How sugars fuel growth: An integrated understanding of the role of sugar transport and signaling in growth regulation under climate change

Aim:

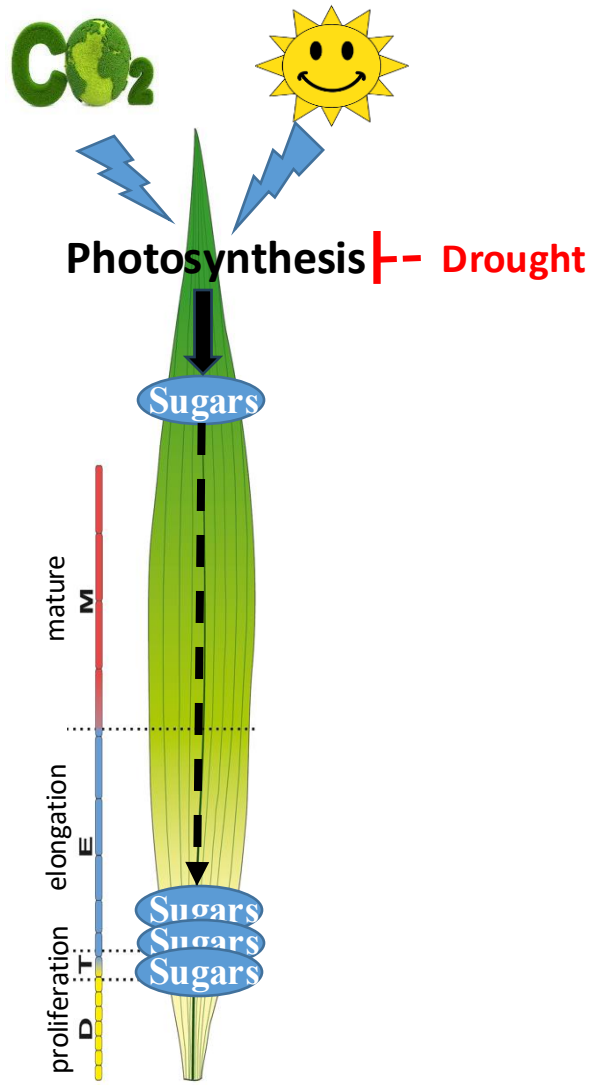
How is growth coordinated with sugar availability at the base of the maize leaf?

Why sugars:

