



2022 MELISSA CONFERENCE
8-9-10 NOVEMBER 2022

CREATING
A CIRCULAR
FUTURE

Characterization of the performance of the Higher Plant Chamber in the MELISSA Pilot Plant under batch and staggered mode of operation using *L. sativa*

Carol Arnau

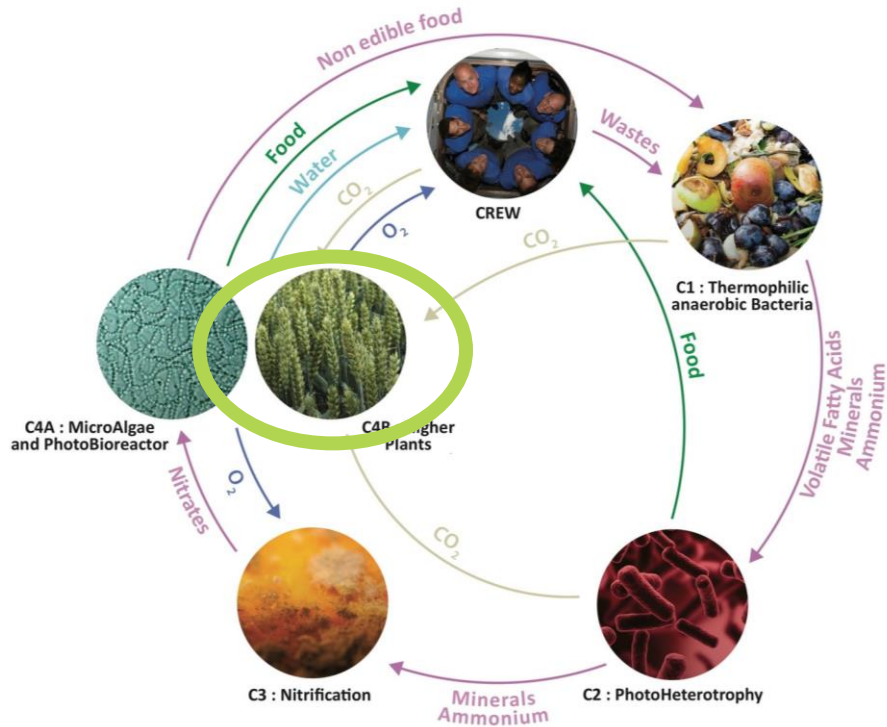
MELISSA Pilot Plant – Claude Chipaux Laboratory, Universitat Autònoma de Barcelona

C. Ciurans, A. Vizcarra, A. Pannico, R. Paradiso, E. Peiro, S. De Pascale, F. Gòdia

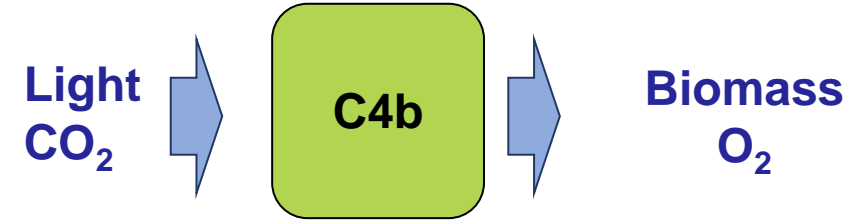


The MELiSSA Concept

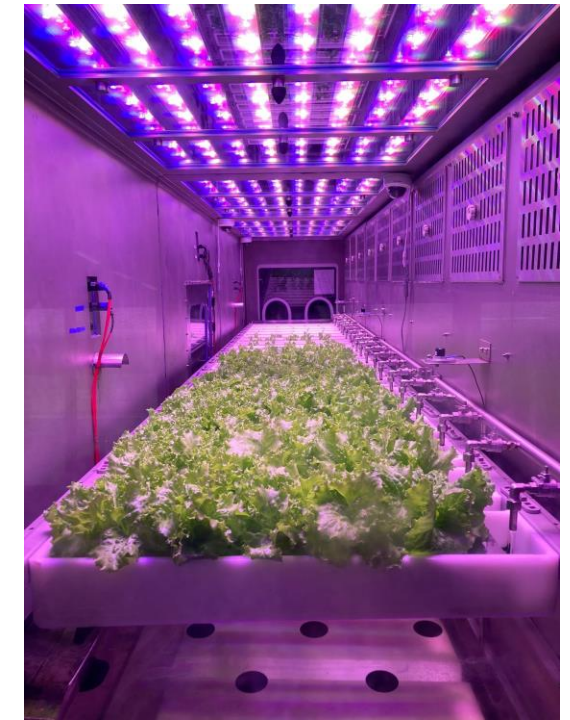
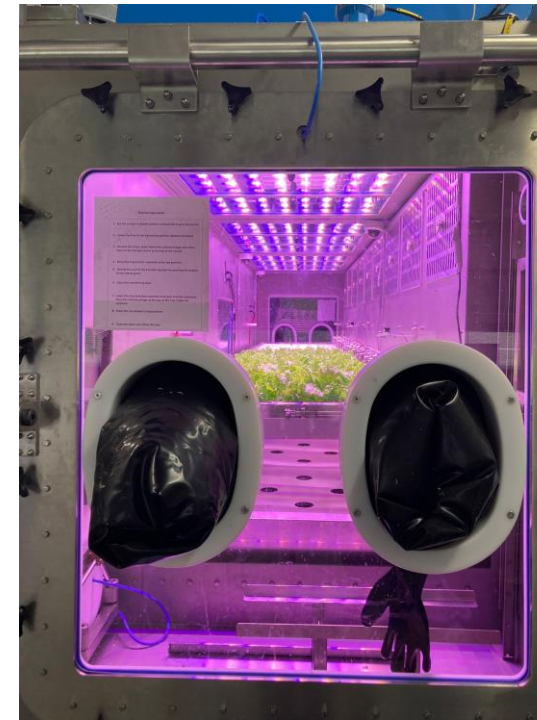
Photosynthetic compartment



