

# Assessing Uniformity in Soil Plant Atmosphere Chambers

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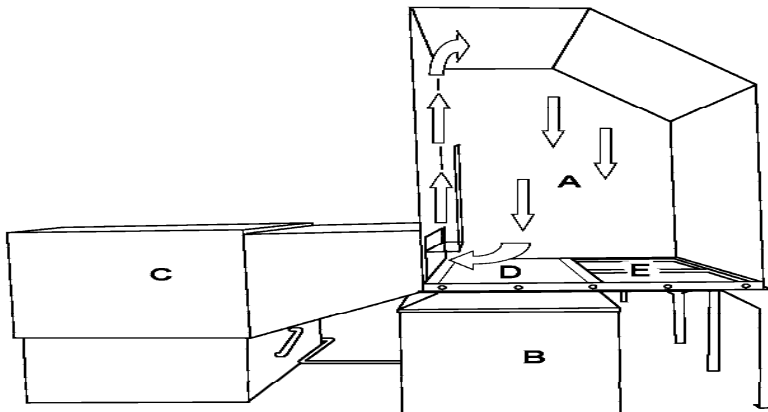
**Crop Systems and Global  
Change Laboratory  
USDA-ARS  
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# SPAR Chambers

## 'Soilbin' Growth Chambers

- 12 chambers
- Realistic Root Volume (2m x 0.5m x 1 m)
- Precise and Repeatable Environmental Controls
- Automated Irrigation / Fertigation
- Whole Canopy Gas Exchange (A, ET)
- Root Imaging / Tracing
- Soil Moisture
- 5-Minute Automated Data Logging



# Background / Goals

- Question: Are treatments influenced by chamber bias?
  - Limited replication (time and space)
  - Quantitative (regression) vs. Qualitative (means) analysis
  - Implications for scientific quality, transferability, design
- Goal: Assess crop response differences between and within chamber to identical ‘treatment’ conditions
  - Between all 12 chambers
    - Are differences significant? Why?
  - Within each chamber
    - Are there location effects? Are they consistent?



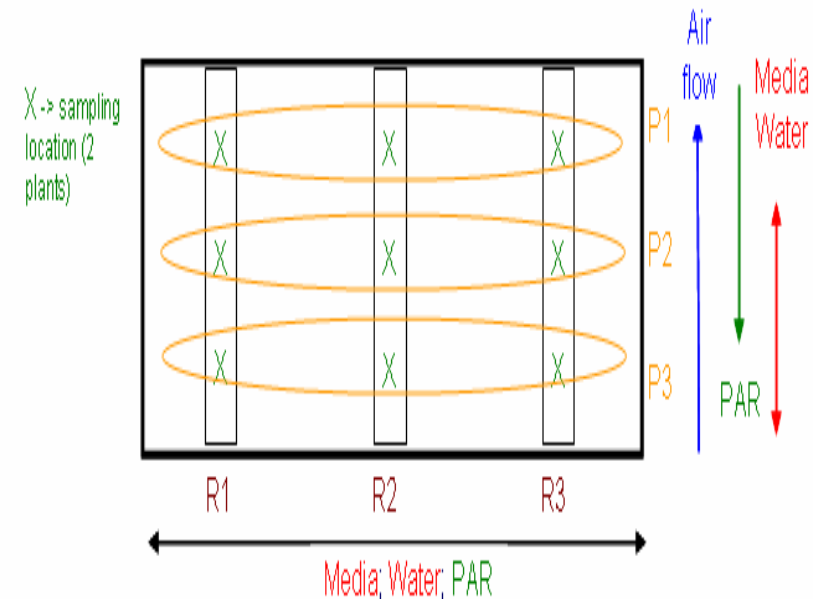
# Approach

- Fast-growing, uniform crop
  - Dwarf wheat (*Triticum aestivum* L. cv. USU-Apogee)
- Identical production conditions
  - 16h 23/18C; 740  $\mu\text{mol mol}^{-1}$  CO<sub>2</sub>
  - 10 L fert. (1/2 Woody's)
- Analysis approach
  - Summary of growth environment
  - Crop responses:
    - Biweekly measurements
    - Dry weights
    - Whole canopy photosynthesis

