# Estimating the carbon balance of growing cactus pear cladodes through different methods

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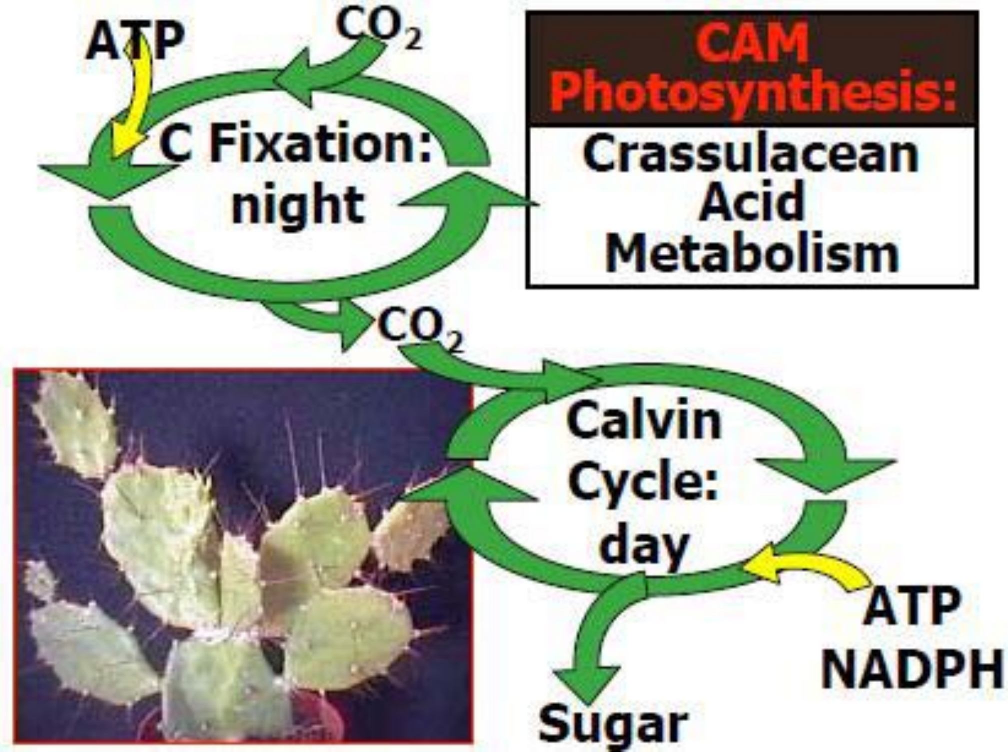
GOBIERNO DE CHILE
FUNDACIÓN PARA LA INNOVACIÓN AGRARIA

# Context: *Opuntia ficus-indica* in Chile

- "Tuna" in Chile is mainly dedicate to **fresh fruit production** oriented to local market.
- Area has fluctuated between **1.000 – 1.500 ha** in small farms around Santiago.
- Low technological development => **low yields (8-12 t ha$^{-1}$) in two crops!**
- Energetic crisis and governmental support for **renewable energy sources**.
- **Carbon sequestration** in arid zones.
- Interest in *Opuntias* for biomass production in arid, irrigated zones (WUE).

# Context: the plant




- *Opuntias* have **CAM** photosynthesis:
- It is **difficult and time consuming to measure photosynthesis** (timing and no leaves!).
- High WUE but **low Photosynthetic rate**.

- In order to develop biomass plantations in Chile we need to develop a **cost-efficient method** for estimating **potential primary production** of different planta materials under different climatic conditions.

**Objective**:

- To evaluate different methods for estimating primary productivity (carbon balance) through direct measuremtens and modelling.

# Materials and methods

- Single young cladodes of local cactus pear selection.
- Emerging from cladode fragments and oriented N <-> S.
- Grown in a green house at the “Las Cardas” esperiment station (Coquimbo, Chile).
- With and without 65 % shading.
- Active growing season.

# Materials and methods

Measurements

- Alometry (cladode height, width and thickness) for estimating biomass and area.

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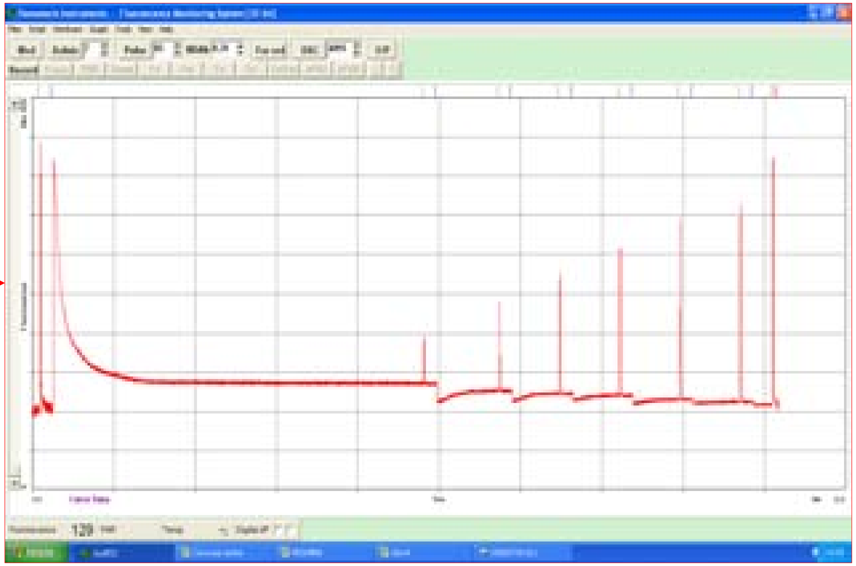

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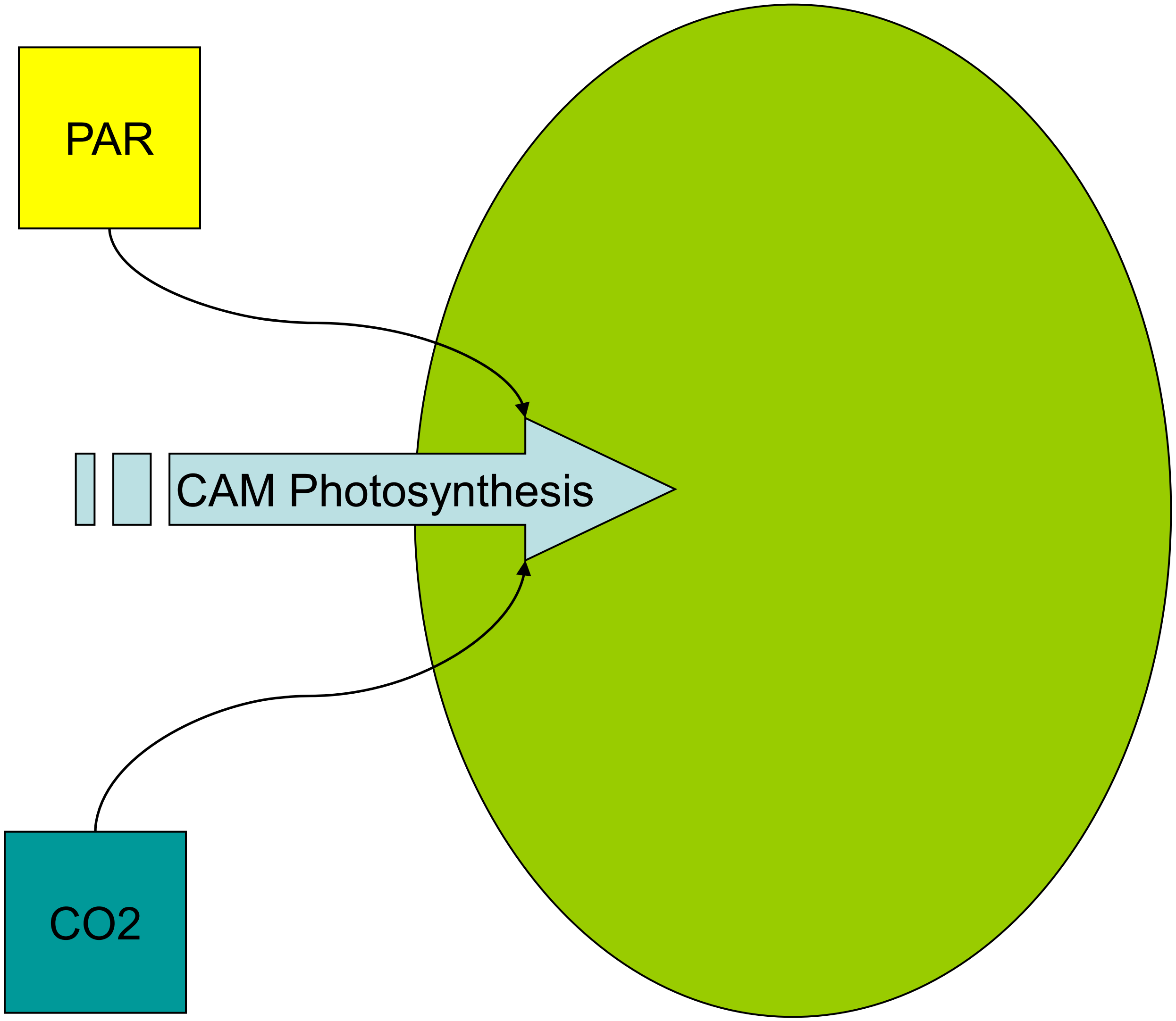
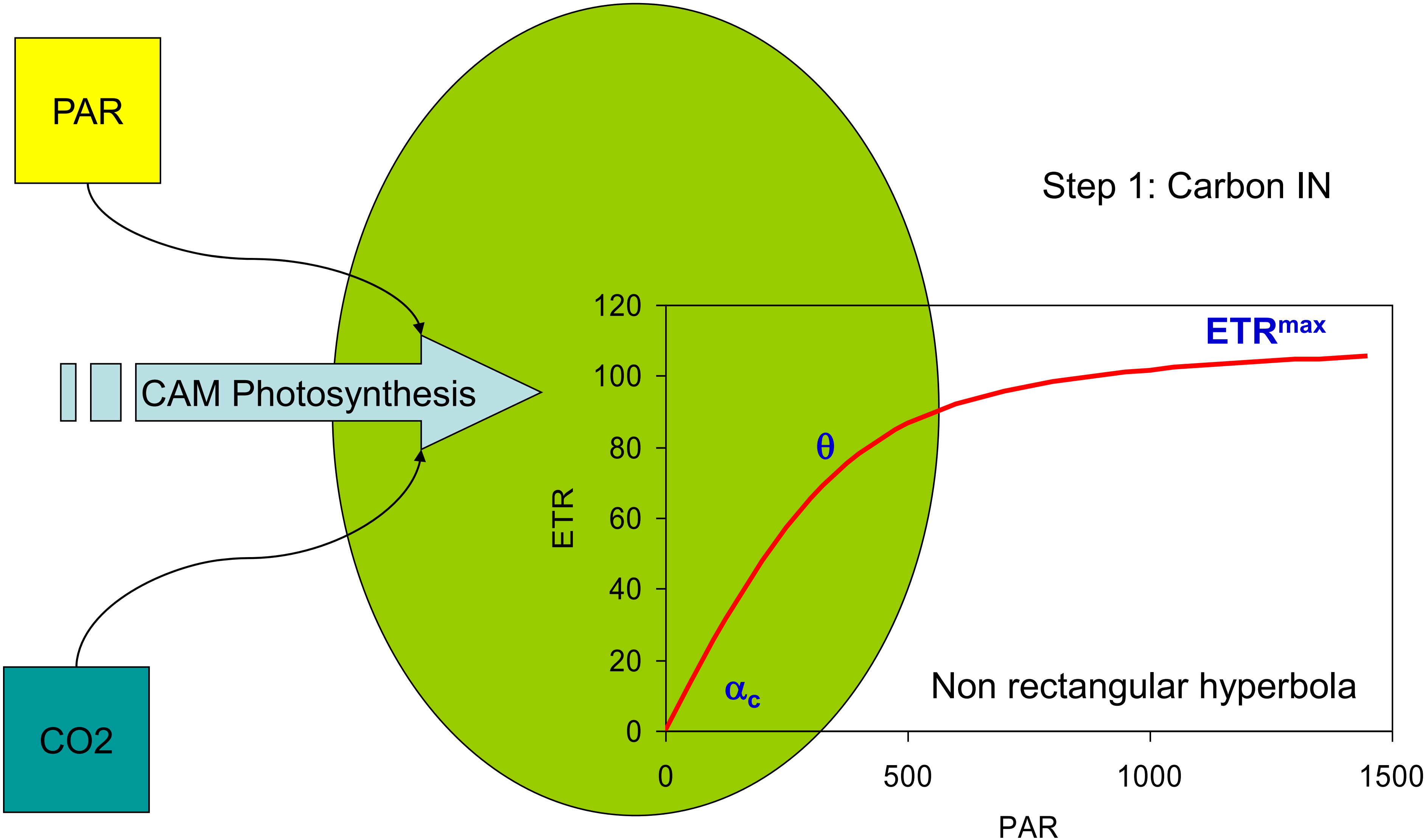
  - Climate: PAR, HR, T°air and PAR and T° on East and West cladode faces.

