# *Estimating organ contribution to grain-filling in wheat cultivars with contrasting source-sink balance*

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# Important concepts in source-sink balance

- **Source:** organs or traits (leaves, photosynthesis, water soluble carbohydrate, leaf area, biomass, light interception).

- **Sink:** organs or traits (grains, structural stem, TGW, grains/$m^2$).

- **Co-limitation:** grain growth or yield is limited by source and sink.

- **Source-sink balance:** the difference between the potential amount of assimilate available for grain filling and the capacity of the grains to store it (Bingham *et al.* 2007).

- **Source-sink manipulation treatments:**
  - Degraining spikes after grain number is set

Bingham, et al. 2007. *FCR* 01(2), 198–211. https://doi.org/10.1016/j.fcr.2006.11.004

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# Background

- Yield is generally sink-limited in favourable growing conditions (Borras et al, 2004).
- Experiments where grain number was boosted by light treatment (Reynolds *et al.* 2005) indicated that while source limits grain set pre-anthesis, sinks limits realization of photosynthetic capacity post-anthesis.
- In modern cultivars, grain growth may be limited by both the source and sink capacity (co-limitation) (Acreche & Slafer 2009).
- Simultaneous increases of source size and sink size are a crucial task in breeding for higher yield potential.


Acreche and Slafer, 2009. *FCR* 110(2), 98–105. http://dx.doi.org/10.1016/j.fcr.2008.07.006
Aisawi et al. 2015. *CS* 55(4), 1749. https://doi.org/10.2135/cropsci2014.09.0601
Borras, 2004. *FCR* 86(2–3), 131–46. https://doi.org/10.1016/j.fcr.2003.08.002
Lopes et al. 2012. *CS* 52(3), 1123. https://doi.org/10.2135/cropsci2011.09.0467
Reynolds et al. 2005. *AAB* 146(1), 39–49. https://doi.org/10.1111/j.1744-7348.2005.03100.x


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# Research questions

i) What is the source sink balance status of elite CIMMYT spring wheat cultivars? Is there a difference between older versus modern cultivars?

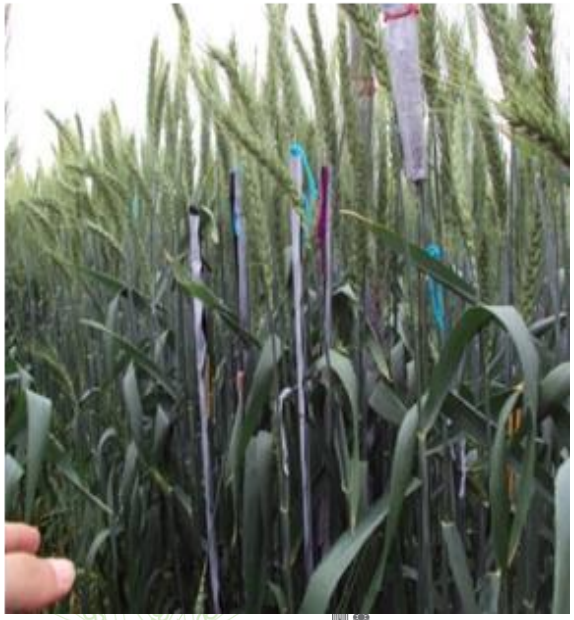
ii) What is the photosynthetic contributions of top-three leaves and stem + sheath to final grain weight (GW)?

iii) Is it possible for plants to upregulate photosynthesis and pre-anthesis reserves translocation to grain in response to artificial reductions in source?

