

## Strategies to Increase Photosynthetic Efficiency, CO<sub>2</sub> Fixation and Resource Allocation in Crops.

Heike Sederoff<sup>1</sup>, Nathan Wilson<sup>1</sup>, Brianne Edwards<sup>1</sup> and Danny Schnell<sup>2</sup>

<sup>1</sup>North Carolina State University, Dept. Plant and Microbial Biology

<sup>2</sup>Michigan State University, Department of Plant Biology

<https://groecamelina.natsci.msu.edu>

### Project Goals:

One of the major limitations in photosynthetic carbon fixation occurs when O<sub>2</sub> competes with CO<sub>2</sub> at the active site of ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco), resulting in the oxygenation of ribulose-1,5-bisphosphate (RuBP). This reduces CO<sub>2</sub> fixation and leads to the non-productive photorespiratory pathway at a significant energy cost and net loss of fixed carbon. Photorespiration accounts for a 30-40% decrease in the efficiency of carbon fixation in C<sub>3</sub> photosynthesis, the pathway of carbon fixation used by the majority of crops, including Camelina, and about 85% of all terrestrial plant species. Our team is developing several distinct, but complementary approaches to address the limitations of CO<sub>2</sub> fixation in source tissues and increase seed yields in the model oilseed crop, Camelina sativa.

### Abstract:

To increase the efficiency of biofuel crops to produce oil from photosynthetic CO<sub>2</sub> fixation, we designed and implemented several metabolic pathway modifications into our model oil seed crop Camelina sativa. One of the major limitations of photosynthetic CO<sub>2</sub> fixation is due to low activity and specificity of the CO<sub>2</sub>-fixing enzyme Ribulose bisphosphate Carboxylase/Oxygenase (RuBisCO) and the CO<sub>2</sub> conductivity of the membrane systems surrounding RuBisCO. Other bottlenecks are due to the export control of assimilated carbon in form of sucrose from the photosynthetic leaf to the seeds and other sink tissues and the allocation of sucrose in seeds to increase the oil content. We used genetic engineering to a) increase the CO<sub>2</sub> conductivity of the leaf tissue by expression of a CO<sub>2</sub> transporter; b) expression of a synthetic CO<sub>2</sub> fixation cycle based on bacterial enzymes; c) expression of a photorespiratory bypass to reduce CO<sub>2</sub> loss; and d) reduction of a cell wall invertase inhibitor to reduce the limitation of sucrose phloem loading and unloading. While each modification (a-d) was successful in generating overall yield increases, integration of those traits show yield increases that are more dependent on environmental conditions like photoperiod and light intensity. This research will enable us to understand mechanisms underlying the integration of genotype and environment to optimize the use of genetic engineered traits in different bioenergy crops and growth regions.

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