Evaluate for between chamber variability and within

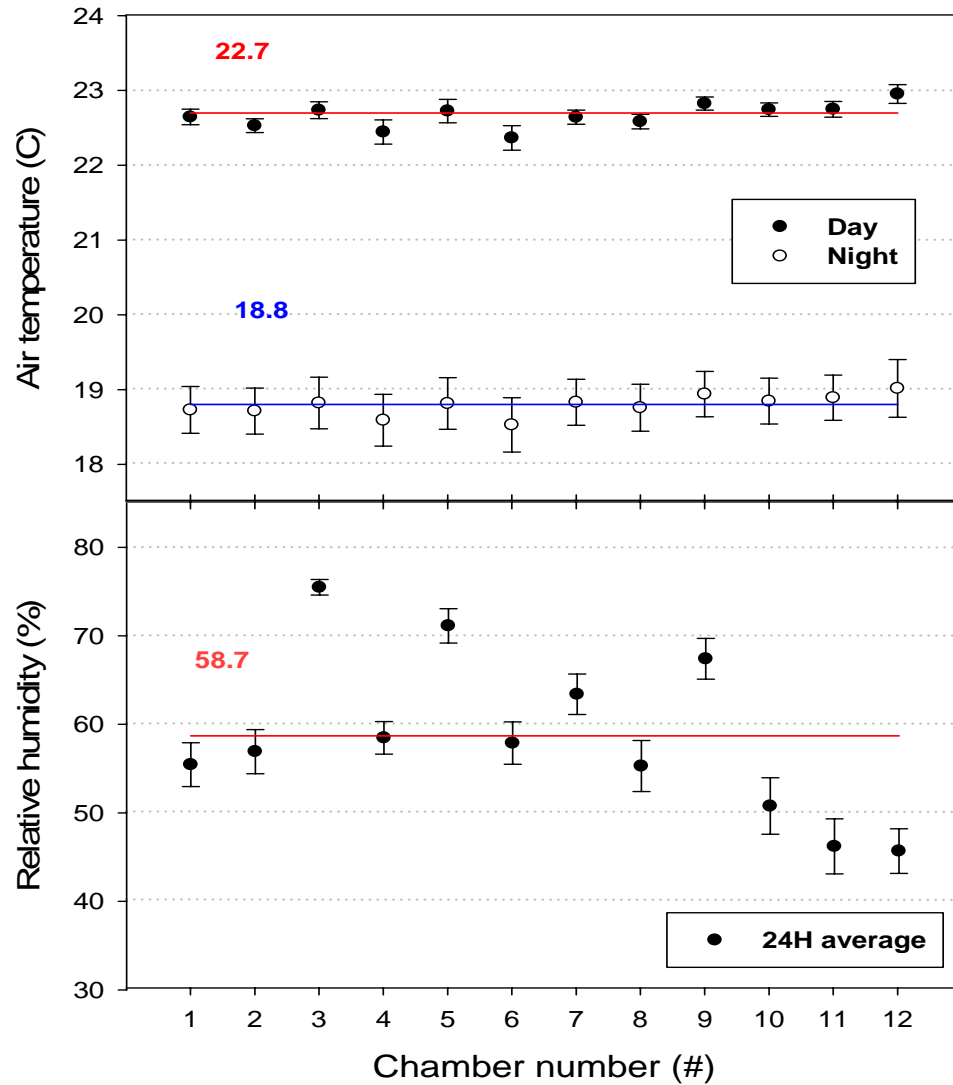
Spatial effects on within-chamber variation