Function in the loop



C4b compartment: Higher Plant chamber description



- 5 m² chamber (9300 L)
- 100 plants capacity (20 trays with 5 plants)
- LED-based lighting system
- Hydroponic solution recirculation
- Online monitoring of O₂ and CO₂
- Gas loop closure
- Air locks system (prevent gas losses during operation)
- Controlled overpressure at 50 Pa
- Compensation tank to manage atmosphere pressure changes

Lettuce Staggered Test cultivation strategy



Number of days spent by plants in HPC

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 7 | 7 | 7 | 7 | 7 | 14 | 14 | 14 | 14 | 14 | 21 | 21 | 21 | 21 | 21 | 28 | 28 | 28 | 28 | 28 |
|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|

H/T every 7 days
(9-days old seedlings)

Age of plants in HPC

| | | | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 16 | 16 | 16 | 16 | 16 | 23 | 23 | 23 | 23 | 23 | 30 | 30 | 30 | 30 | 30 | 37 | 37 | 37 | 37 | 37 |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|

Operating cond.

Lettuce (*Lactuca sativa* L. cv. Grand Rapids)

pH: 5,9

EC: 1,9 mS/cm

RH - Day 50% - Night 70%

T° - Day 26°C - Night 20°C

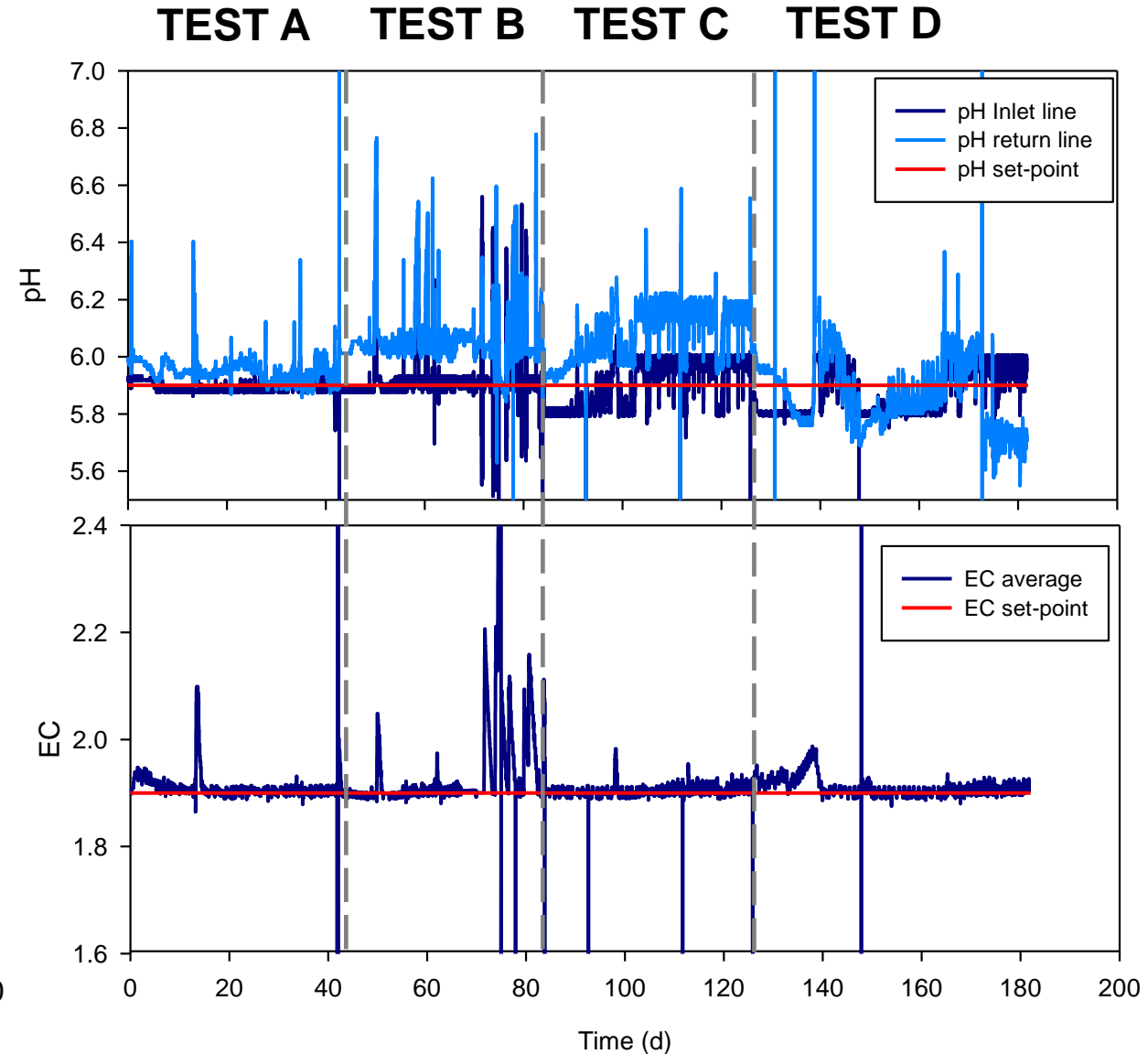
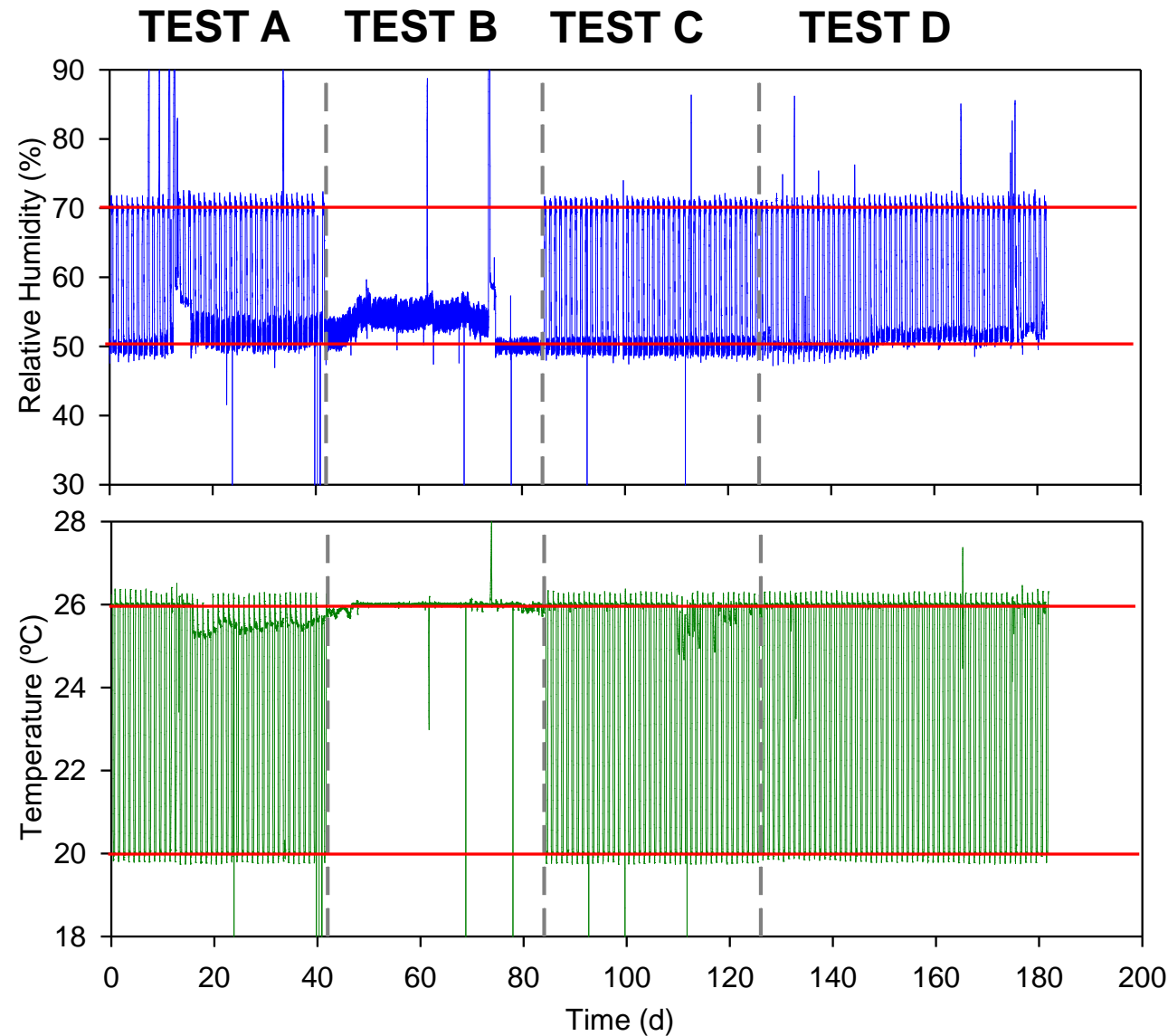