# Materials and methods: Model




Step 1: Carbon IN

# Materials and methods: Model



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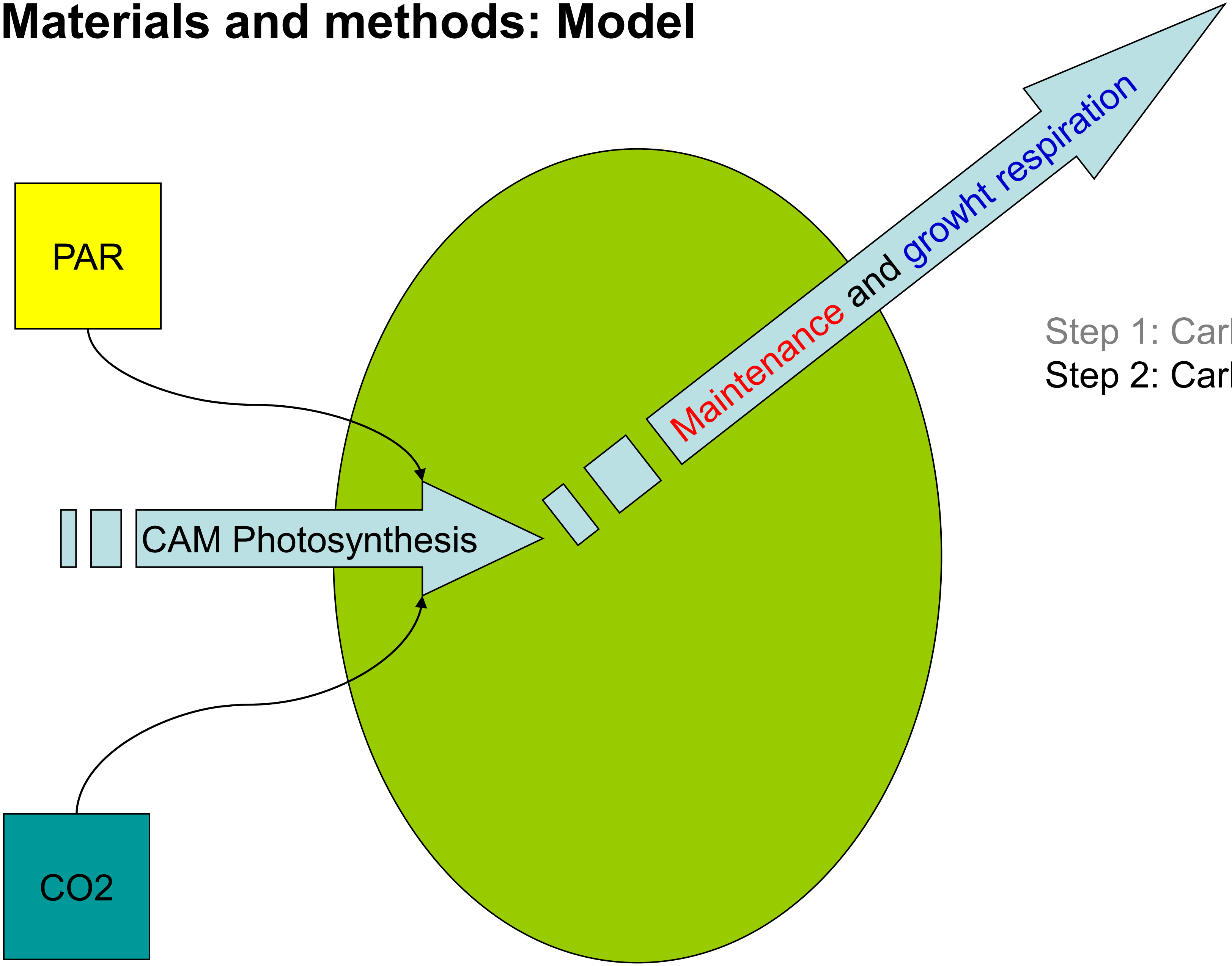
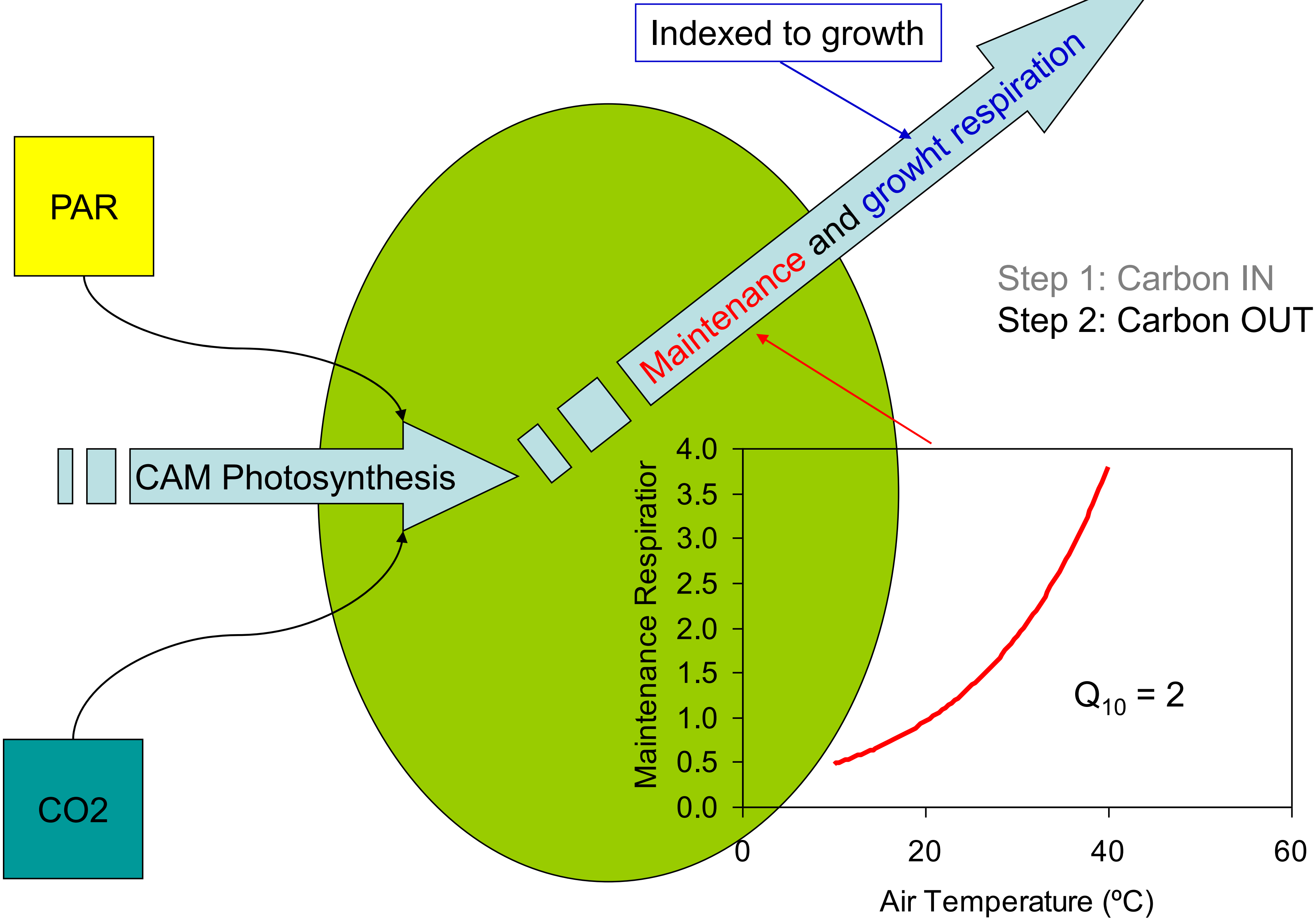



