CAPITALISE

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BREEDING FOR BETTER PHOTOSYNTHESIS

- **>60% increase in world crop productivity is needed by 2050**
- **typically ≤ 1% annual increases in crop yields**
- **innovation is needed NOW**

BENEFITS FOR BREEDERS

Photosynthesis is the only remaining major trait available for improvement to further increase crop yield

INCREASED YIELD

- Research indicates improving photosynthesis can increase crop yield

40% increase in wheat grain yield has been achieved through transgenic manipulation of specific enzymes in the Calvin-Benson Cycle

20% improvement in carbon assimilation rate in wheat can be gained by faster activation of the critical enzyme RuBisCO

SAVED WATER

- Stimulation of photosynthesis can lead to enhanced water-use efficiency under field conditions.
- Decreased chlorophyll content can reduce transpiratory water loss.

25% reduction of water use was observed in field grown transgenic tobacco plants with altered photoprotection levels.

N_2 SAVED NITROGEN

- C3 crops invest about 60–80% of leaf nitrogen in the chloroplasts.
- Reducing over investment of crops in chlorophyll-binding proteins has the potential to save nitrogen.

OUR IMPROVEMENT STRATEGIES

1. TUNING THE CALVIN-BENSON CYCLE

The Calvin-Benson Cycle is responsible for assimilation of atmospheric CO_2 into sugar phosphates used for growth and development.

There is potential to increase crop yield by eliminating inefficiencies of this Cycle, such as improving the poor catalytic properties of RuBisCO, and optimising key enzymes in the regeneration phase**.**

Transgenic line Wild type

Transgenic wheat with **improved photosynthesis, increased total biomass and dried seed yield.** (Modified from Driever et al. 2017 [1])

2. PHOTOSYNTHESIS IN THE CHANGING LIGHT

Plants in full sunlight activate a protective mechanism and dissipate damaging excess absorbed light energy as heat.

Slow responses to both increases and decreases in light intensity limit photosynthesis. **Faster recovery of photoprotection has been shown to increase plant biomass by 15%.**

3. TUNING LEAF CHLOROPHYLL CONTENT

The light harvesting apparatus of plants has shown the tendency to be optimized for low light.

Limiting over investment in chlorophyll-binding proteins could save resources and allow more light to reach lower leaves.

In modern agriculture, optimised sowing density improves light canopy penetration. **Tuning chlorophyll can improve light use efficiency.**

The maize Photosynthetic Mutant library [2] includes **accessions displaying low chlorophyll content**.

References: [1] DOI: 10.1098/rstb.2016.0384; **[2]** http://pml.uoregon.edu/photosyntheticml.html

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