Row x Position

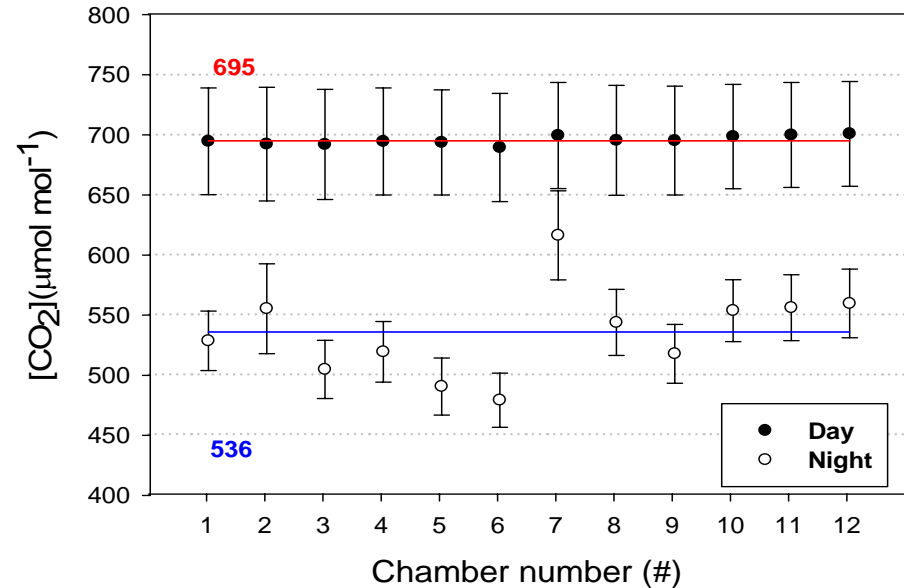


# 1. Environmental Summary

Top: Average 24H Day / Night Temperature  
Bottom: Average 24H Relative Humidity



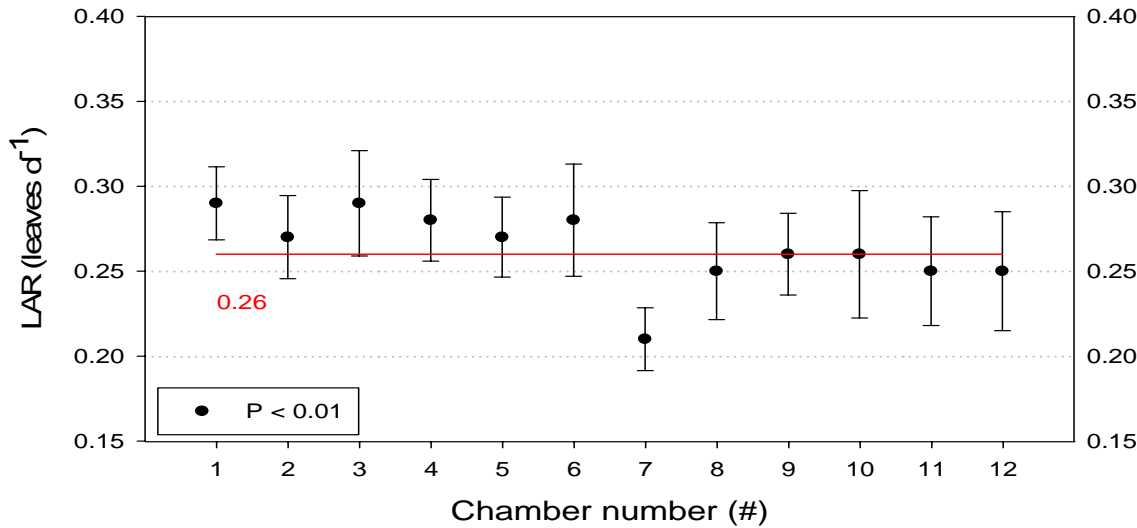
Average 24H Day / Night CO<sub>2</sub> Concentration



- Uniform T, CO<sub>2</sub>, PAR
- Problems with RH control
  - Chambers 3,5,9 > 10,11,12

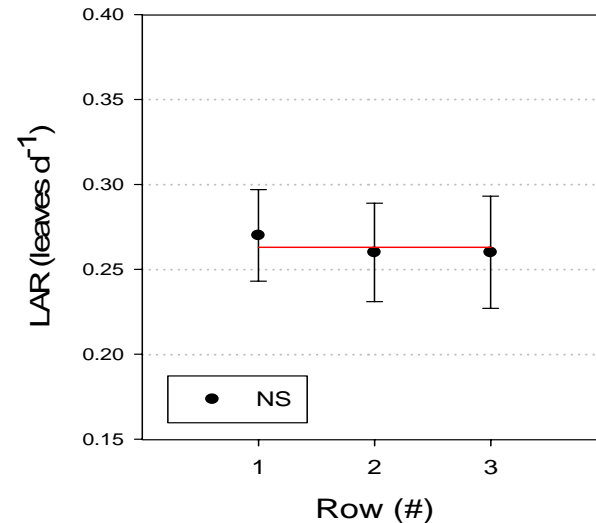
# 2. Leaf Appearance Rates (LAR)