# Field trials under yield potential conditions

# Treatments and traits

- **Source sink manipulation treatments**
  - Degraining (26)
  - Defoliation, top three leaves (9)
  - Stem shading (4)
  - Unmanipulated control shoots



# Treatments and traits

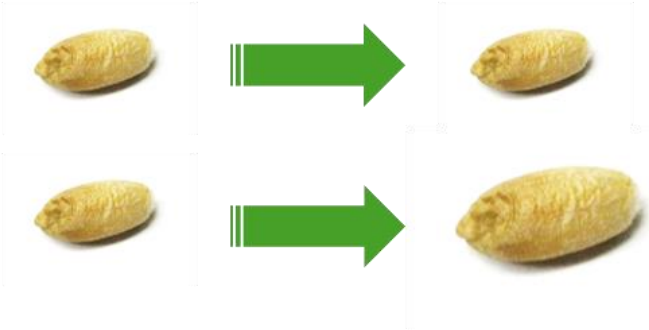
- **Traits and responses**
  - Final grain weight (GW)
  - Contribution of pre-anthesis reserves (CPA, %)
  - Dry-matter translocation efficiency (DMTe, %)
  - Flag-leaf and spike photosynthesis (PS)
  - Light interception, green area index (for estimations of reductions by defoliation)

# Interpreting results from source sink manipulation treatments

## Degraining

**Limitation by *Sink***

***Co-limitation to source limitation***



GW response: 0 – 10% increase = sink limitation
GW response: 10 – 30% increase = co-limitation to source limitation

## Defoliation or shading

Organ contribution estimated by % reductions in GW as a response to the treatment

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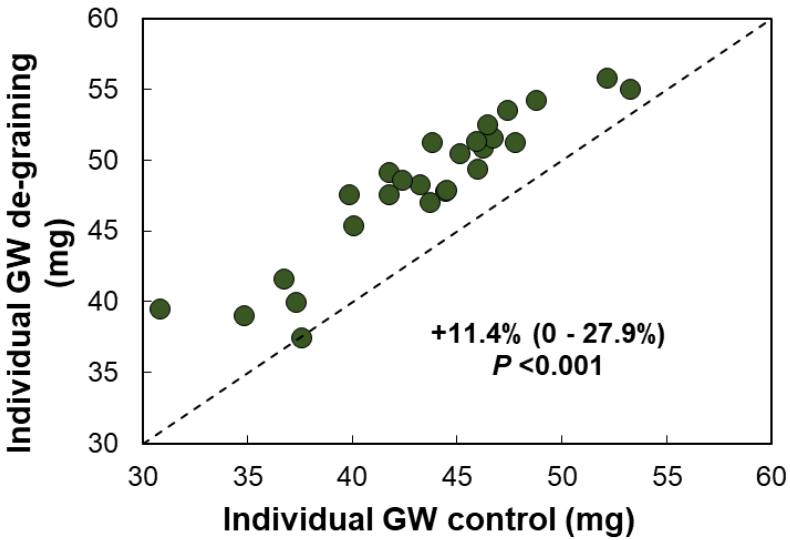
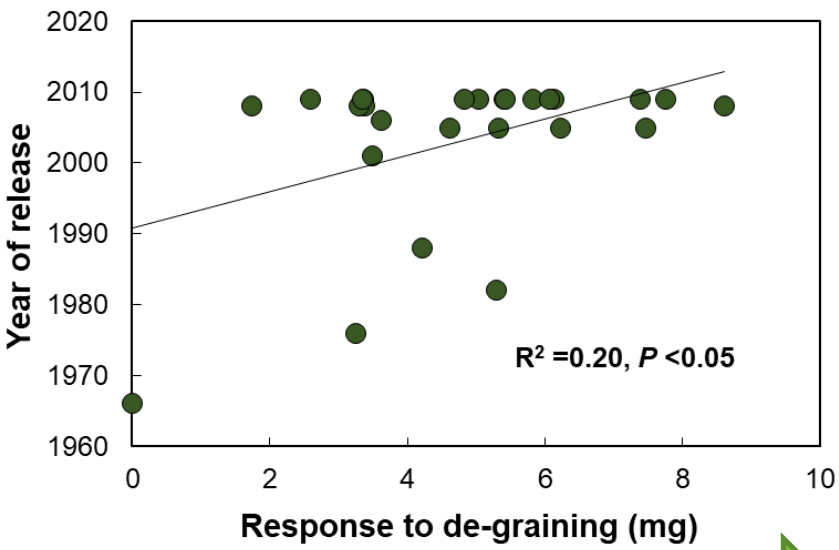
# De-graining treatments results




Sink <----------> Source lim

GW responses were in average +11.4% with a range of 0 to 27.9% (*P* <0.001).