Staggered test conditions: Characterization of C4b



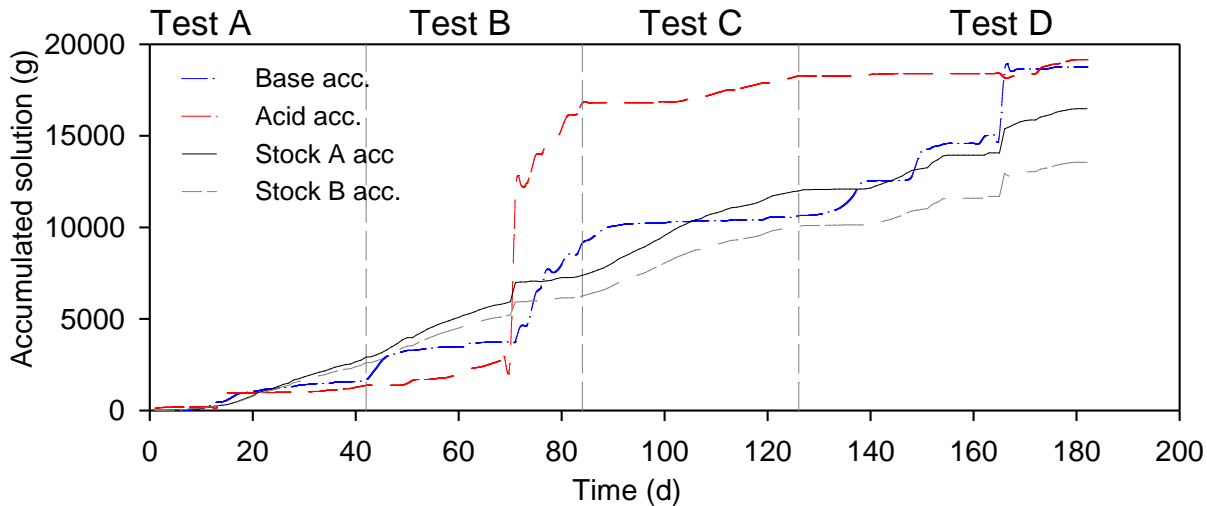
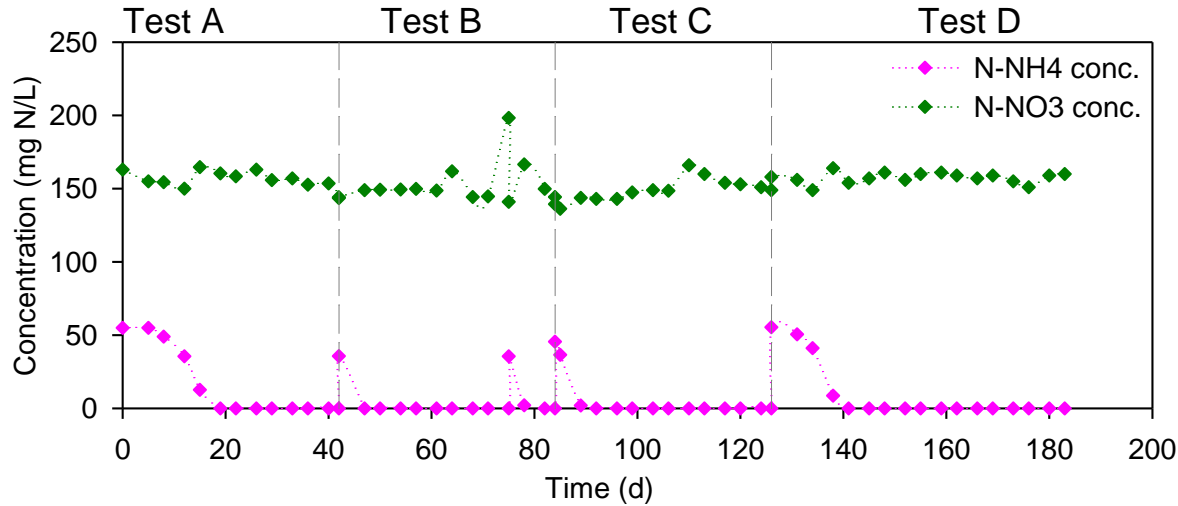
| Experiment A | Experiment B | Experiment C | Experiment D |
|--|--|---|--|
| <p>STANDARD ILLUMINATION PPFD 400 $\mu\text{mol}/\text{m}^2/\text{s}$ R:B=4.0 ; R:Fr=8.0 16/8 day/night CO₂ 1000 ppm 6 weeks duration</p> | <p>CONTINUOUS ILLUMINATION PPFD 400 $\mu\text{mol}/\text{m}^2/\text{s}$ R:B=4.0; R:Fr=8.0 24/0 day/night CO₂ 1000 ppm 6 weeks duration</p> | <p>HIGH INTENSITY ILLUMINATION PPFD 550 $\mu\text{mol}/\text{m}^2/\text{s}$ R:B=4.0; R:Fr=8.0 16/8 day/night CO₂ 1000 ppm 6 weeks duration</p> | <p>HIGH CO₂ CONCENTRATION PPFD 550 $\mu\text{mol}/\text{m}^2/\text{s}$ R:B=4.0; R:Fr=8.0 16/8 day/night CO₂ 5000 ppm 8 weeks duration</p> |