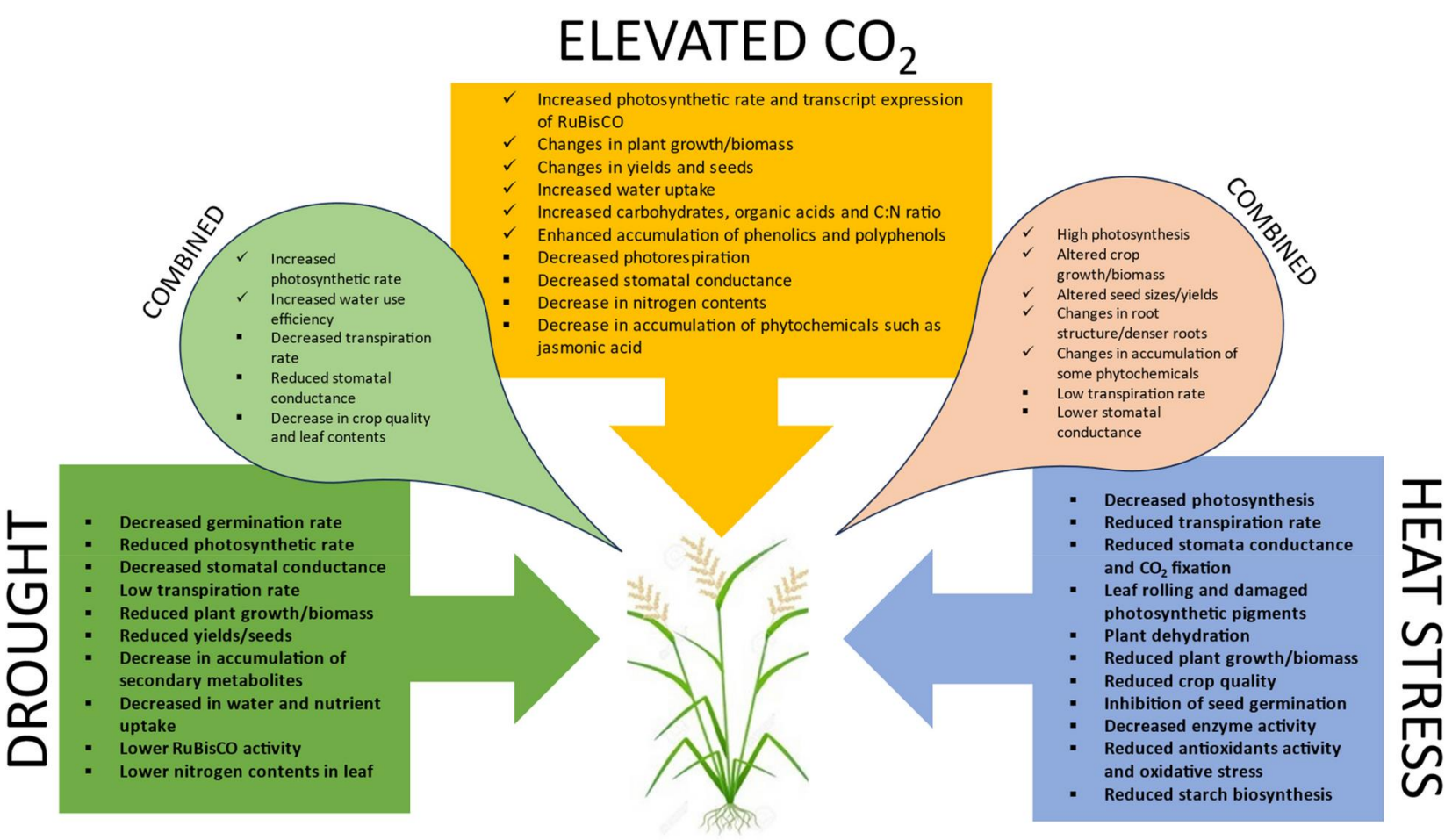
Sugars, the product of photosynthesis, are both the energy source to drive plant growth, the building blocks to execute it, and the signal to modulate it.

Hypothesis:

Sugar transport from mature to growing zones in maize leaves regulates leaf growth under climate change by balancing stress defense and controlling cell division and expansion through a novel molecular mechanism.

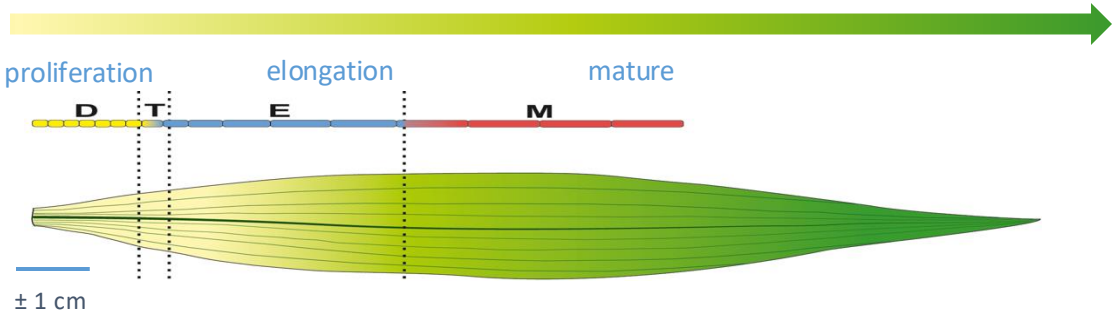


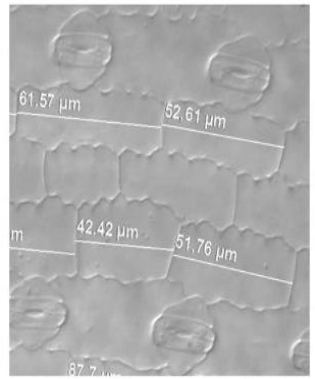
Climate change impact

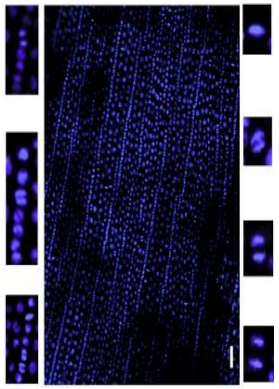


Novelty: **C**limate change impact sugar production in mature tissues. Whole-plant source-sink dynamics, focussing on how mature leaves export photoassimilates to other sink organs of the plant is well studied. However, this project uniquely examines **how sugar signaling controls cellular growth and stress responses specifically in the leaf growth zone of maize leaves.**

Why maize leaf as a model system?