Step 1: Carbon IN
Step 2: Carbon OUT

# Materials and methods: Model



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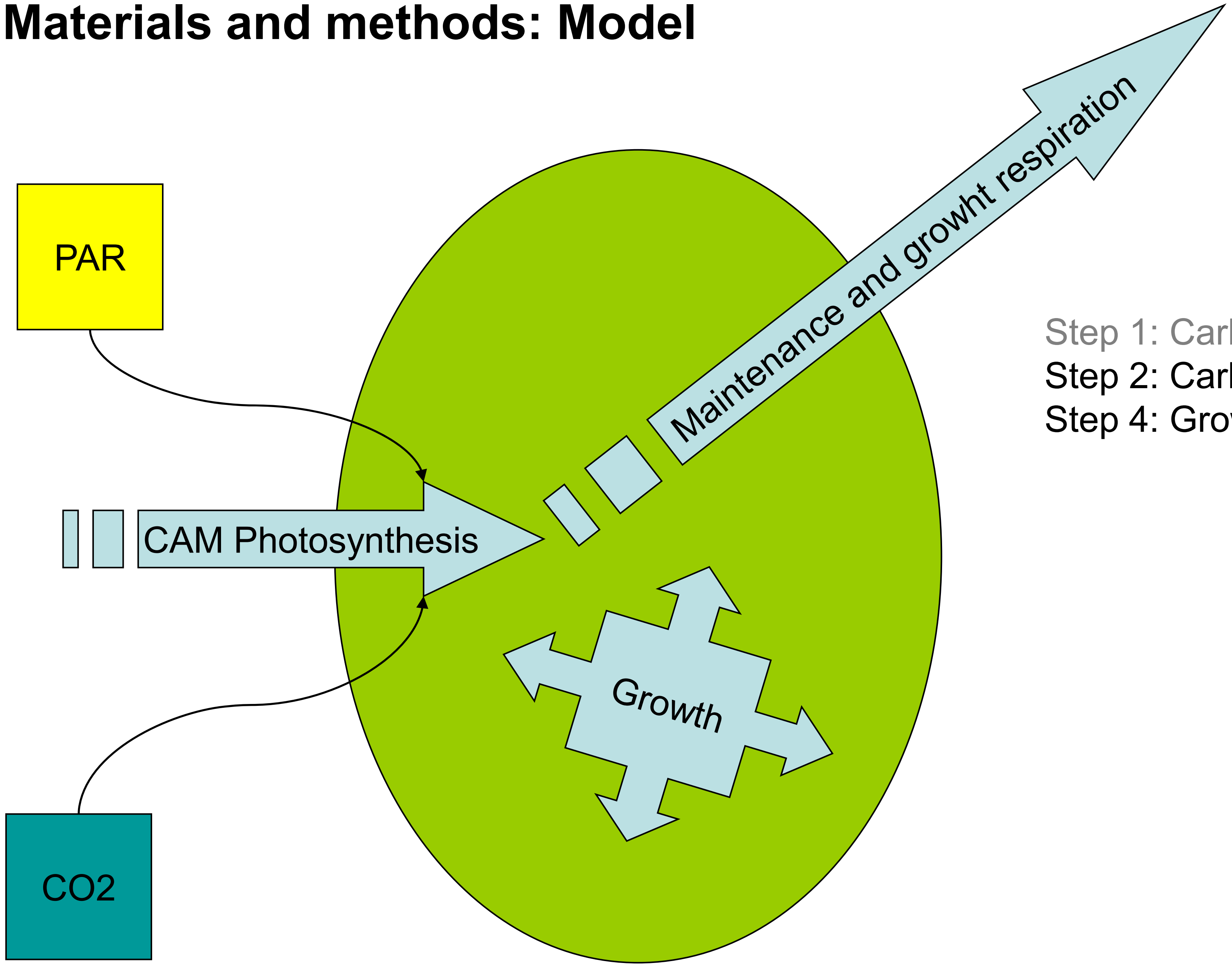
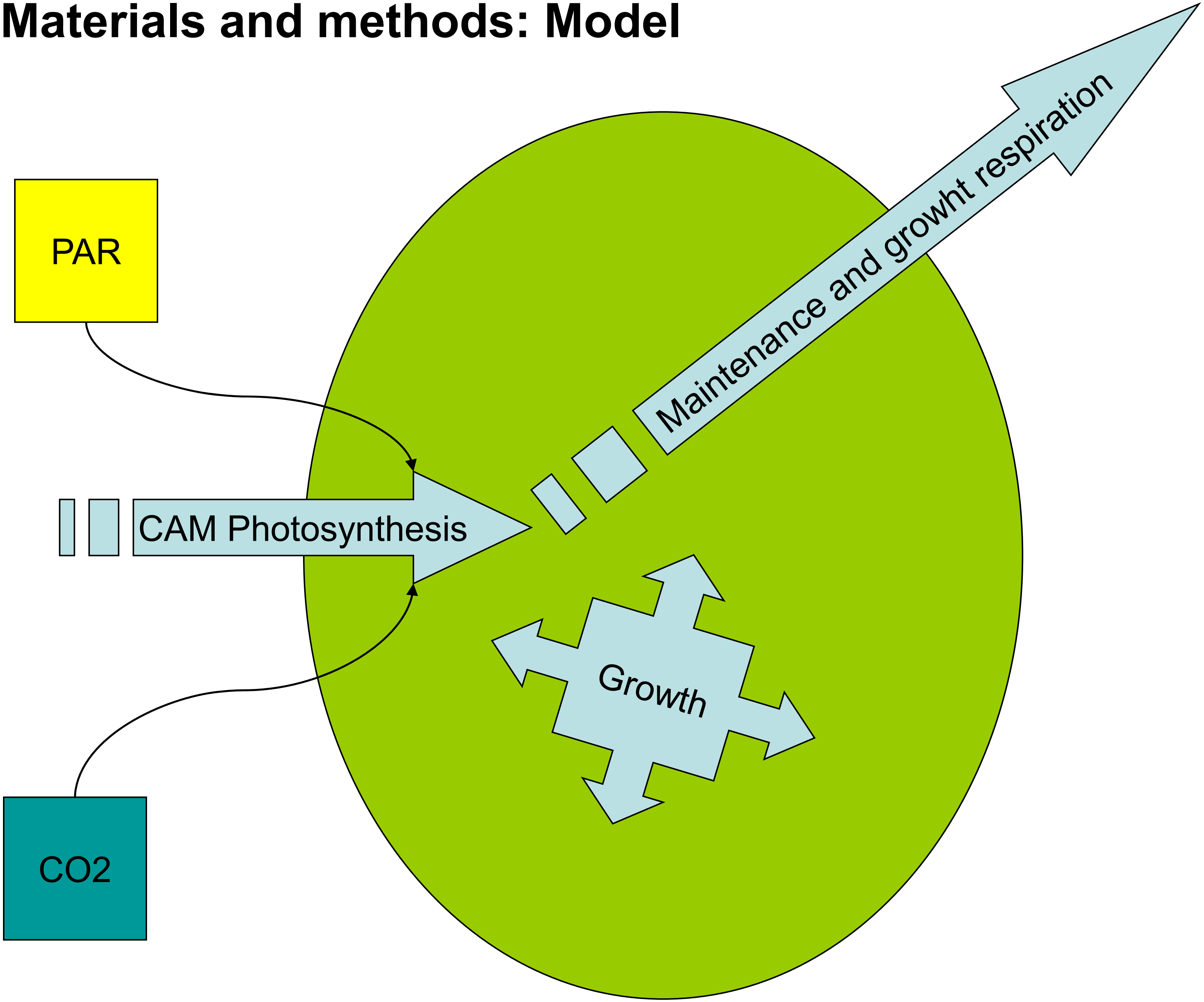
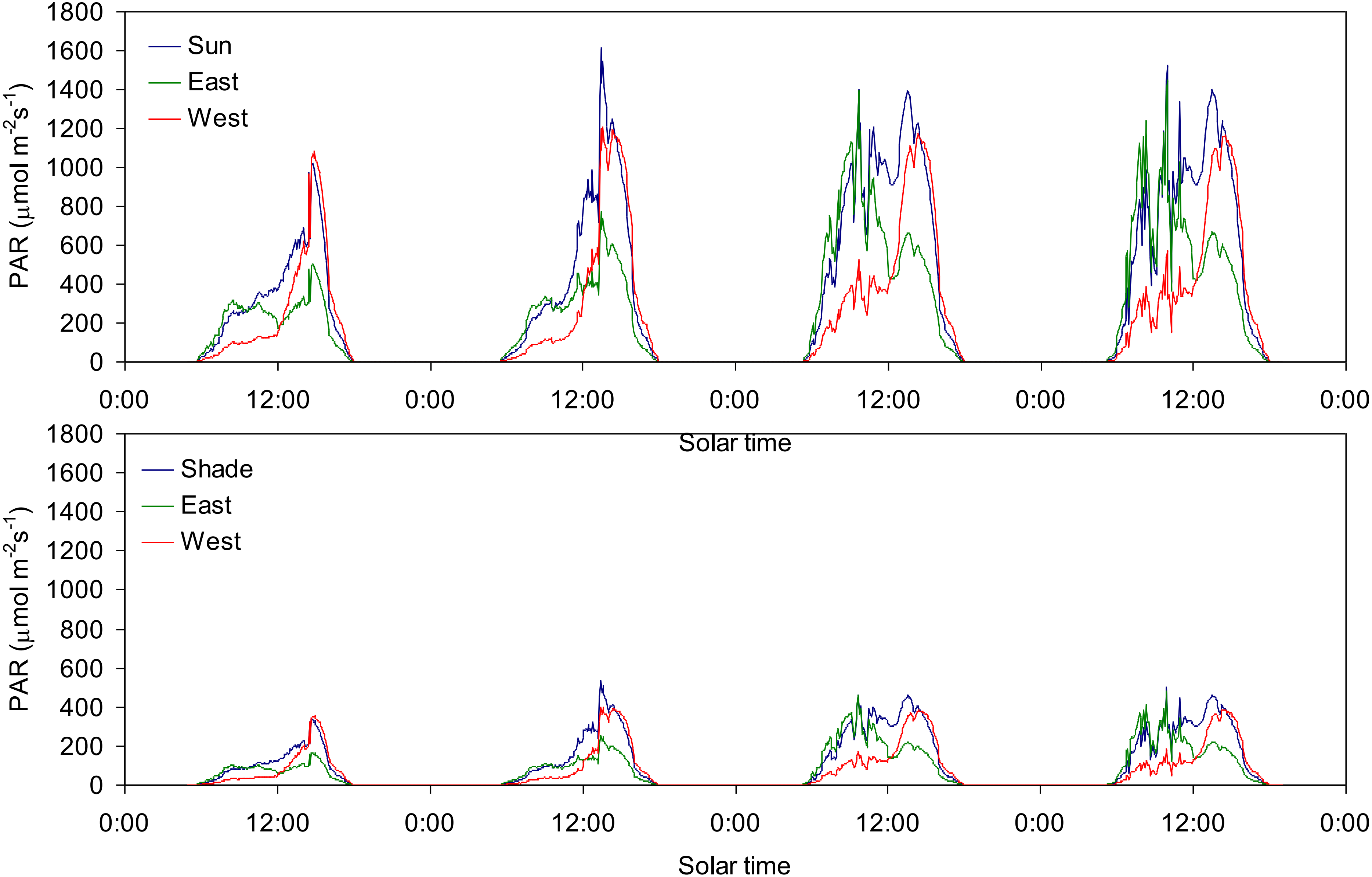



