CABBI
CENTER FOR ADVANCED BIOENERGY AND BIOPRODUCTS INNOVATION

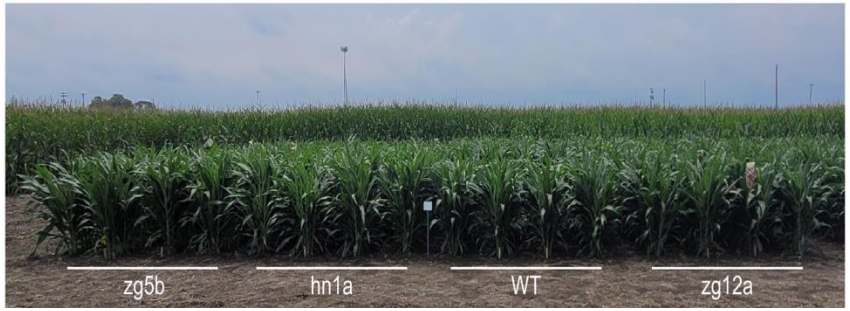
# Adapting $C_4$ Photosynthesis to Atmospheric Change and Increasing Productivity by Elevating Rubisco Content in Sorghum and Sugarcane

## *Background/Objective*

$C_4$ crops, while few in number, account for a large proportion of agricultural productivity, including bioenergy and bioproducts. Rising atmospheric [$CO_2$] has very recently made Rubisco, the enzyme used for all carbon fixation in plants, the greatest limitation to light-saturated photosynthesis in $C_4$ crops.

## *Approach*

To test the hypothesis that this improvement would be more generally possible across this key economic clade of crops and result in increased productivity in the field and greenhouse, Rubisco was upregulated in both sorghum and sugarcane.




**Side view of 4 of the 24 four-row plots of the four sorghum genotypes tested at boot stage in the field in Urbana, Illinois summer 2023.**

## *Results*

We successfully overexpressed the Rubisco small subunit (*RbcS*) with Rubisco accumulation factor 1 (*Raf1*) in both sorghum and sugarcane, resulting in significant increases in Rubisco content of 13 to 25% and up to 90% respectively. Light-saturated leaf $CO_2$ assimilation rates increased 12 to 15% and Rubisco enzyme activity ~40% in three independent transgenic events of both species. Sorghum plants also showed increased speeds of photosynthetic induction. These improvements translated into average increases of 15.5% in biomass in field-grown sorghum and a 37 to 81% increase in greenhouse-grown sugarcane.

## *Significance/Impacts*

This suggests a potential opportunity to achieve substantial increases in productivity of this key economically important clade of $C_4$ crops, future proofing their value under global atmospheric change.

Salesse-Smith et al. 2025. "Adapting C4 photosynthesis to atmospheric change and increasing productivity by elevating Rubisco content in Sorghum and Sugarcane." *PNAS*. DOI: 10.1073/pnas.2419943122.