LAR - Chamber Basis

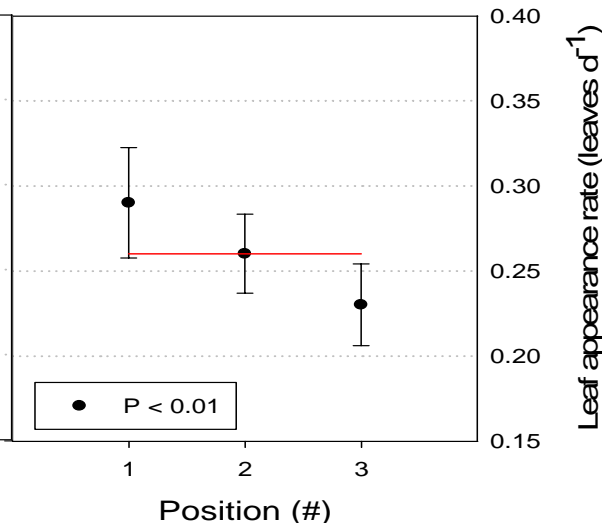


- LAR: 0.26
- Between chamber:
  - 0.08 leaves d<sup>-1</sup>
    - Impact?
- Within chamber:
  - No row effect
  - Position 1 > 2 > 3:
    - 0.04 leaves d<sup>-1</sup>
      - Impact?

LAR - Row Basis

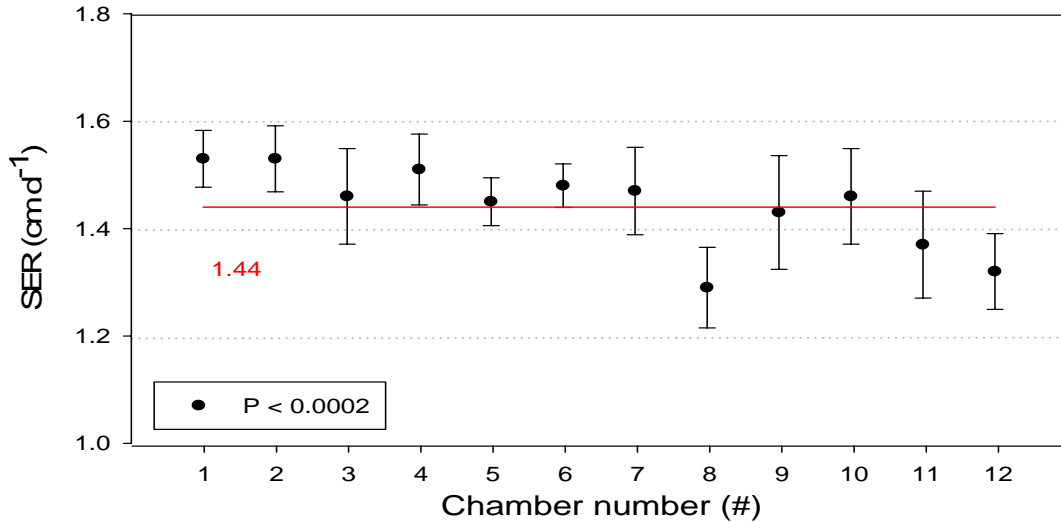


LAR - Position Basis



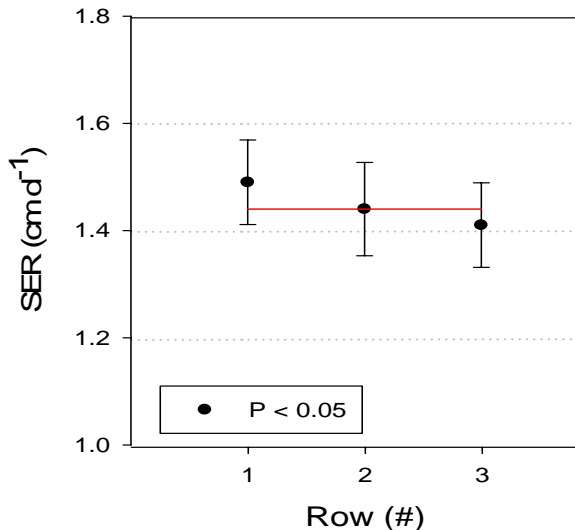
# Stem Elongation Rates (SER)