Results: Main controlled variables performance

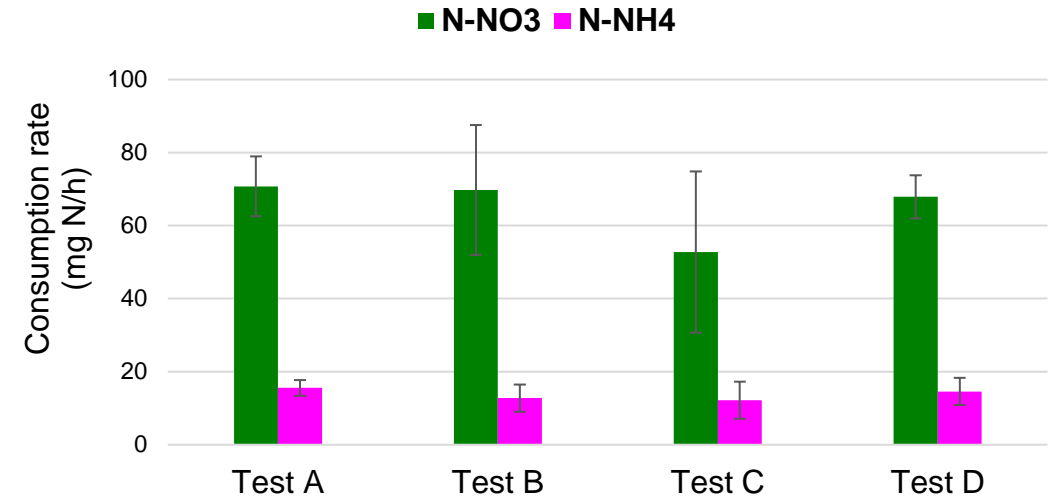


Results:

Ammonium and Nitrate nutrient solution profiles



Ammonium and Nitrate consumption rate

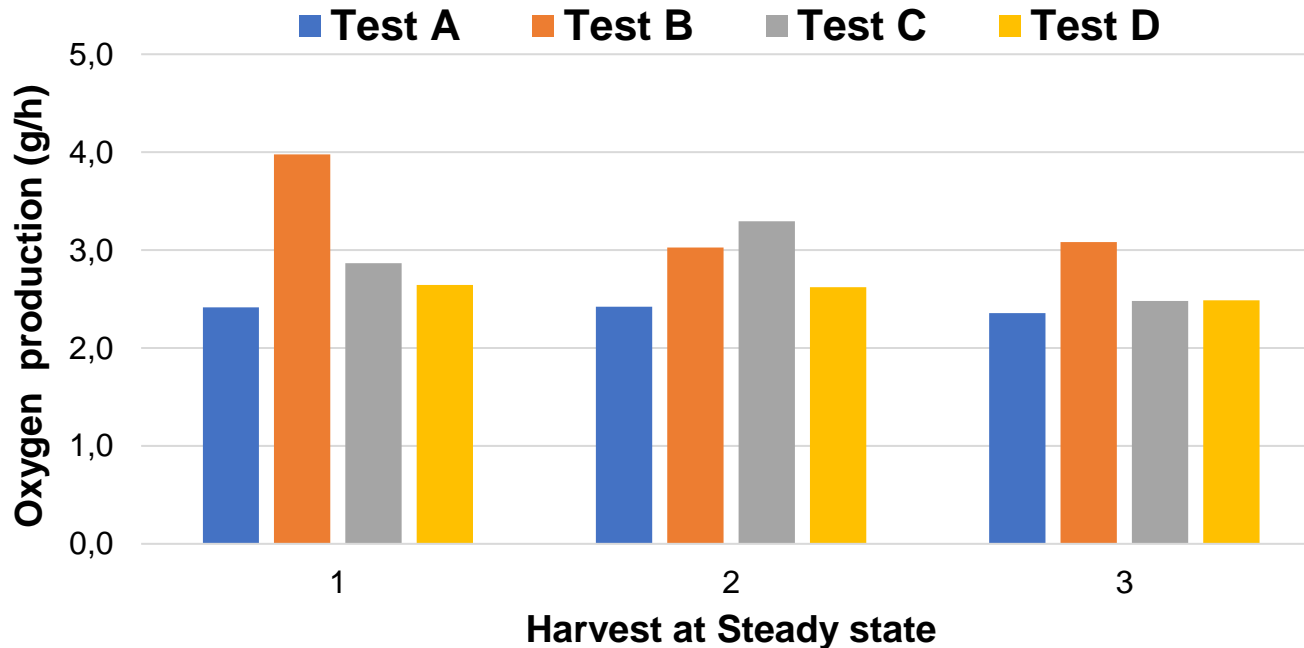


- Ammonium is consumed after approx. 20 days when the plant chamber is started with 100 (9 days-old) seedlings crops.
- During the staggered phase ammonium is completely consumed.
- Nitrate is consumed secondly and its kept constant at approx. 150 mg N-NO₃/L
- Ammonium and nitrate consumption rates at 16 mg N-NH₄/h and 75 mg N-NO₃/h, respectively