Step 1: Carbon IN
Step 2: Carbon OUT
Step 4: Growth

# Materials and methods: Model

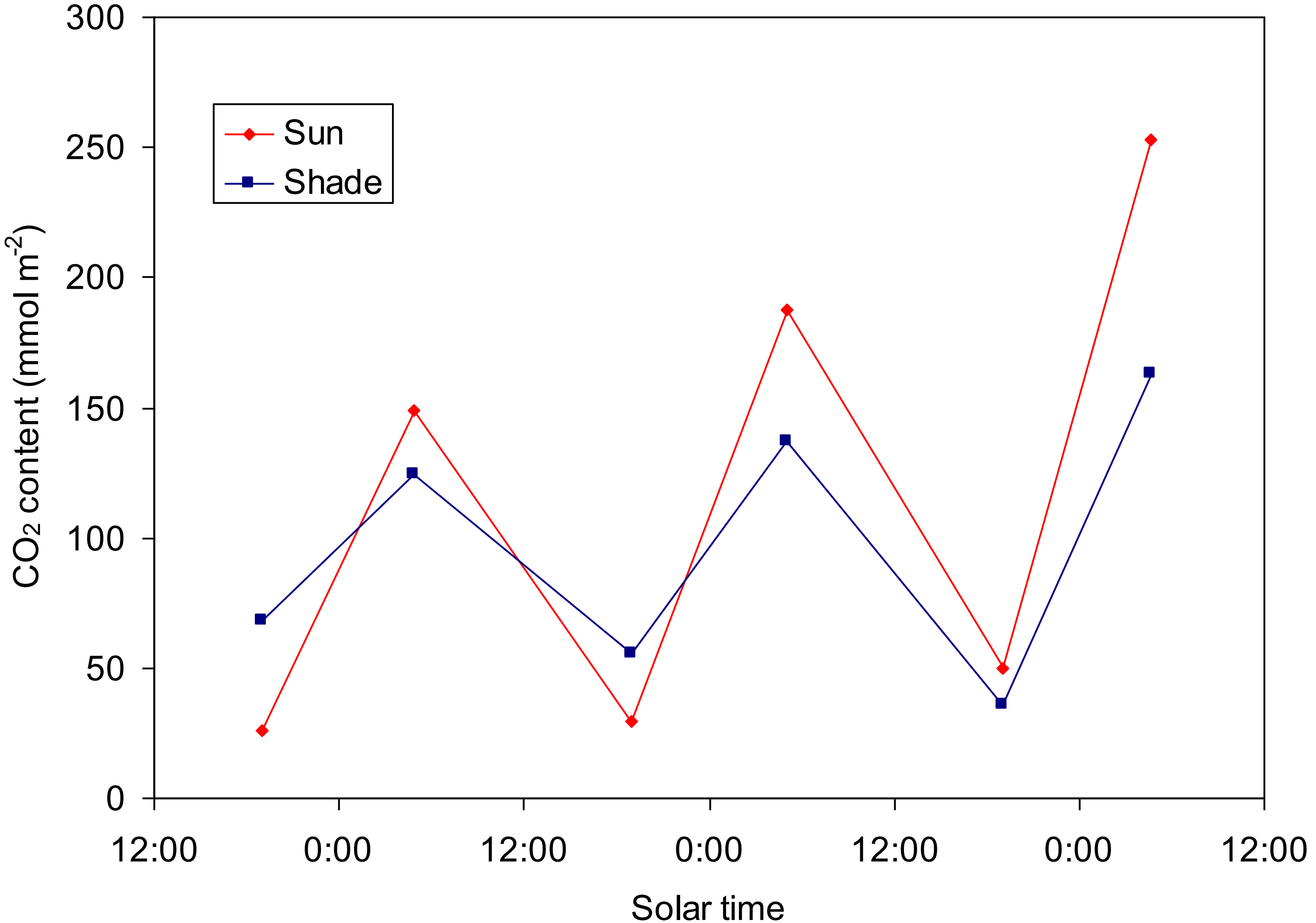


# Results: climatic conditions




Average Day/Night Temperature: 23.6±2.3 °C/10.4±0.8°C

# Results: Carbon Assimilation (CA) estimated from Titratable Acidity (TA)