Year of release versus GW response to degraining indicated a higher extent of source limitation in modern cultivars.

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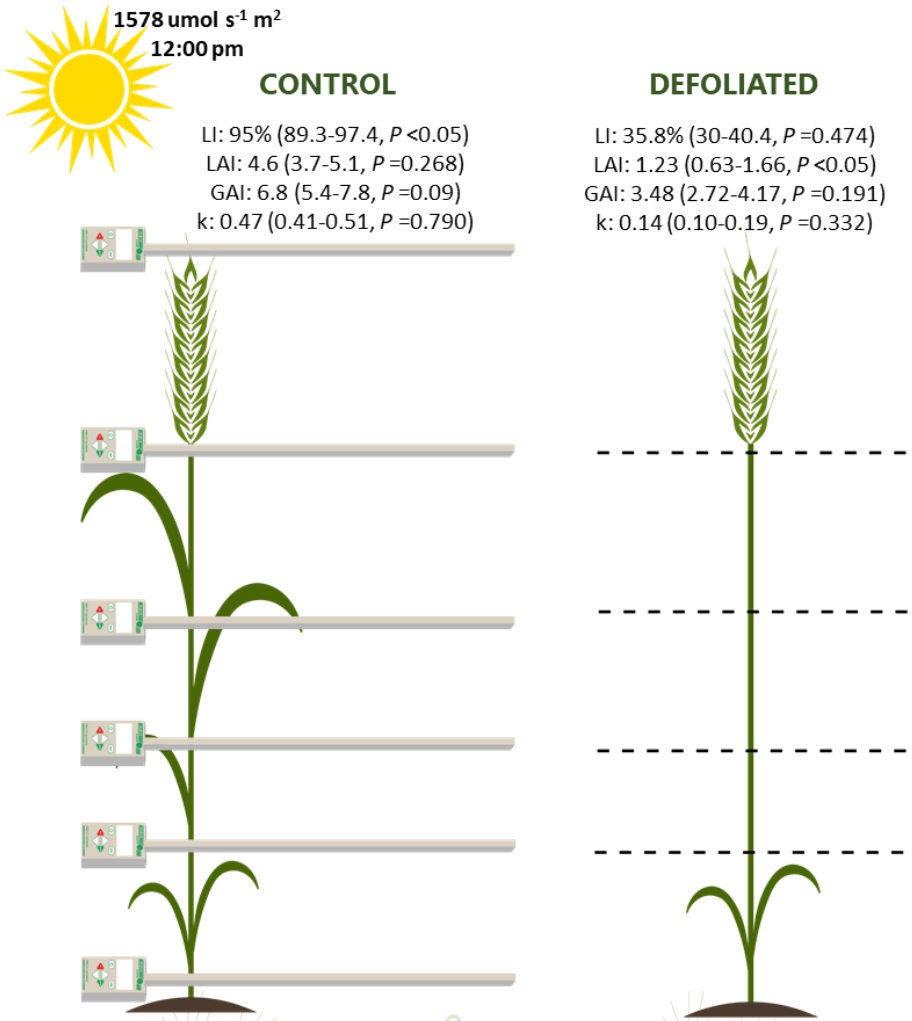
# Reductions in light interception and green area




- LI was reduced from 95.0% in control shoots to 35.8% in defoliated shoot: ***-62%***
- GAI from 6.8 in control shoots to 3.5 in defoliated shoots: ***- 49%***