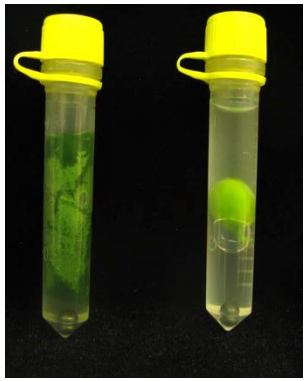


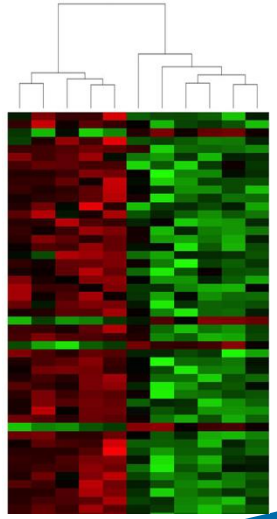


The young maize leaf has an extensive period of steady-state growth, in which

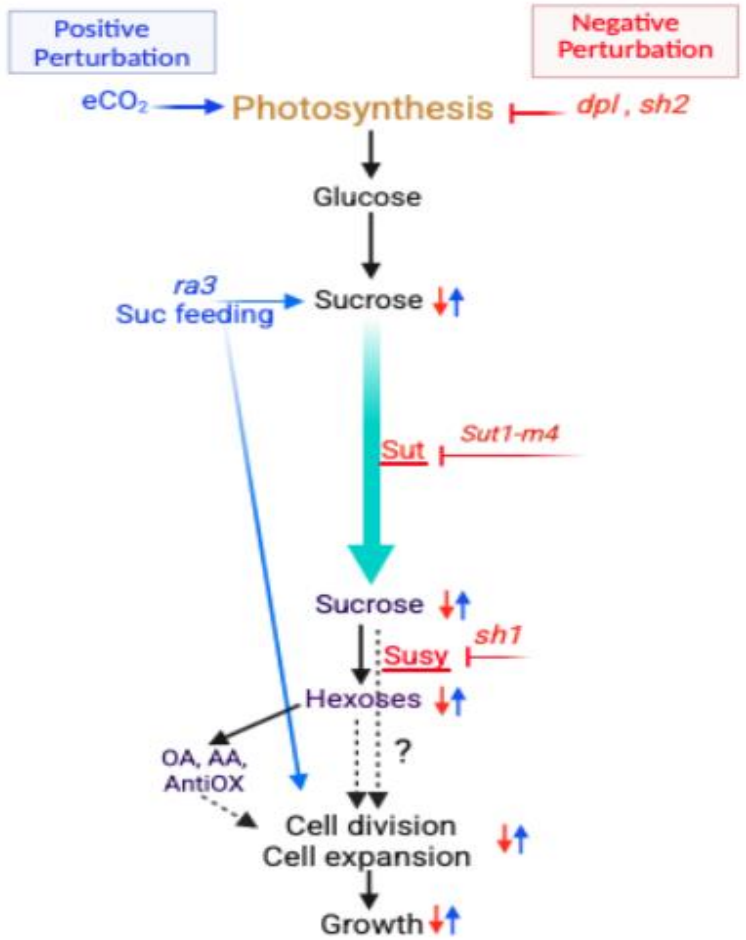
- **Kinematic growth analysis** allows quantification of cell division and expansion

- **The size of its growth zone** allows sampling for molecular and metabolic analyses





Key Results: impact of perturbation of sugar availability in the meristem on leaf growth at a high temporal regulation ?