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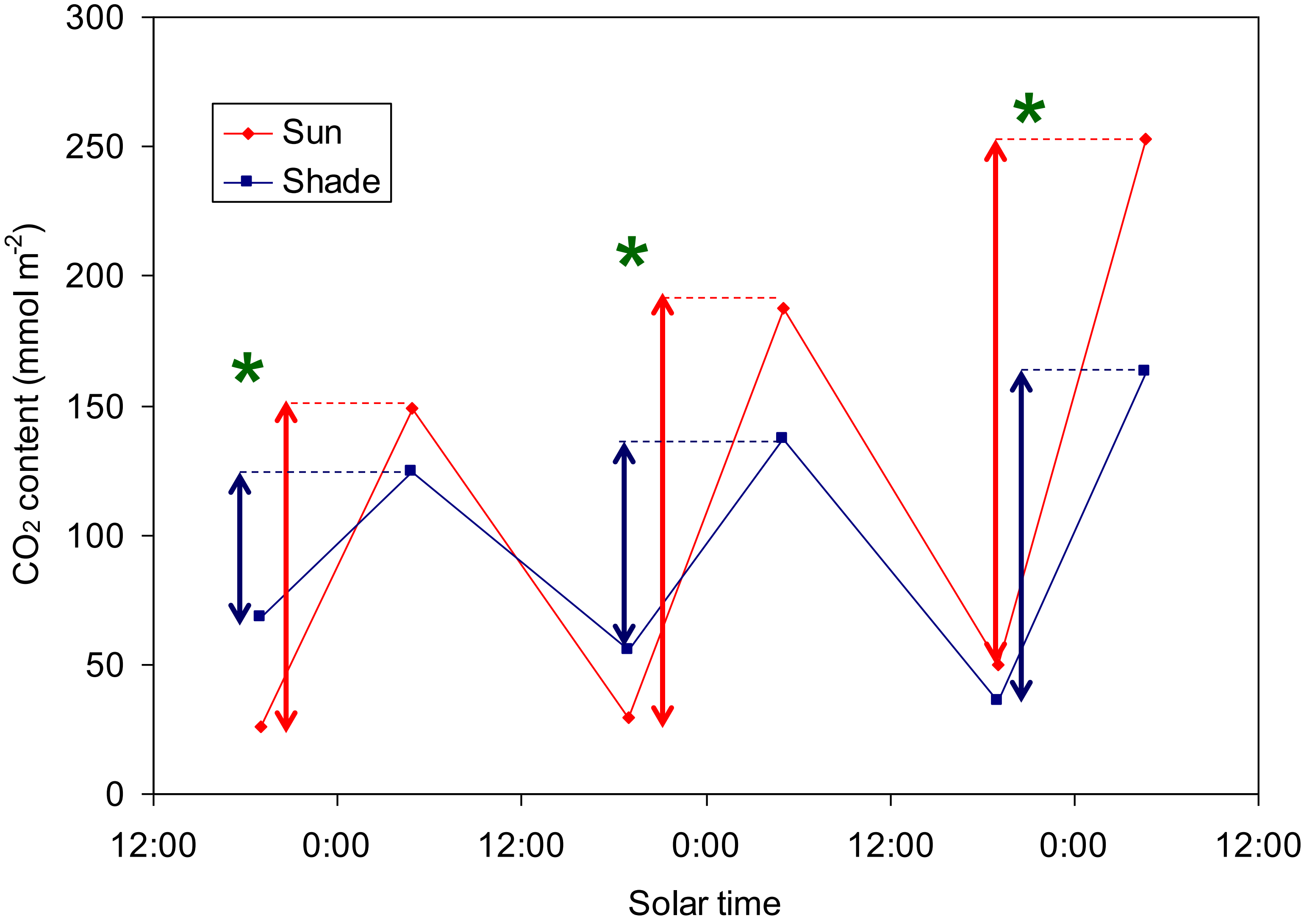
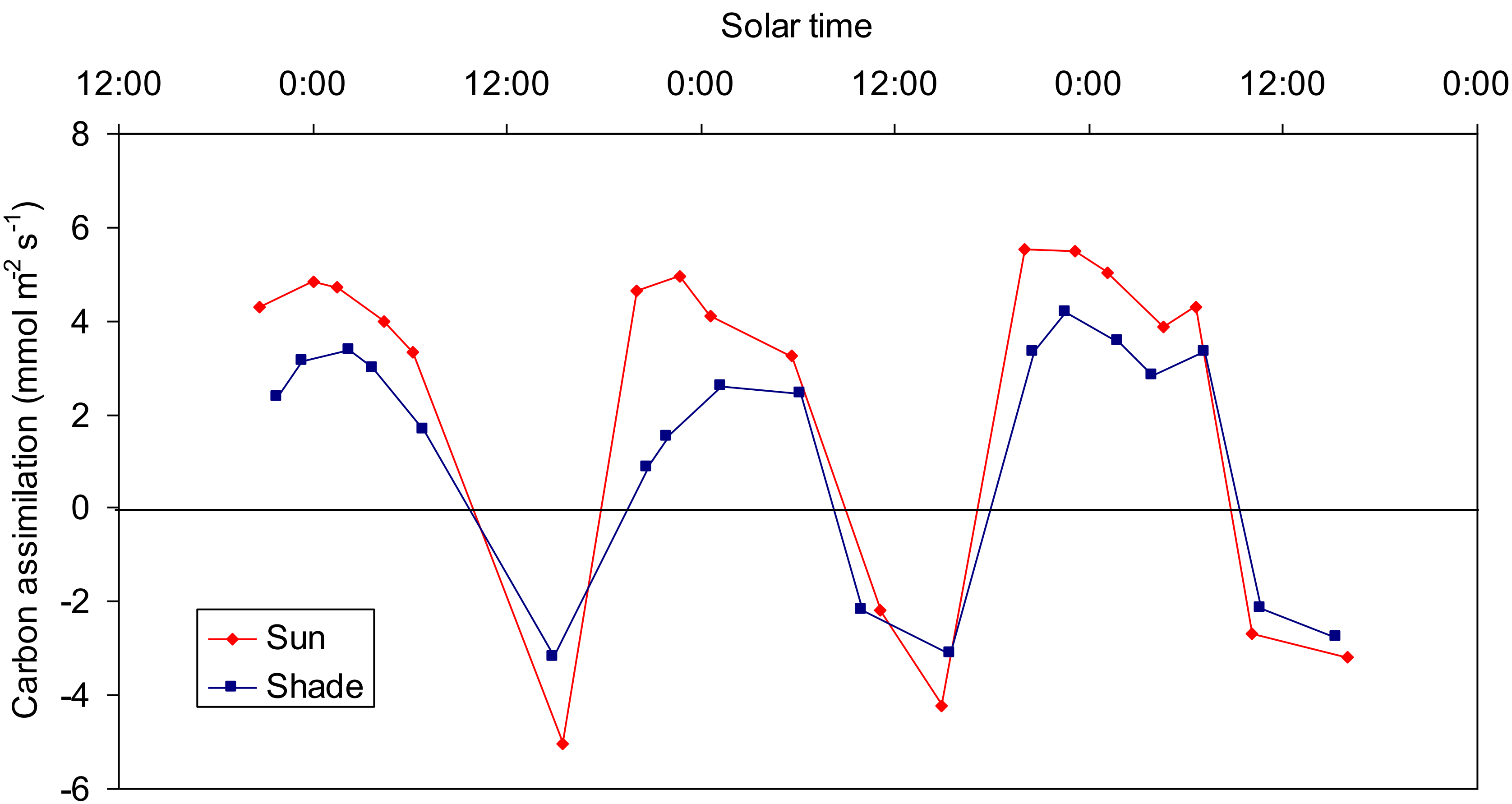


# Results: CA - IRGA



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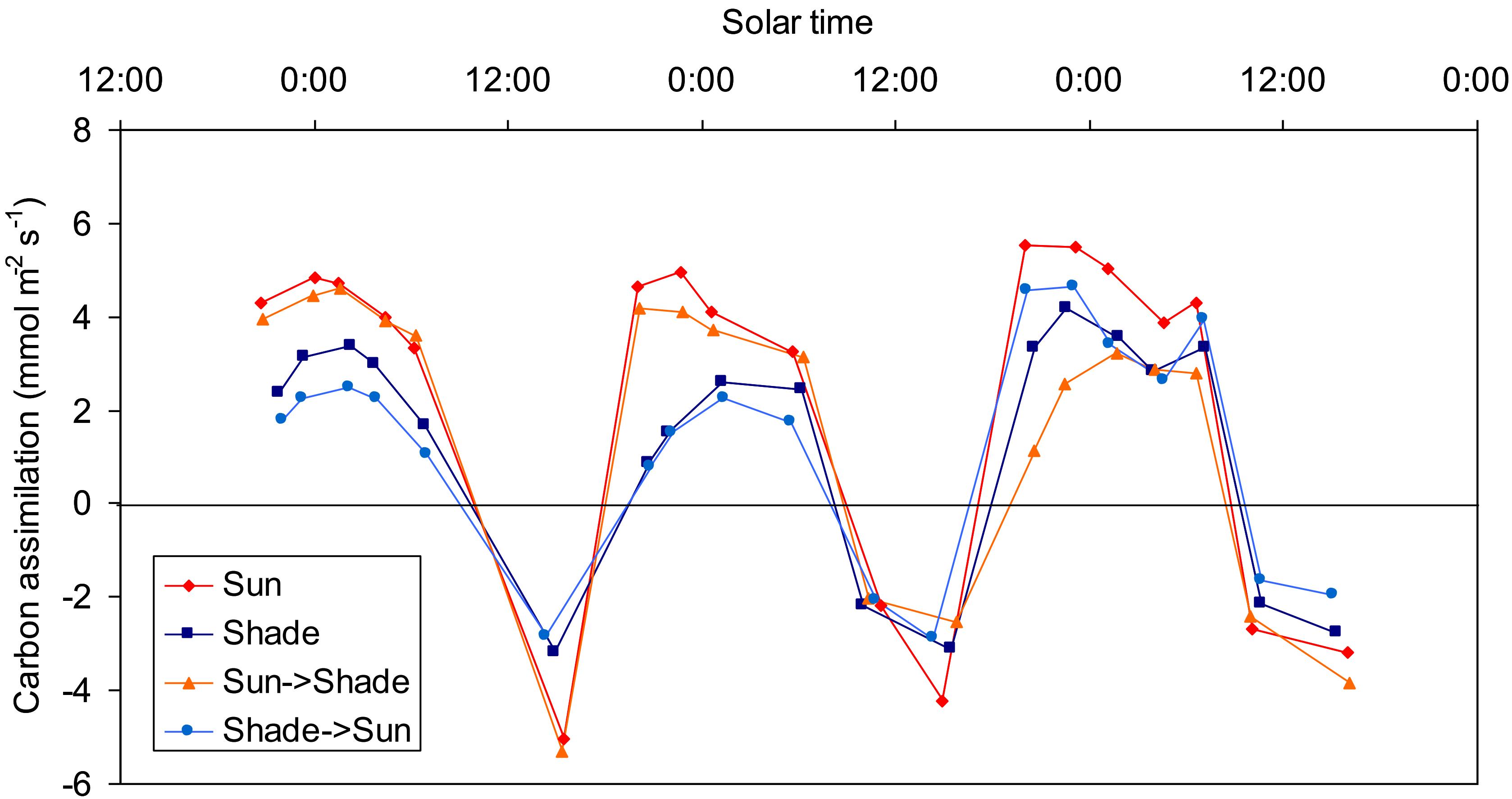
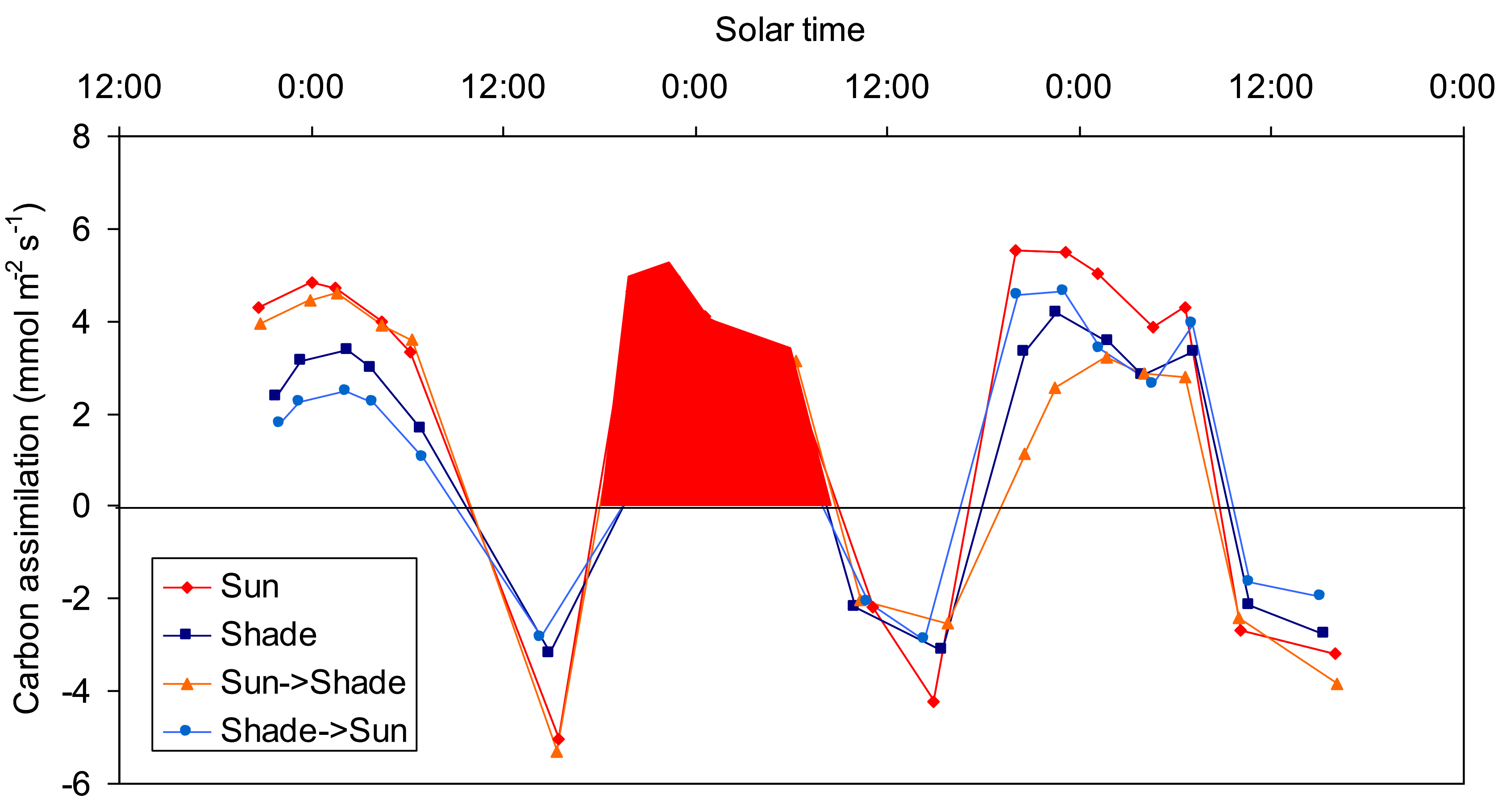