Results: C4b Oxygen Production at steady state



Mean Oxygen Production at Steady State



- High repeatability of oxygen production for test A and D
- Variability within same testing conditions (for test B and C)
- Higher oxygen production at 24h illumination (Test B; H1)
- CO₂ concentration at 5000 ppm has no effect on Oxygen production (Test D)

Results:

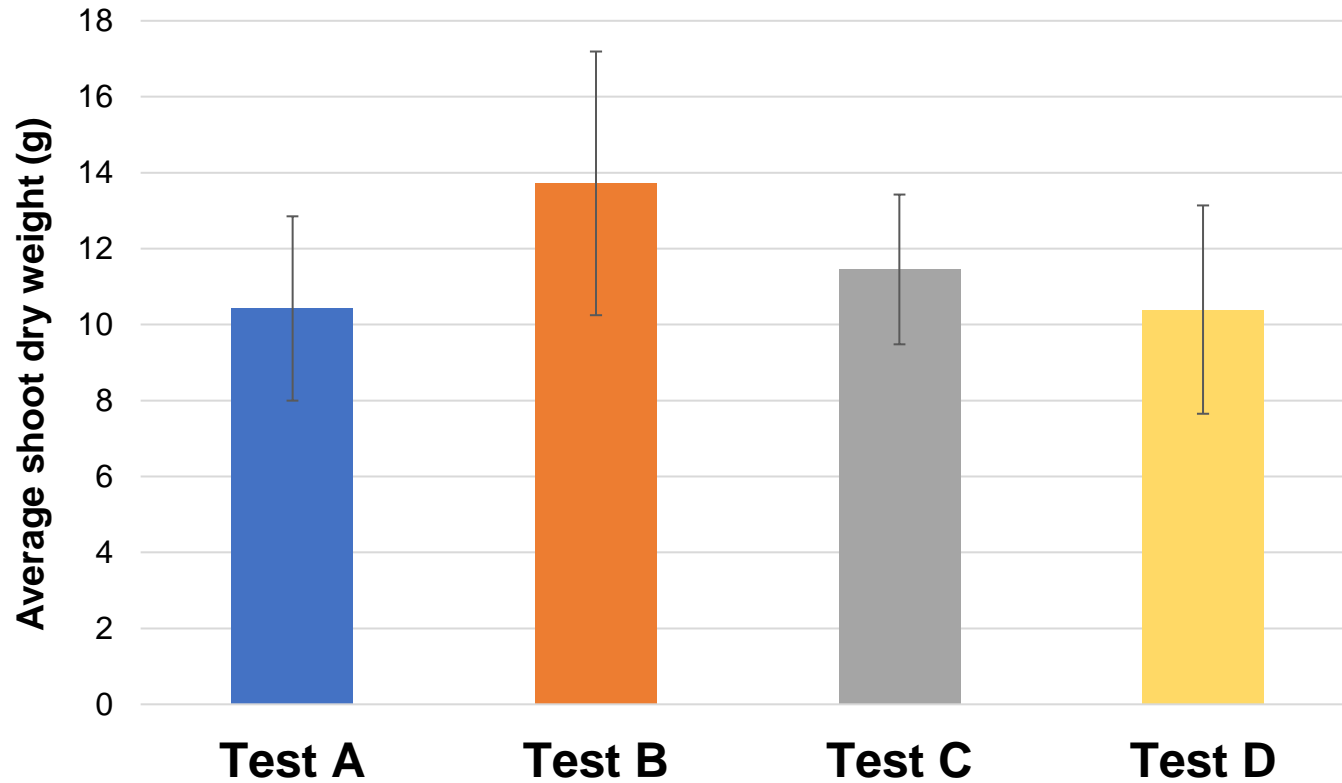
O₂ production – CO₂ consumption at steady state



Comparison of Oxygen production and carbon dioxide consumption, average during the day for the first harvest at steady state