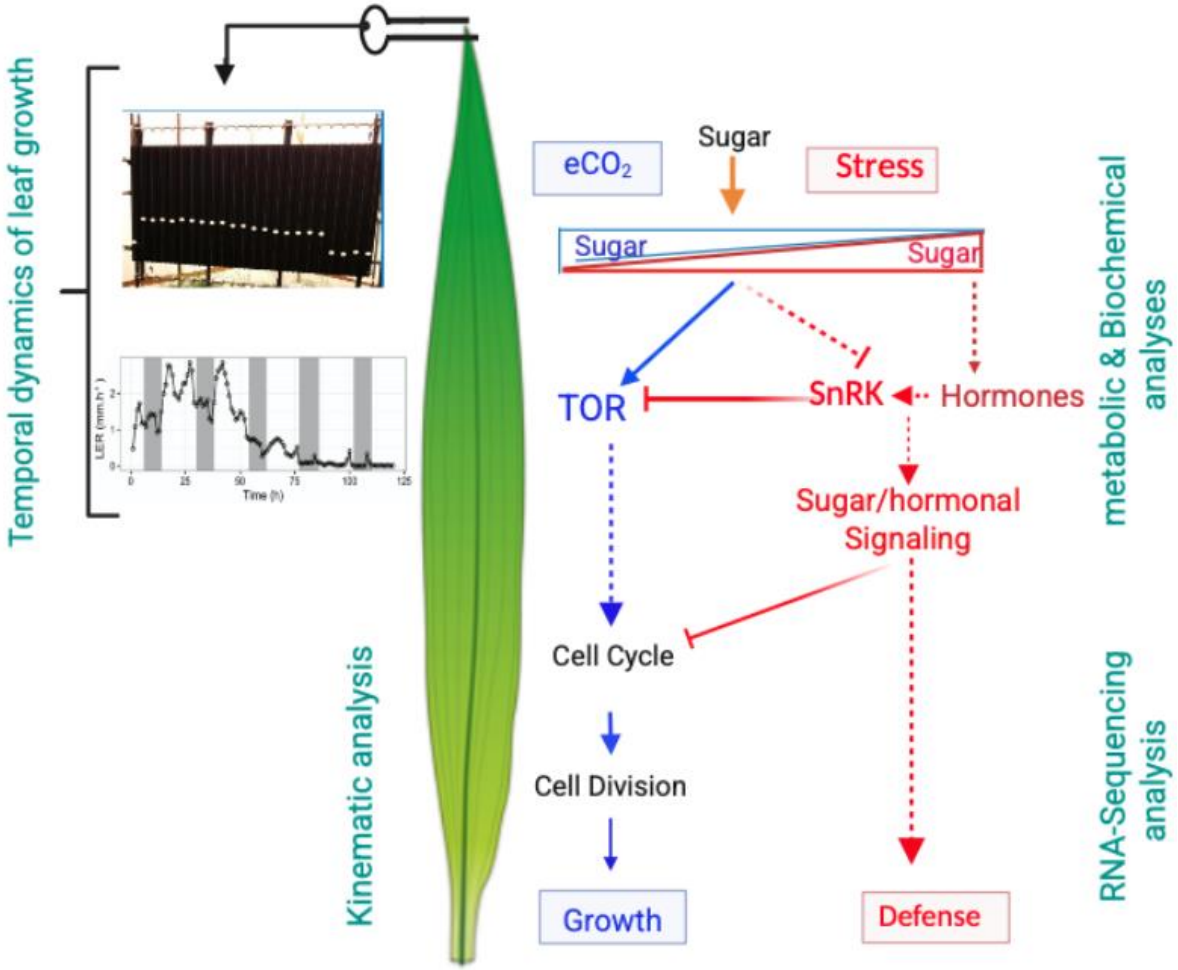
We found that perturbation of sugar transport/supply affects leaf cell division.

Examples include:

- *sut*1 (defective in sucrose transport), mn1 (cell wall invertase), sh1 (sucrose synthase), *sh*2 (ADP-glucose pyrophosphorylase), and *dpl* (dwarf & pale) mutants, all showing reduced growth zone sugar and cell division.
- A mutant (*ra*3) with elevated sugar in the growth zone shows increased meristem size, cell division, and organ growth.
- Increased sugar influx into the meristem under eCO_2 promotes growth; reduced sugar availability slows growth by limiting cell division.

This highlights the critical role of sugar availability and transport in regulating maize leaf meristem activity and growth under varying environmental conditions.