# Results: CA – IRGA: estimations



# Results: ¿CA estimated from TA vs CA estimated from IRGA?

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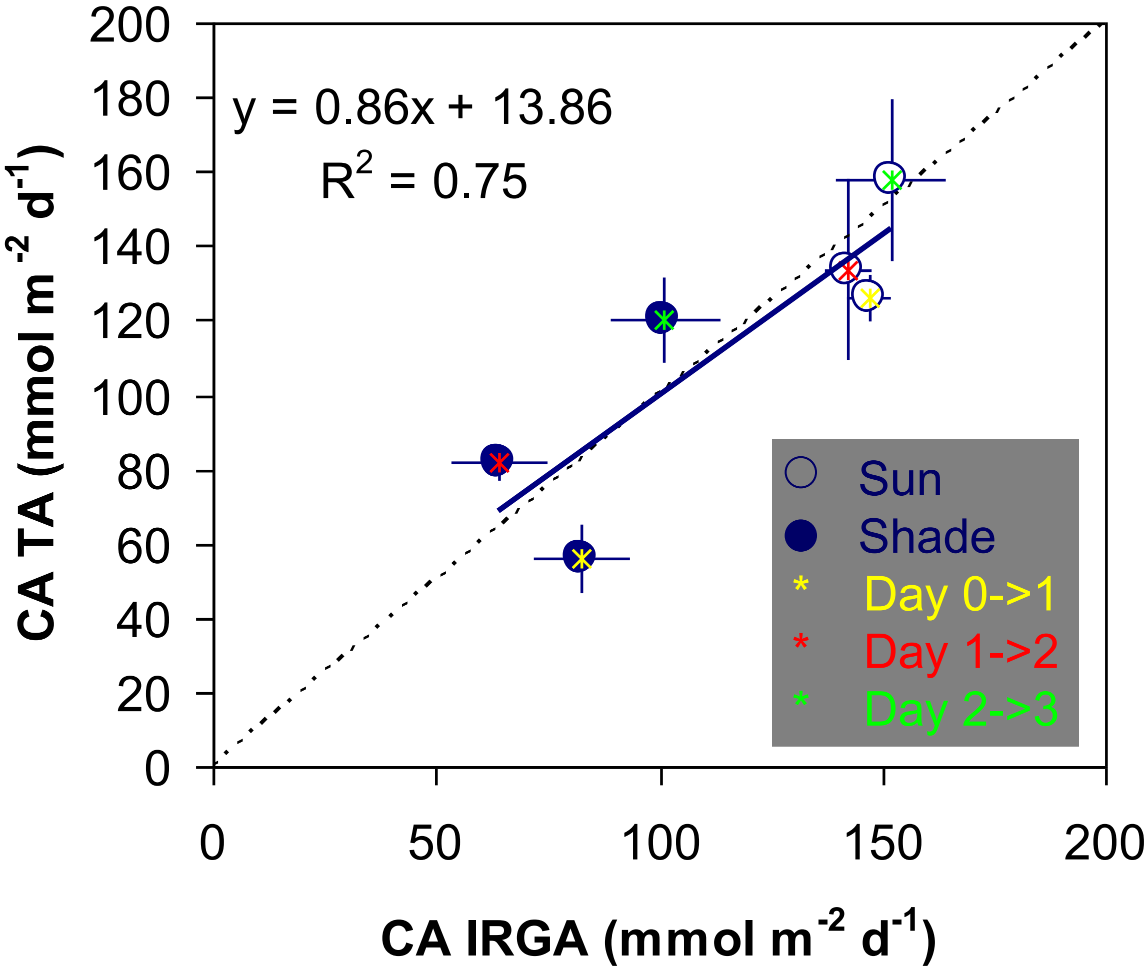

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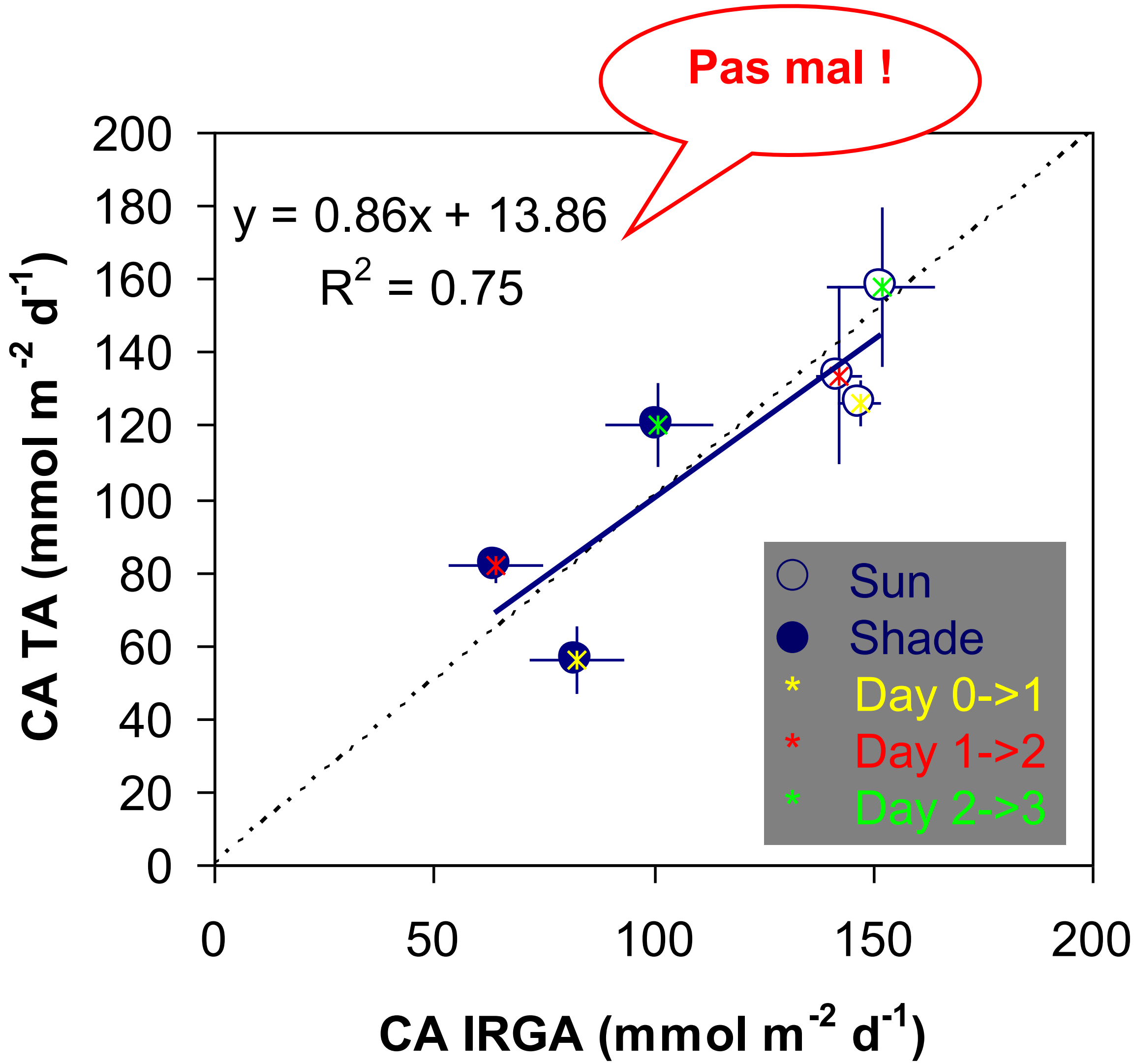