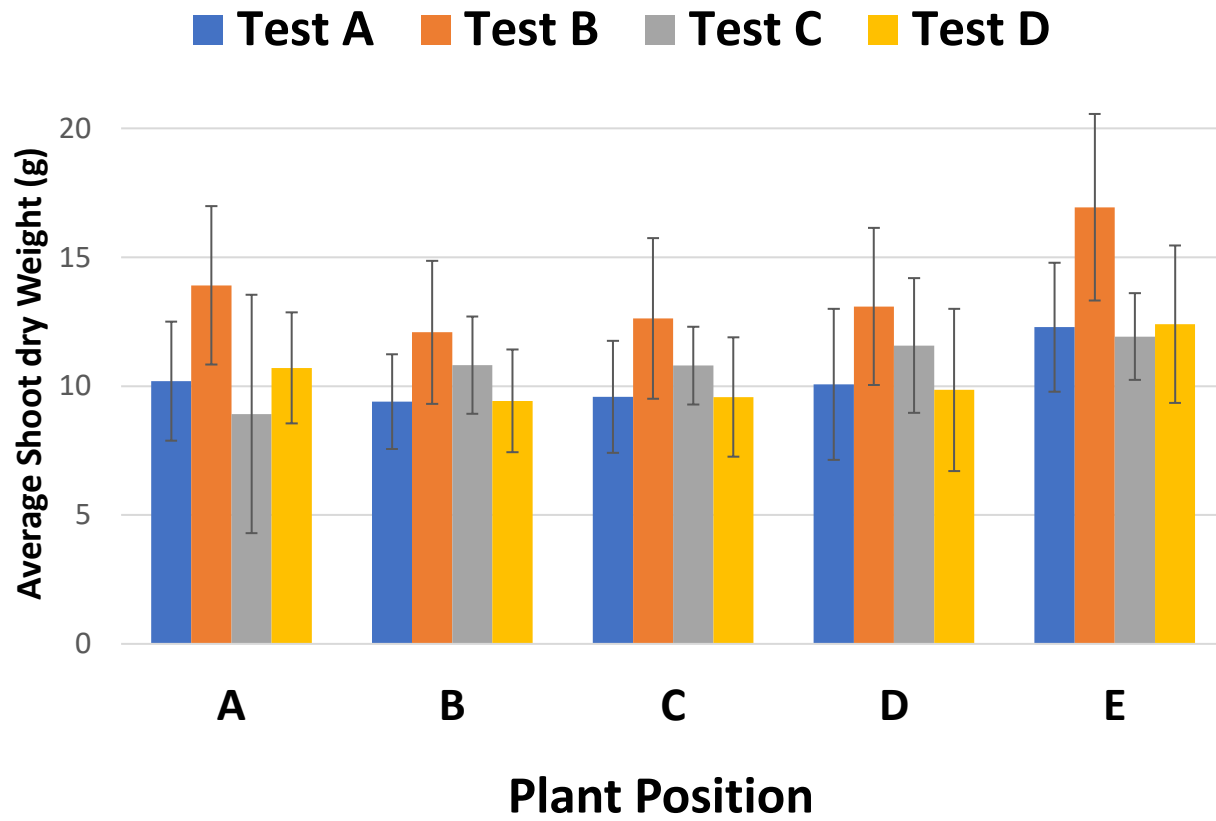
| Test | O ₂ production | | | CO ₂ consumption | | |
|---------------|---------------------------|--------------------------|--|-----------------------------|--------------------------|--|
| | (g h ⁻¹) | (mol day ⁻¹) | Per cultivated area (μmol m ⁻² s ⁻¹) | (g h ⁻¹) | (mol day ⁻¹) | Per cultivated area (μmol m ⁻² s ⁻¹) |
| Test A | 2.42 | 1.81 | 4.20 | 2.85 | 1.56 | 3.60 |
| Test B | 3.98 | 2.98 | 6.91 | 4.87 | 2.65 | 6.14 |
| Test C | 2.87 | 2.15 | 4.98 | 3.47 | 1.89 | 4.38 |
| Test D | 2.64 | 1.98 | 4.59 | 2.03 | 1.11 | 2.57 |

Results: Average shoot dry weight at steady state



- Higher shoot dry weight obtained at 400 $\mu\text{mol}/\text{m}^2/\text{s}$ at 24 h photoperiod (test B)
- Similar shoot dry weigh obtained at 400 and 550 $\mu\text{mol}/\text{m}^2/\text{s}$ at 16/8 h photoperiod (test A&C)
- Minor impact in shoot dry weigh at high CO_2 concentration (5000 ppm) (test D)

Results: Average Shoot dry weight at Steady State per *plant position*



Position A (Spigot side)