SER - Chamber Basis

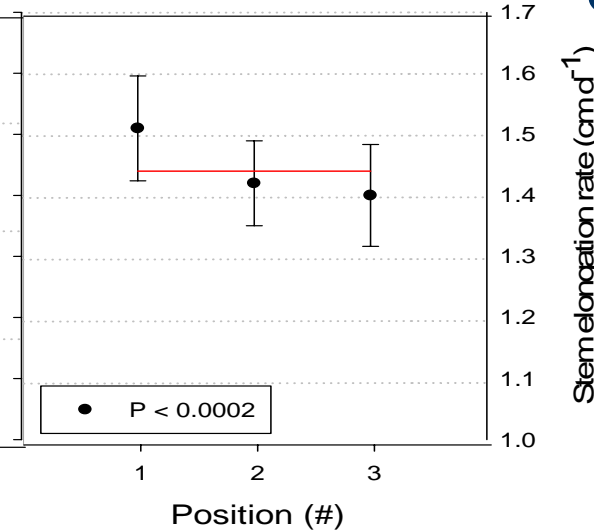


- SER:  $1.44 \text{ cm d}^{-1}$
- Between chamber:
  - Max diff.  $\sim 0.24 \text{ cm d}^{-1}$
  - Impact?
    - End of season heights NS ( $\pm 4 \text{ cm}$  (55 cm))

SER - Row Basis



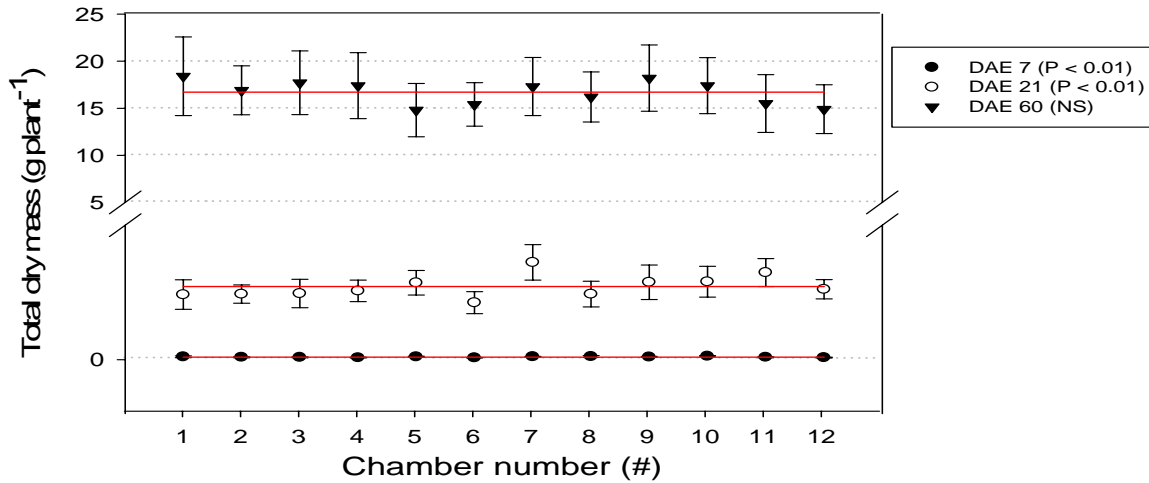
SER - Position Basis



- Within chamber:
  - P1 < P2 and P3
    - Impact?
    - Max diff.  $\sim 0.1 \text{ cm d}^{-1}$

