Researchers describe how Vitamin E works in plants under extreme conditions

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The new study highlights the biological role of vitamin E in the process of cell communication that goes from chloroplast to the cell nucleus. Credit: Sergi Munné-Bosch (Research Group ANTIOX of the University of Barcelona)

Vitamin E is a strong antioxidant that could act as a sentinel in plants, sending molecular signs from chloroplast, a cell organelle, to the nucleus under extreme environmental conditions. This is among the conclusions of an article published in *Trends in Plant Science* by Sergi Munné-Bosch and Paula Muñoz from the Faculty of Biology of the University of Barcelona (UB).

This flow of information reaching the cell nucleus, retrograde signaling, is a molecular mechanism that eases the adaptive response of plants in physiological stress situation (salinity, lack of nutrients, drought, senescence, etc.).

A communication pathway from chloroplast to cellular nucleus

Vitamin E gathers a group of molecules with natural origins—tocopherols and tocotrienols—synthesized by photosynthetic organisms. These molecules, which have similar function and chemical structures, differ from each other in their distribution and location. While tocopherols are distributed globally in the plant kingdom, tocotrienols are only found in certain species and organs, and are regarded as secondary metabolites.

The new study highlights the biological role of vitamin E in the process of cell communication between chloroplast and cell nucleus. "The role of vitamin E would be to send signals from the chloroplast to the nucleus to make a cell reprogramming at a molecular scale and unchain proper responses to several stress situations. This flow of information going to the cell nucleus would regulate key aspects of development in plants, such as senescence of organs (leaves, flowers), or ripening of fruits," says Sergi Munné-Bosch, lecturer at the Department of Evolutionary Biology, Ecology and Environmental Sciences, and ICREA Academia.

Chlorophyll degradation route

The best characterized vitamin E synthesis so far combines two routes: the one in the non-mevalonate pathway, which generates the phytyl or geranylgeranyl in the chemical structure of tocopherols and tocotrienols, respectively, and the one in shikimic acid, which produces homogenistic acid—and then the chromanol ring—in both antioxidants.

There is also another synthetic pathway for vitamin E with the chlorophyll degradation. "This is a biologically important route in the plant field, and as a result, a chemical compound is created: phytol. It would finally enable obtaining the phytyl without participation of methylerythritol phosphate," the authors write.

The new pathway is possible when VTE5 and VTW6, two enzymes with kinase activity, are activated and ease the conversion from phytol to phytyl diphosphate, and thus, the entry of this molecule into the biosynthesis of tocopherols. "We know little about how this alternative biosynthetic route is regulated, but we know it acts in stress situations and senescence related to an active degradation of chlorophyll," says Sergi Munné Bosch, head of the Research Group ANTIOX of the UB.

Vitamin E is involved in physiological processes related to the growth, photoprotection, blooming, longevity and senescence of plants. "It is an essential factor in the protection of photosynthetic and non-photosynthetic tissues. If there is a lack of vitamin E, the effects on plants can be higher or lower depending on the species, the studied organ, and mostly, the conditions under which the experiment is undertaken if talking about a research study. In general, the higher the stress the plant is under, the bigger effect we will see."

A better understanding of the role of vitamin E in non-photosynthetic tissues of plants—roots, nodules, reserve tissues, some flowers and some

kinds of fruits—is one of the future work lines for the Research Group ANTIOX of the UB, which will work on new research studies in the field of biotechnology, food and eco-physiology.

"All these findings are relevant for fundamental biology and for biotechnology since they will enable a modification of aspects such as ripening of fruits and longevity of flowers, before and after the harvest," conclude the authors.

More information: Paula Muñoz et al, Vitamin E in Plants: Biosynthesis, Transport, and Function, *Trends in Plant Science* (2019). DOI: 10.1016/j.tplants.2019.08.006

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