CalClim

Plant adaptation to calcareous soil upon climate change

The evolution of the climate is predicted to exacerbate the impact of environmental stresses on agriculture. Increasing average temperature, heat wave episodes and drought are among the major threats for plant growth and yield. Strikingly, at the worldwide scale, most of the zones predicted to be highly impacted by high temperatures overlap with the distribution of calcareous soils. These soils, that represent more than 30% of the earth surface in temperate, Mediterranean and tropical regions, are characterized by very high concentrations of carbonates that establish high alkaline soil conditions. This particular soil composition severely affects the concentration and availability of nutrients (N, P, Fe, Mn, Zn, Cu) and also provokes nutritional imbalances between elements such as K, Mg and Ca. The typical effects of these nutritional disorders on plants are leaf chlorosis and stunted growth.

Clearly, climate change, expansion of cultures to poor soils and increasing price and scarcity of fertilizers are threatening the crop yields. Therefore, there is an urgent need to improve both the nutritional use efficiency and the tolerance to high temperatures of crops in order to maintain global food safety.

From a biological point of view, the main question raised by this combination of environmental clues is how plants perceive, respond and adapt to multiple stresses, since it has been established that responses to multiple stresses do not merely correspond to the addition of responses to individual stress. In particular, the impact of heat wave episodes on plants growing on calcareous soils has, to the best of our knowledge, never been addressed.

The CalClim project proposes to tackle this important agronomical and biological question using two model plant species, Arabidopsis thaliana, Medicago truncatula and a crop, durum wheat. The project will be articulated around several axes where we will couple (i) a thorough physiological characterization (root architecture, shoot biomass, chlorophyll content, photosynthetic activity, ionomics) of the responses of plants to the combination of high temperatures (HT) and a calcareous soil condition (addition of bicarbonates, BiC, to growth media), (ii) gene expression responses to HT and BiC treatments by transcriptomic and epigenomic analyses, (iii) the use of natural variations to perform Genome Wide Association Studies (GWAS) on the traits described above, (iv) the combination of the information generated by gene expression and GWAS by systems biology approaches to identify key master regulators, gene regulatory networks and functional modules involved in the responses to this multiple stress. This project will also represent a unique opportunity to develop a translational biology approach where a crop species is used, in parallel to model plants, to directly address fundamental biological questions.

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