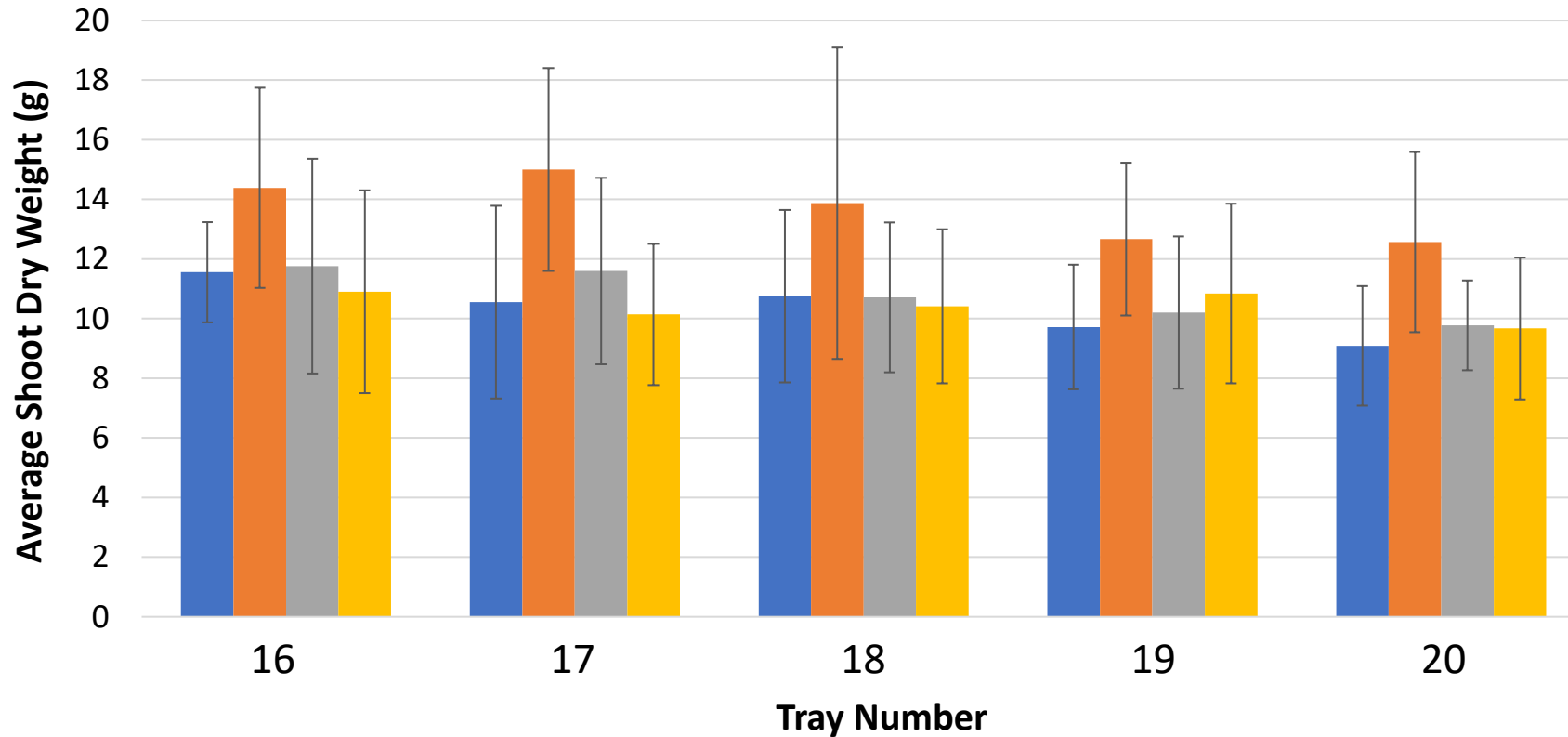
Position E (Collector side)



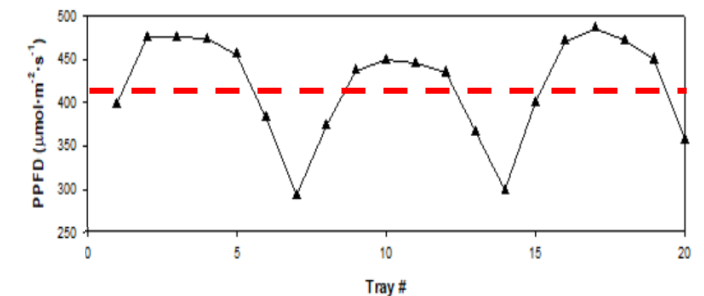
Example of plant growth at different position in the tray at 28 days cycle at steady state (Test A)

Results: Average Shoot dry weight at Steady State per *Tray number*

■ Test A ■ Test B ■ Test C ■ Test D



- Similar Shoot dry weight obtained after 28 days cultivation in all harvested trays
- High degree of homogeneity in the chamber



Results:

Biometric characteristics of plants at steady state (Harvest 1; 25 plants)



| Test | Leaf area (cm ² plant ⁻¹) | Leaf number (no. plant) | Plant dry weight (g plant ⁻¹) | Roots dry weight (g plant ⁻¹) | Shoot fresh weight (g plant ⁻¹) | Shoot dry weight (g plant ⁻¹) | Shoot dry matter (%) | Harvest index |
|---------------------|---|----------------------------|--|--|--|--|-------------------------|---------------|
| Test A (28 days) | 2228 | 36.64 | 11.41 | 0.853 | 232.05 | 10.70 | 4.62 | 0.94 |
| Test B (28 days) | 2375 | 49.68 | 13.76 | 1.442 | 287.30 | 12.23 | 4.29 | 0.89 |
| Test C (28 days) | 2255 | 45.36 | 13.41 | 1.389 | 272.75 | 12.02 | 4.42 | 0.90 |
| Test D (28 days) | 2509 | 34.86 | 11.67 | 1.273 | 243.42 | 10.39 | 4.26 | 0.89 |

CONCLUSIONS



- Controllability of the chamber parameters allows an excellent monitor and control of atmospheric gas conditions (RH and T) and hydroponic solution (pH, EC and T)
- Similar ammonium and nitrate consumption rates for all conditions tested (≈ 16 mg N-NH₄/h and ≈ 75 mg N-NO₃/h)
- Oxygen production higher than 2.5 g O₂/h for all conditions tested.
- The highest Oxygen production (3.89 gO₂/h) is obtained at 24 hours photoperiod at 400 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ light intensity on the first harvest at steady state
- High degree of homogeneity of plants growth at 28 days cultivation in the chamber
- Similar Shoot Dry Weight obtained after 28 days cultivation in all harvested trays



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THANK YOU.

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