CHEW

Carbon-Hungry Rice and Wheat

ABSTRACT

The concentration of CO2 in the atmosphere has dramatically increased since the pre-industrial period and may, within the next few decades, reach 600 ppm irrespective of the ongoing policies to reduce human-based C emission. This increase is expected to promote crop yield in particular in C3 species (whose photosynthesis directly depends on external CO2 concentration) as predicted by experiments under elevated CO2 (eCO2) and model projections. However, there is also growing evidence that C3 cereals tend to be carbon sink limited under eCO2 due to the inability of sinks such as reproductive parts to benefit from additional C available, causing a downregulation of photosynthetic called acclimation. Large gains in eCO2 yield response are therefore expected if sink eCO2 responsiveness can be selected for. As costs of breeding in CO2 FACE field trials are prohibitive, proxy traits able to predict eCO2 sink response based on evaluation under current CO2 could be of high value to orientate breeding towards genotypes making the most of eCO2.

CHEW aims to provide validated, predictive proxies for two major cereals of world diet, rice and wheat. We will search for such proxies under the specific conditions these species are most often encountering in the field: flood for rice and water-limitation for wheat. The later condition is of high interest because drought is expected to further limit sink strength more than photosynthesis (source). Genetic diversity of sink:source trait interactions and plasticity will be studied under current (400) and projected (600 ppm) [CO2]. Drought effects will be studied at vegetative and grain filling stages. Different acclimation processes will be analyzed and modelled, involving photosynthetic regulation, CHO pools, developmental and morphological plasticity, and N-dilution due to enhanced growth.

The project has a duration of 2 years and will require funding of 190 k EUR.
Main outputs will be i) physiological understanding of eCO2 acclimation processes and traits contributing to them as well as interactions between eCO2 and drought, ii) protocols for validated proxy traits to be applied in phenotyping and breeding, iii) candidate genes for proxy traits in rice, later usable for translational genetic research on wheat.

Keywords : Acclimation to enhanced [CO2], Acclimation, Proxy traits, Sink-source relationships, Photosynthesis, Water deficit, Rice, Wheat

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Research units in the network :
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End date : 2023-12-31
Flagship project : no

Project leader : Michael Dingkuhn
Project leader's institution : CIRAD
Project leader's RU : AGAP LEPSE

Budget allocated : 190000 €
Total budget allocated (including co-financing) : 190000 €
Funding : Labex

GOAL

CHEW’s general objectives are to (i) understand traits controlling feedbacks of sources on sinks under climate change conditions and (ii) enable rice and wheat breeders to select for greater growth and yield response to eCO2, generating more productive and water-use efficient crops. This will enable effective breeding for greater yields of two world staples under rising [CO2] while saving water. Such breeding is impossible without reliable proxy traits, as costs of CO2-FACE trials are prohibitive.
Easily observable proxy traits predicting eCO2 response of flooded rice and rainfed wheat will be developed and validated. Interactions with water deficit will be studied for wheat. Two types of eCO2 acclimation will be studied, i) photosynthetic downregulation via sink limitation and N dilution (source); and ii) developmental and structural acclimation (sink adjustment). We will study genotypic variation for both species, and genetics of proxy traits only for rice as a as model for future translational research.
AGAP Institut (PHENOMEN team) will lead the work on rice and the UMR LEPSE that on wheat, involving modeling approaches that are a strength of both partners. The project’s goals fall into the units’ core competencies, as they address pre-breeding for crop adaptation to climate change.

ACTION

Three WPs will i) identify and validate proxies in controlled environments (CE), ii) study interactions with drought in CE (wheat only), and iii) study the genetics for proxies by GWAS using existing field phenotype data. WP4 will focus on the outreach of the project through a mini-workshop with potential users. The UMR AGAP will lead the rice work and the UMR LEPSE that on wheat. CHEW plays into the strengths of both units and will generate impact via their extensive partnerships with breeders. An associated partner at WUR (NL) with whom both groups regularly collaborate will contribute to the modelling.