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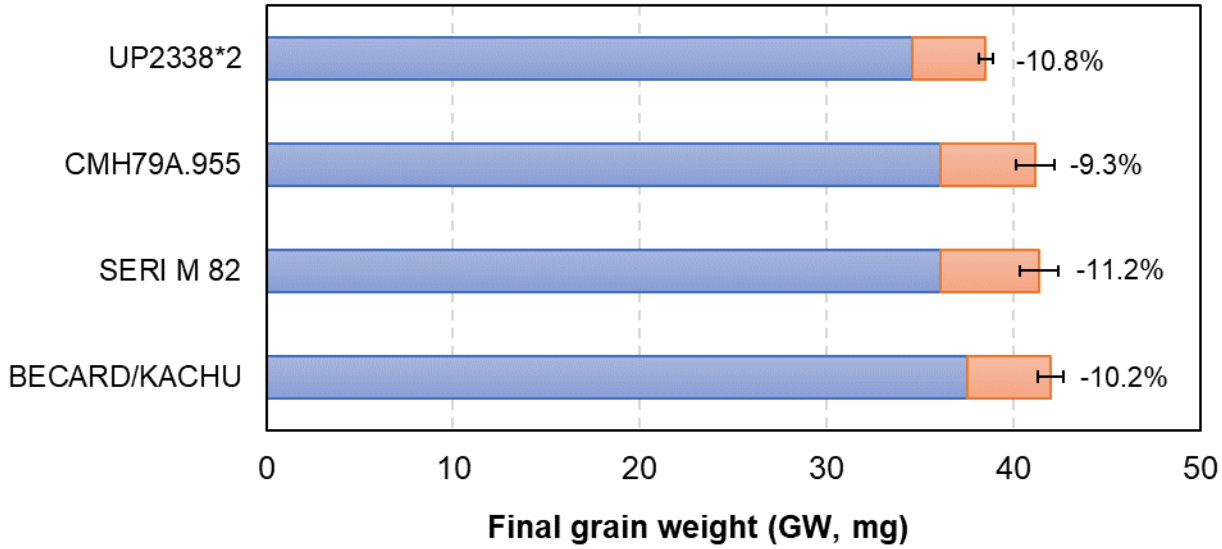
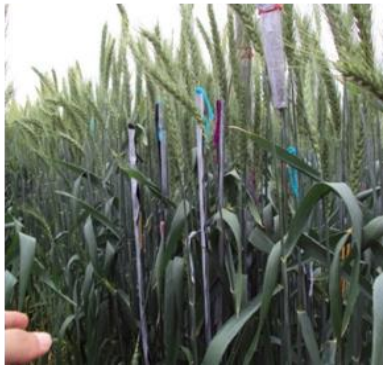
# GW responses by stem shading – contribution of leaves to GW



- GW responses for stem covering ranged from -9.3 to -11.2% (average of -10.3%).
- There were no significant cultivar differences for GW response to StemCOV (similar stem area too).