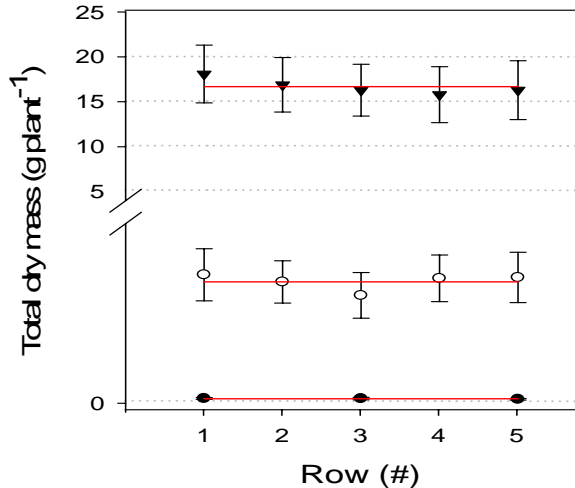
# Dry Mass Harvests

**Total D.M. - Chamber Basis**

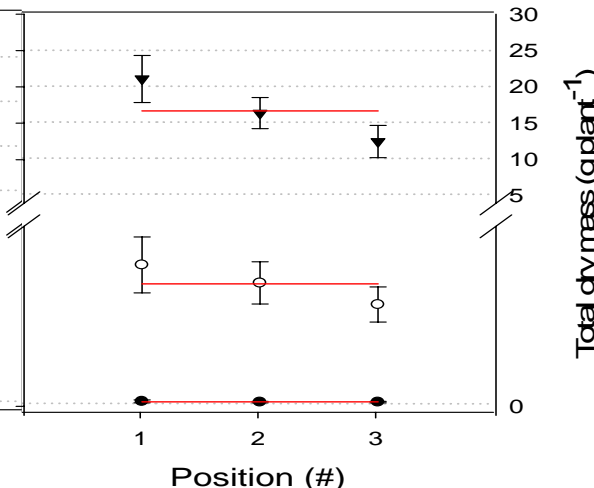


- Similar trend for yield
- Between chamber :
  - NS at final harvest
  - CH12 ~2.3 g plant<sup>-1</sup> less
    - Leaf area / mass
- Within chamber:
  - Position:
    - P1 > P2 > P3
    - ~8.5 g plant<sup>-1</sup> (!)
  - No consistent Row effect

**Total D.M. - Row Basis**



**Total D.M. - Position Basis**



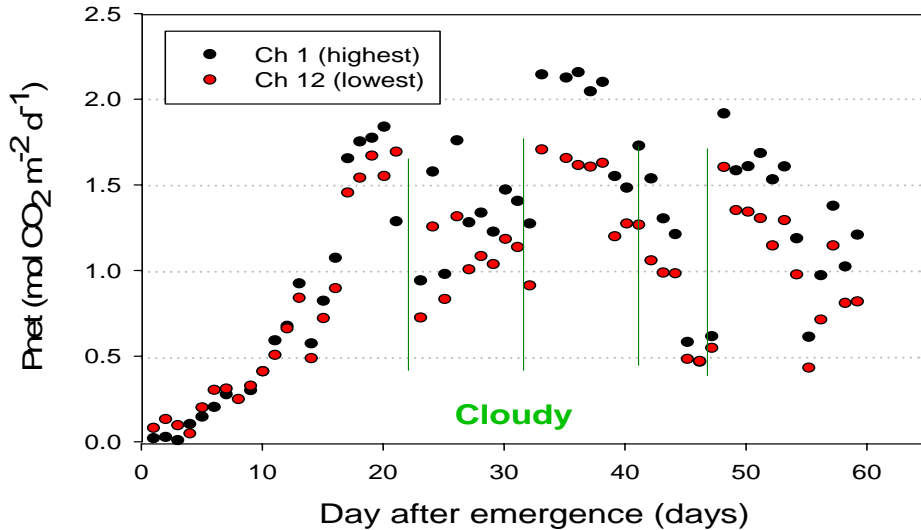
● DAE 7 (NS)  
○ DAE 21 (NS)  
▼ DAE 60 (NS)

● DAE 7 (NS)  
○ DAE 21 (p < 0.001)  
▼ DAE 60 (p < 0.001)