# Results: The Model: electron transport response to PAR

| | Parameter | East | West | **Total** |
|---|---|---|---|---|
| | | Orientation | | |
| Shade | $\theta$ | 0.77±0.06 | 0.81±0.1 | **0.79±0.08** |
| Shade | $\alpha$ | 0.27±0.01 | 0.24±0.04 | **0.25±0.03** |
| Shade | $ETR^{max}$ | 106.9±10.2 | 99.5±17.3 | **102.5±13.8** |
| Sun | $\theta$ | 0.86±0.05 | 0.92±0.05 | **0.87±0.06** |
| Sun | $\alpha$ | 0.28±0.03 | 0.27±0.02 | **0.28±0.03** |
| Sun | $ETR^{max}$ | 127.3±15.7 | 95.4±14 | **118.2±21** |
| **Total** | $\theta$ | **0.83±0.07** | **0.85±0.09** | **0.84±0.08** |
| **Total** | $\alpha$ | **0.28±0.03** | **0.25±0.03** | **0.27±0.03** |
| **Total** | $ETR^{max}$ | **121.5±16.7** | **97.9±14.3** | **111.6±19.4** |

No significant differences in parameters between shades and orientations

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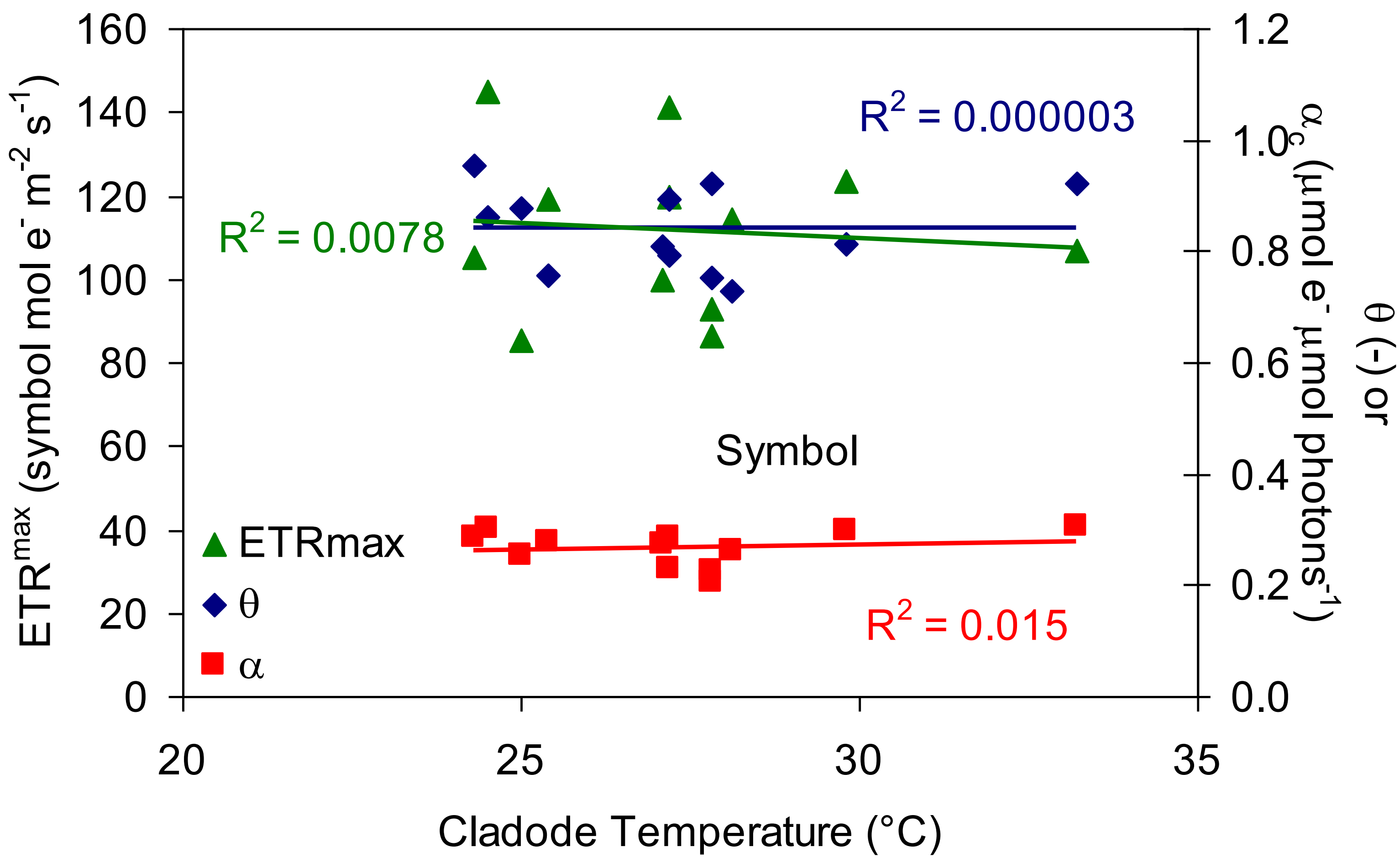
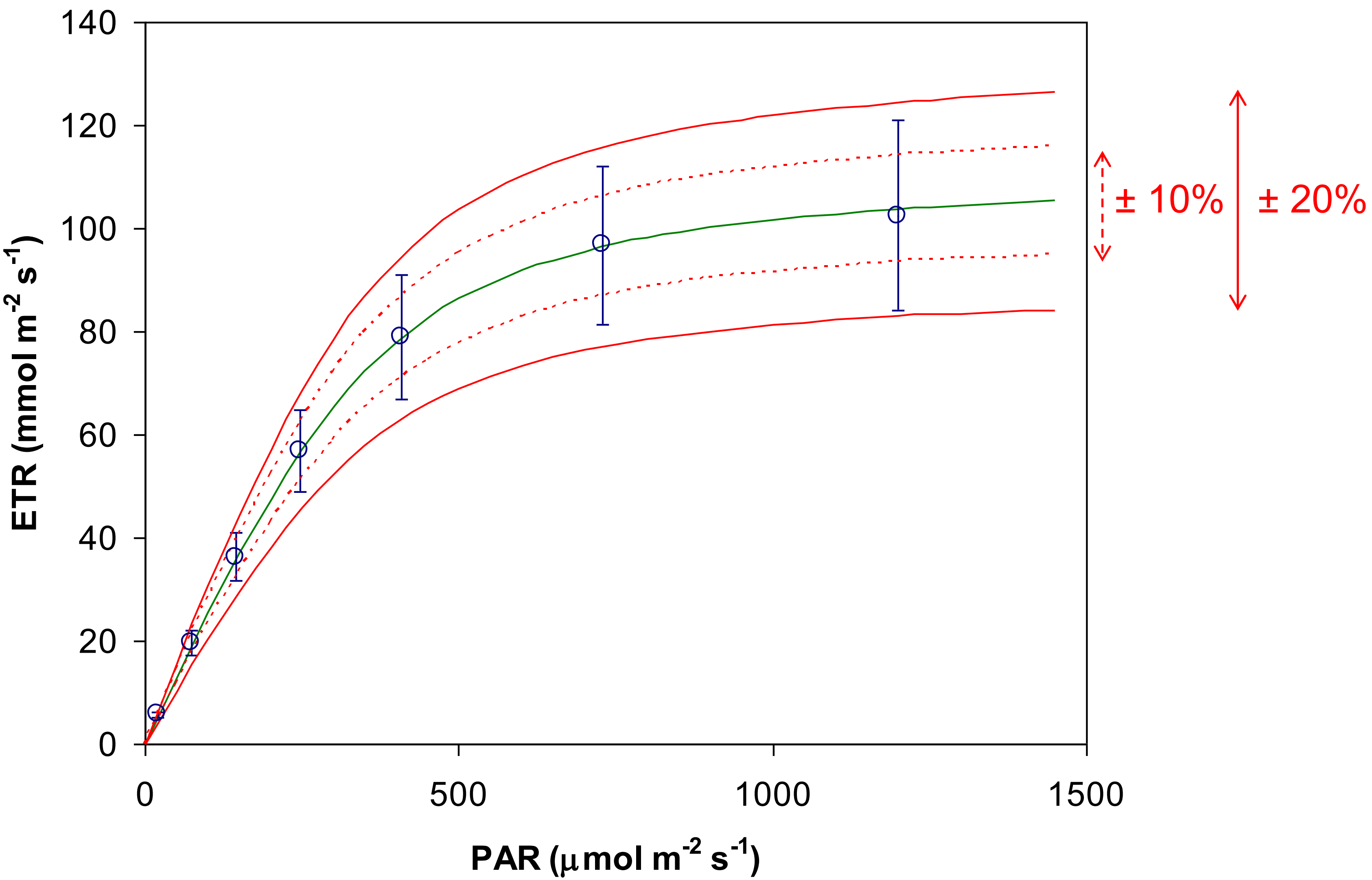