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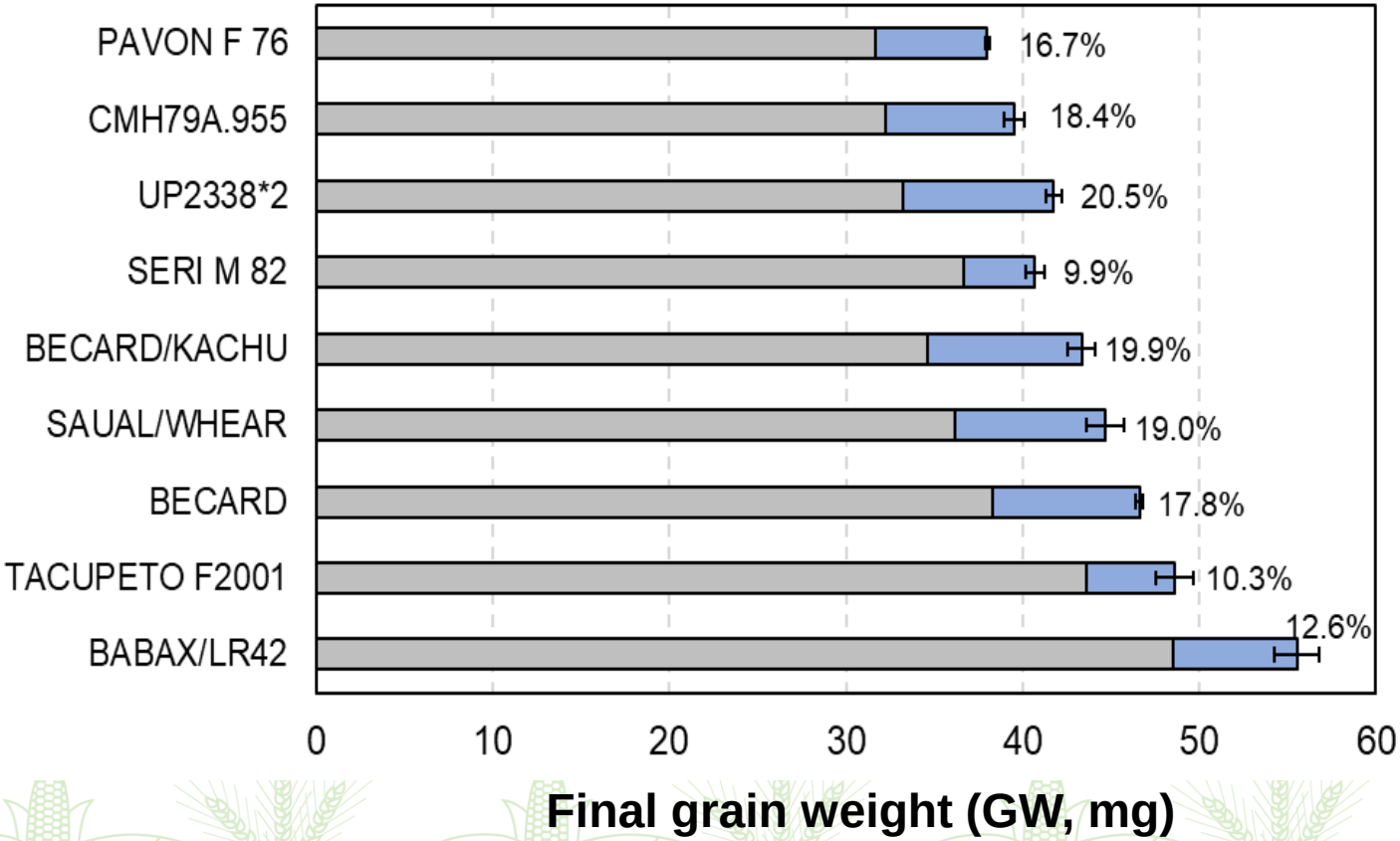
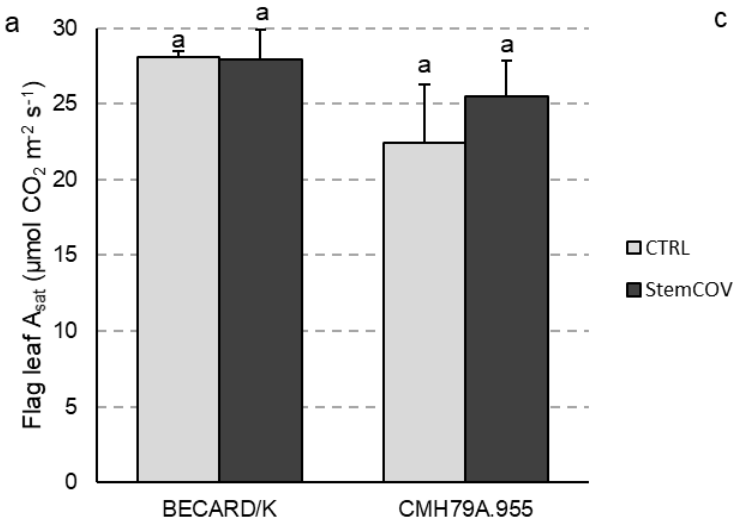
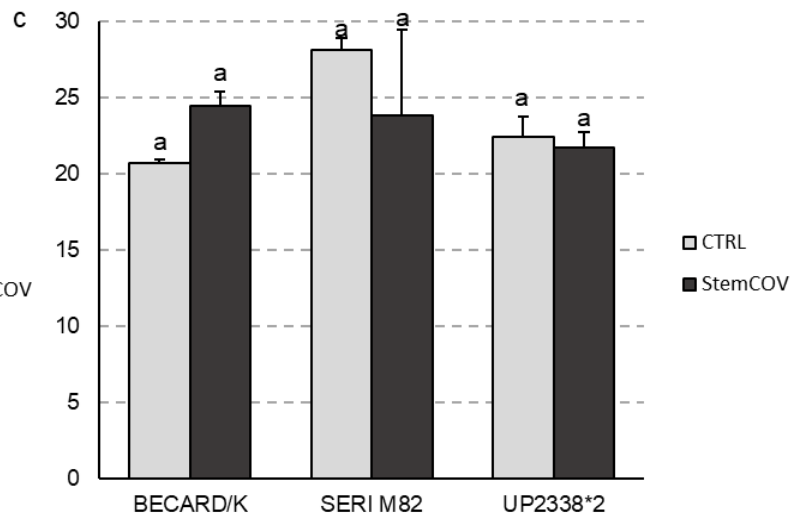
# GW responses by defoliation of top three leaves – contribution of leaves to GW