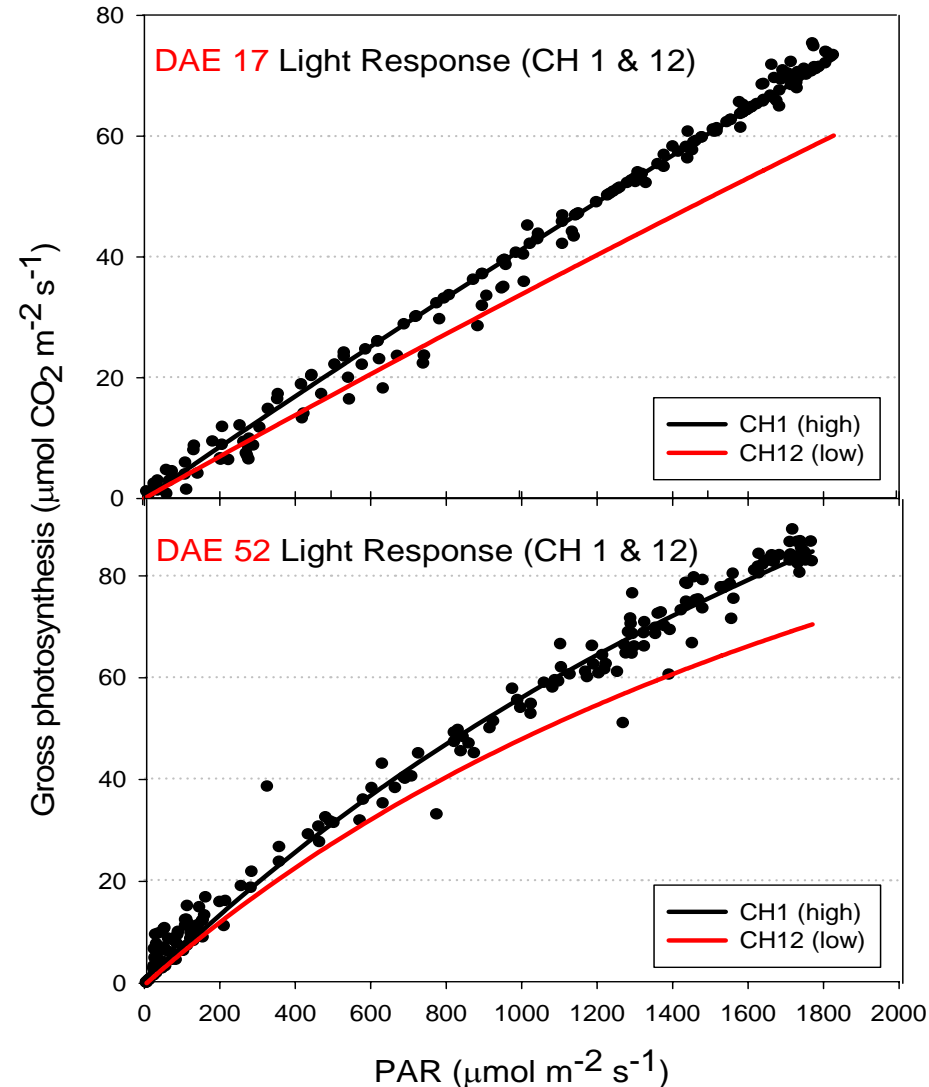


# Gas Exchange (High / Low CH)

Daily Pnet for Chambers 1 and 12



- Gas exchange data supports quantifiable differences
- Differences are reflected in seasonal and most diurnal responses



# Summary of Findings

- Between Chambers:
  - Developmental rate effects present
    - Too small to be meaningful?
  - Dry matter values
    - Final total harvest NS, differences in leaf, stem
  - Gas exchange values support dry mass findings
  - No consistency between RH and crop response
- Within Chambers:
  - Positional effect critical
    - Shading, Wind

# What's Next?

- Quantify variability / chamber bias
  - Covariate analysis
    - e.g. quantify chamber bias on dry matter production and remove from analysis of treatment effect
    - e.g. quantify error between seasonal gas exchange and total C content in dry matter and adjust gas exchange analysis in other experiments
- 'Universality' of uniformity
  - Variability tied into crop sensitivity?
    - Monocot vs Dicot
  - Technical / Season issues
    - Significant role RH will play on non-measured responses (e.g. water stress experiment)

# Acknowledgments

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Crop Systems & Global Change Lab



*Applying Systems Theory*

*To Complex*

*Agricultural Problems*