Speeding the Adjustment of Photosynthesis to Shade-Sun Transitions to Increase Yield Potential in the Field

Project Lead

Name: Elizabete Carmo-Silva
Institution: Lancaster University, GBR

Principal Investigators

Name: Stephen Long
Institution: Lancaster University, GBR

Name: Gemma Molero
Institution: CIMMYT, MEX

Abstract

Recent findings, including field proof-of-concept, show improvement of photosynthetic efficiency to be a major, and largely untapped, target for achieving the "Breakthrough" sustainable crop yield increases needed to meet future food demand. Efforts to date have focussed on increasing efficiency under steady-state (constant) conditions. However, in the field the light environment of every single leaf is constantly changing. A considerable increase in productivity could be achieved by accelerating the speed at which photosynthetic efficiency adapts to the rapidly changing light environment. We have recently shown that slow adjustment of photosynthetic efficiency in the wheat flag leaf during shade-sun transitions could cost 20% of potential carbon uptake over the course of a day. The overall objective of this project is to tap this unrealised potential by accelerating induction of photosynthesis through breeding. To do so, we will utilize a high-throughput, leaf level, modulated chlorophyll fluorescence screen to identify genetic variation in speed of photosynthetic induction among a total of 200 elite and synthetic high biomass lines in the field at CIMMYT (HiBAP and SynPan). Based on this screen, the 20 best lines will be selected for more detailed analysis to establish the relationship of CO2 assimilation induction kinetics with Rubisco activation in vivo and in vitro and identify the underlying mechanism for faster photosynthetic induction by establishing its association with variation in

Rca sequences, relative abundance of isoforms and regulation of activity in response to light-induced stimuli. To determine the suitability of wheat germplasm showing fast induction speeds for producing higher grain yields we will evaluate field productivity of the 20 lines to estimate heritability and contribution to yield in multiple environments, including through low and middle-income country partners covering mega-environments 1 & 4. GWAS using induction-related traits and Rubisco activation traits collected over 2 years will enable identification of SNPs associated with increased speed of induction, particularly with respect to Rca. The main direct outcome of this project will be: photosynthetic induction-related traits included for the first time in the wheat breeding pipeline. Lines with faster photosynthetic induction will be backcrossed into elite parents, and the developed HTP method for screening will facilitate early generation selection to accelerate the progress towards substantial grain yield increases.