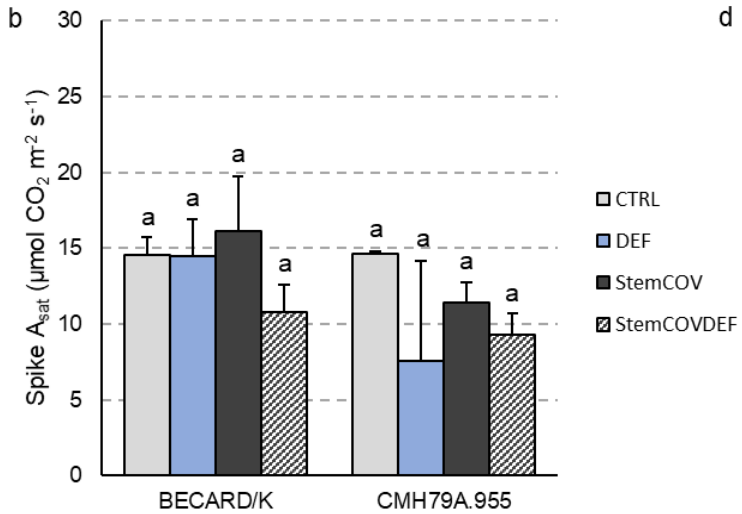
The average GW response (% reduction) in defoliated shoots was **17%** across 9 cultivars (*P* <0.001).

