most popular crops in the Russian Far East are rice, soybeans and corn. It is important to increase their resistance to cold and water deficit. In Taiwan, work needs to be done to increase the resistance of plants to heat and drought. In fact, this is the most pressing issue in the world as a

whole right now. New approaches in 'memory bioengineering' may help solve both problems," Dr. Bulgakov concluded.

More information: Victor P. Bulgakov et al, Coordination of ABA and Chaperone Signaling in Plant Stress Responses, *Trends in Plant Science* (2019). DOI: 10.1016/j.tplants.2019.04.004