Identifying the cellular, molecular and biochemical basis of sugar-controlled leaf growth during the day/night cycle



Key Analyses:

1. **Sugar level manipulation (sugar feeding and sugar mutants)**
2. **Temporal growth dynamics of leaf growth using leaf length tracker**
3. **Kinematic analyses**
4. **Metabolic and biochemical analyses**
5. **Transcriptome analyses (RNA-Seq)**

A framework of methodological approaches includes leaf length tracking (for diurnal growth analysis), kinematic analysis (cellular analysis), RNA-seq and biochemistry analysis to study responses to sugar fluctuations under eCO_2 and drought conditions.

Methodology

Sugar perturbation under climate change

Supplying the plants with sugars through the cut tips of the leaves

Mutant affected in sugar metabolism and transport :
Cell wall invertase (*mn1*)
sucrose transporter1 (*sut1*)

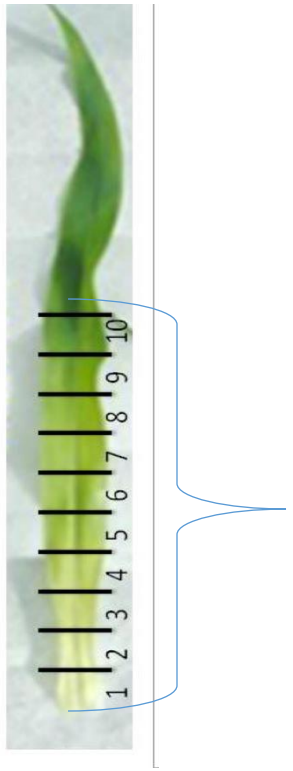
Sucrose Supply

WT ***sut1*** **WT** ***mn1***

Growth dynamics

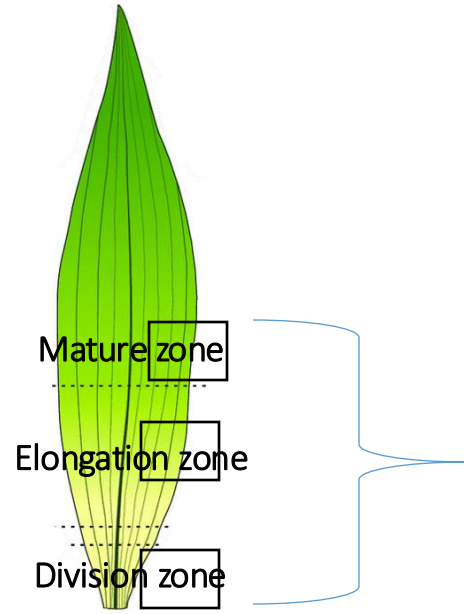
Leaf length tracker system
measures the leaf length at a time scale of minutes

Biochemical Analysis



Metabolome
Metabolite analyses
Pathway analyses
Chromatography
Spectrometry

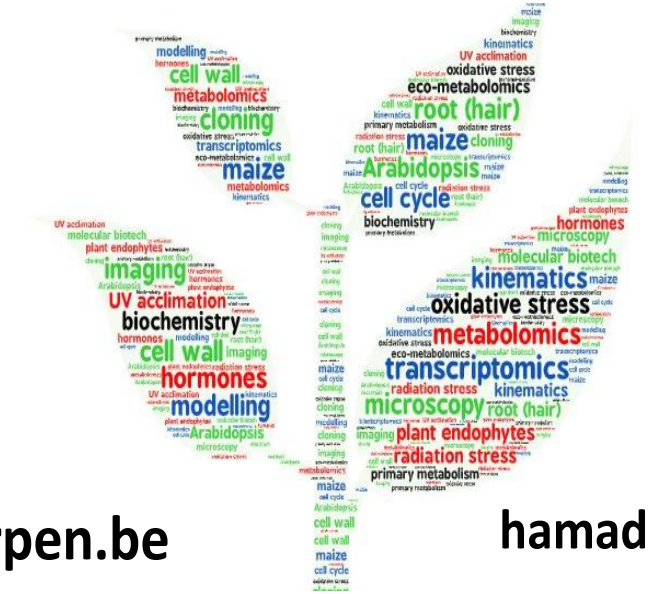
Transcriptional Analysis



Transcriptome
RNA sequencing (NGS)
Genes expression analysis
Pathway analysis
Bioinformatic

Where to find us?

Universiteit Antwerpen



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Integrated Molecular Plant Physiology Research