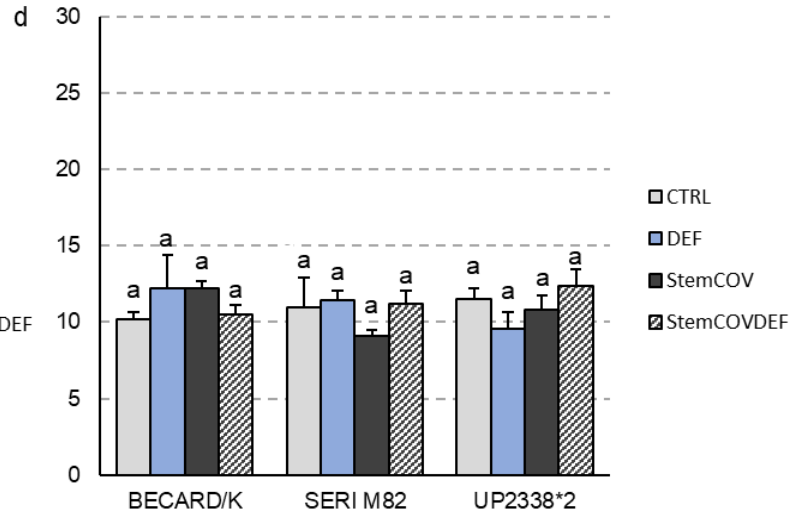



# Flag-leaf and spike photosynthesis

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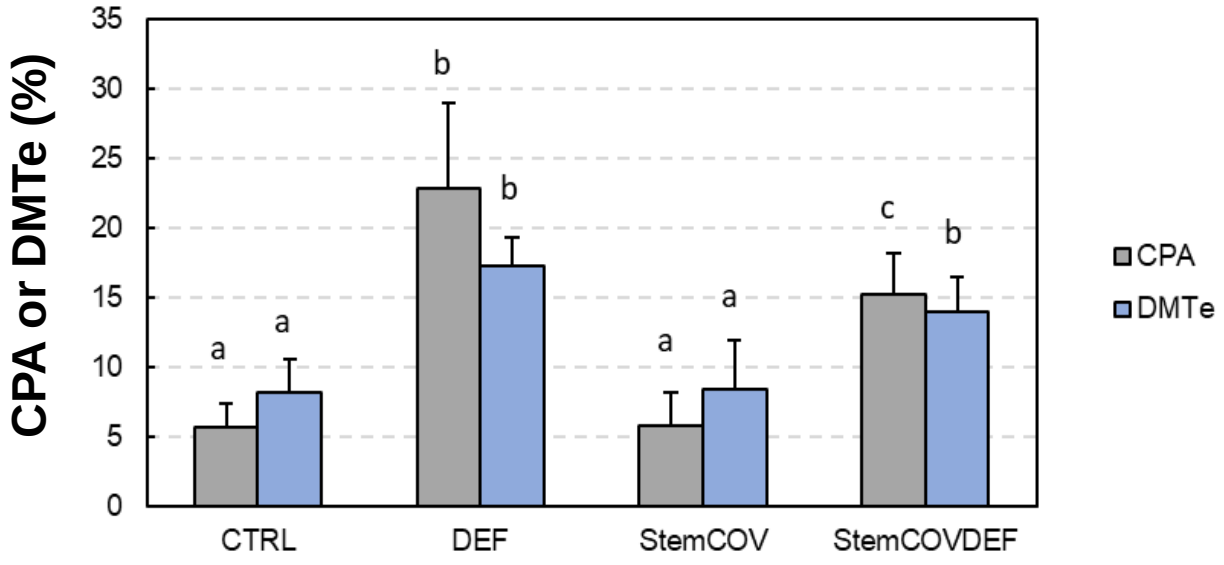
# Contribution of pre-anthesis reserves (CPA) and dry-matter translocation efficiency (DMTe)




- CPA was ~59% higher in defoliated shoots compared to control shoots with significant differences among cultivars.
- DMTe was ~54% higher in defoliated compared to control shoots with significant differences among cultivars.

# Conclusions

- Degraining increased grain weight (GW) between 0 to 28% suggesting both sink and source-sink co-limitation.
- Modern elite and historic lines were more limited by source than older lines.
- Even with extreme reduction in light interception (60%) during grain filling, grain weight reduction was moderate (ca. 17%).
- Stem Ps contributes 10% to GW during grain filling, similar to previous estimates of FL contributions.
- We did not detect PS upregulation in response to reductions in source but the contribution of pre-anthesis reserves was doubled.

# Thanks for your attention!

# Thanks to the funders!

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