

# (SD2020-397) Identification of the plant stomatal CO<sub>2</sub> sensor and uses thereof

Tech ID: 33201 / UC Case 2021-Z08-1

## ABSTRACT

Drs. Schroeder and Takahashi of UC San Diego have discovered and characterized a stomatal CO<sub>2</sub> sensor and the underlying mechanism in plants. This unique plant CO<sub>2</sub> sensor shows very strong phenotypes in mutants, with complete lack of a CO<sub>2</sub> response. Moreover, the researchers can reconstitute this CO<sub>2</sub> sensor with the recombinant protein complex in vitro. They are using this discovery to further develop genetic applications to modify CO<sub>2</sub> sensing and water use efficiency in plants. The researchers have identified two protein kinases, which regulate a Raf-like protein kinase which in turn controls another Raf-like kinase activity in response to change in CO<sub>2</sub>/bicarbonate concentration in vitro. Mutants in each of these proteins completely disrupt CO<sub>2</sub> responses in plants, consistent with our CO<sub>2</sub> sensor findings. Biochemical structure analyses reveal important phosphorylation sites and provide insight into the direct CO<sub>2</sub> sensing and signaling core mechanism in plant cells.

## DESCRIPTION

This invention solves a long-term question of how plants sense atmospheric [CO<sub>2</sub>] changes, and provides a potent tool for improving plant water use efficiency and plant performance under water-limited and also in regions with water-replete conditions, given the continuing steep increase in the atmospheric CO<sub>2</sub> concentration.

Plants control water loss and control gas exchange between plant leaves and the atmosphere via stomatal pores. This exchange of gases includes CO<sub>2</sub> influx for photosynthesis, O<sub>2</sub> efflux, and transpirational water loss through stomatal pores in their leaves. Plants lose over 90% of their water by transpiration. The balance of exchange of water loss and CO<sub>2</sub> intake is achieved by a proper control of stomatal apertures in response to environmental stimuli.

Elevation in atmospheric [CO<sub>2</sub>] induces stomatal closure and impacts plant growth and dramatically water-use efficiency and crop yields. With the present 50% higher CO<sub>2</sub> concentration in the atmosphere compared

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## OTHER INFORMATION

### CATEGORIZED AS

- ▶ Agriculture & Animal Science
- ▶ Plant Traits

### RELATED CASES

2021-Z08-1

to 100 years ago, and the continuing increase in the CO<sub>2</sub> concentration, plants could take in the same amount of CO<sub>2</sub> from the atmosphere, while losing 33% less water. However, the CO<sub>2</sub>/bicarbonate sensor that controls plant transpiration and water use efficiency has remained unknown.

## APPLICATIONS

Traits that can be engineered:

Enhance drought tolerance of crop plants.

Enhance growth under the present and continuing elevated CO<sub>2</sub> concentration of crop plants.

Enhance early monitoring of CO<sub>2</sub> elevation effects, drought and heat stress by crop plants and trees.

Early mounting of stress resistance in crop plants and trees.

## STATE OF DEVELOPMENT

This patent-pending technology is available for commercialization. Contact UC San Diego's Office of Innovation & Commercialization for availability.

## RELATED MATERIALS

- ▶ Takahashi Y, Bosmans KC, Hsu PK, Paul K, Seitz C, Yeh CY, Wang YS, Yarmolinsky D, Sierla M, Vahisalu T, McCammon JA, Kangasjärvi J, Zhang L, Kollist H, Trac T, Schroeder JI. Stomatal CO<sub>2</sub>/bicarbonate sensor consists of two interacting protein kinases, Raf-like HT1 and non-kinase-activity requiring MPK12/MPK4. *Sci Adv.* 2022 Dec 9;8(49) - 12/07/2022
- ▶ Dubeaux G, Hsu PK, Ceciliato PHO, Swink KJ, Rappel WJ, Schroeder JI. Deep dive into CO<sub>2</sub>-dependent molecular mechanisms driving stomatal responses in plants. *Plant Physiol.* 2021 Dec 4;187(4):2032-2042 - 12/04/2021
- ▶ Schulze S, Dubeaux G, Ceciliato PHO, Munemasa S, Nuhkat M, Yarmolinsky D, Aguilar J, Diaz R, Azoulay-Shemer T, Steinhorst L, Offenborn JN, Kudla J, Kollist H, Schroeder JI. A role for calcium-dependent protein kinases in differential CO<sub>2</sub> - and ABA-controlled stomatal closing and low CO<sub>2</sub> -induced stomatal opening in *Arabidopsis*. *New Phytol.* 2021 Mar;229(5):2765-2779. doi: 10.1111/nph.17079. Epub 2020 Dec 9. - 12/09/2020

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