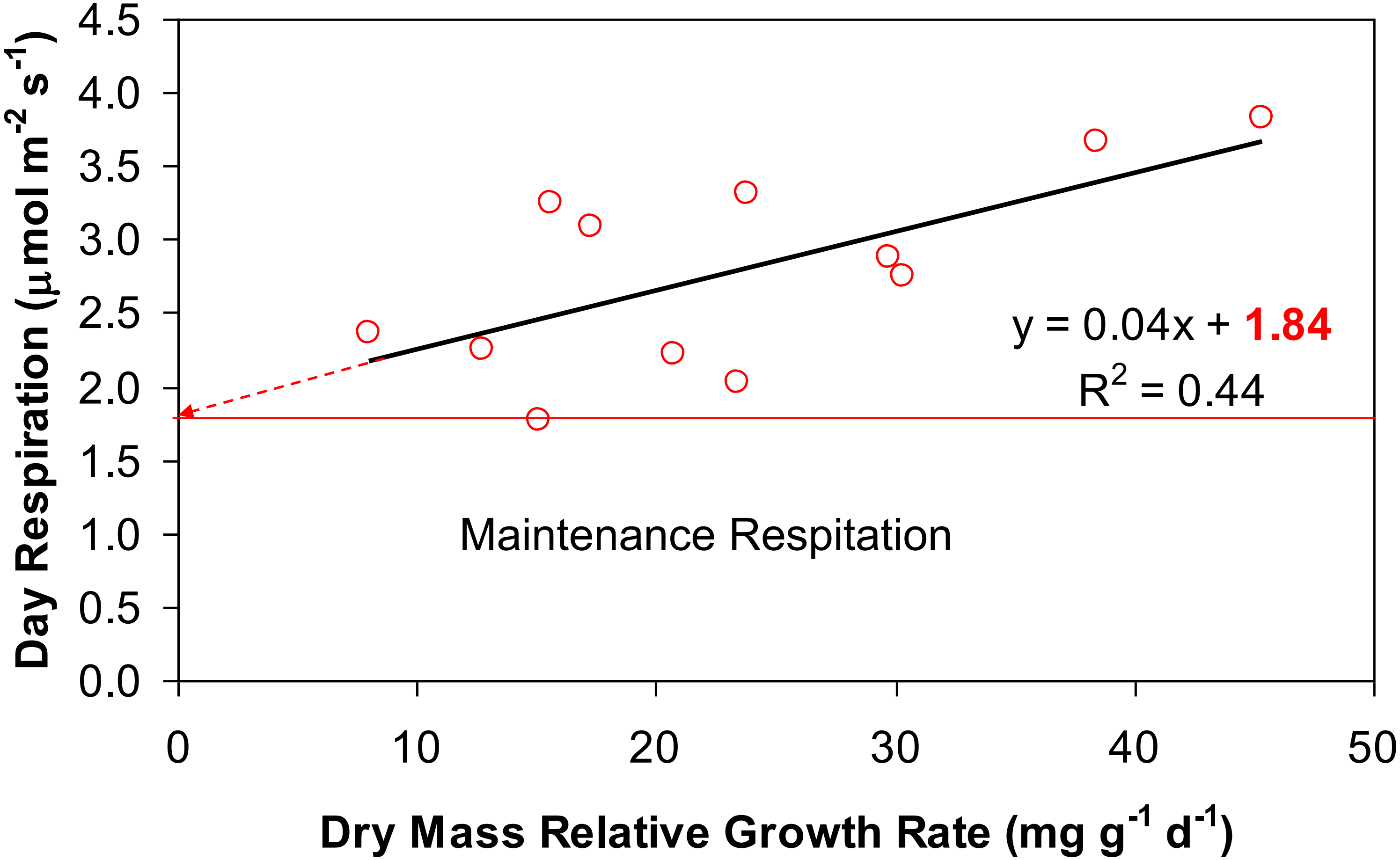

No effect of cladode temperature on parameters..!?

# Results: The Model: electron transport response to PAR



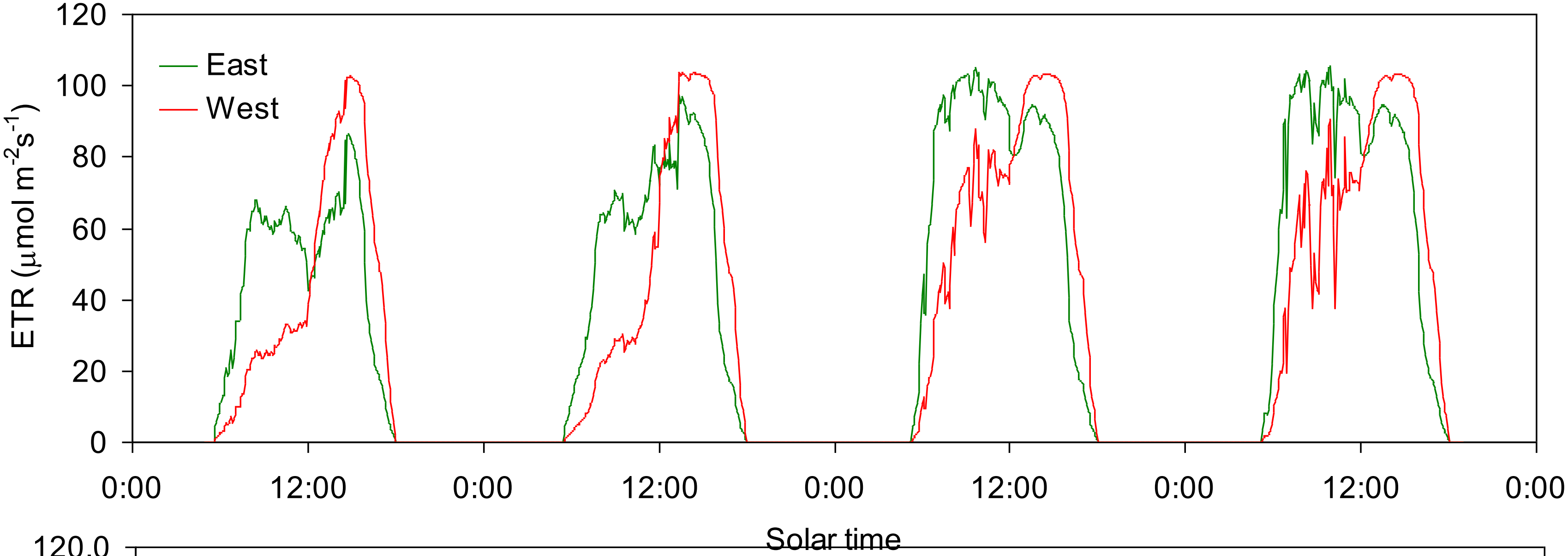

We hence adjusted a single curve

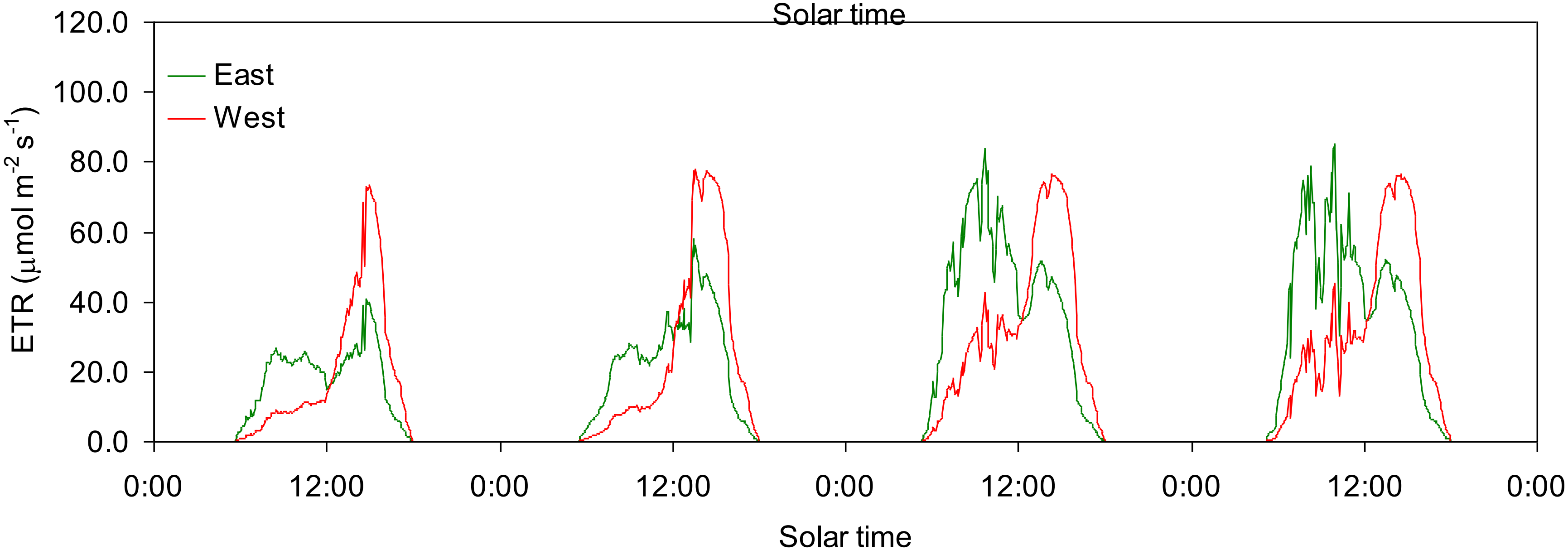
# Results: The Model: Respirations




T° air = 29.4 ± 0.7 °C

# Results: Simulations: ETR



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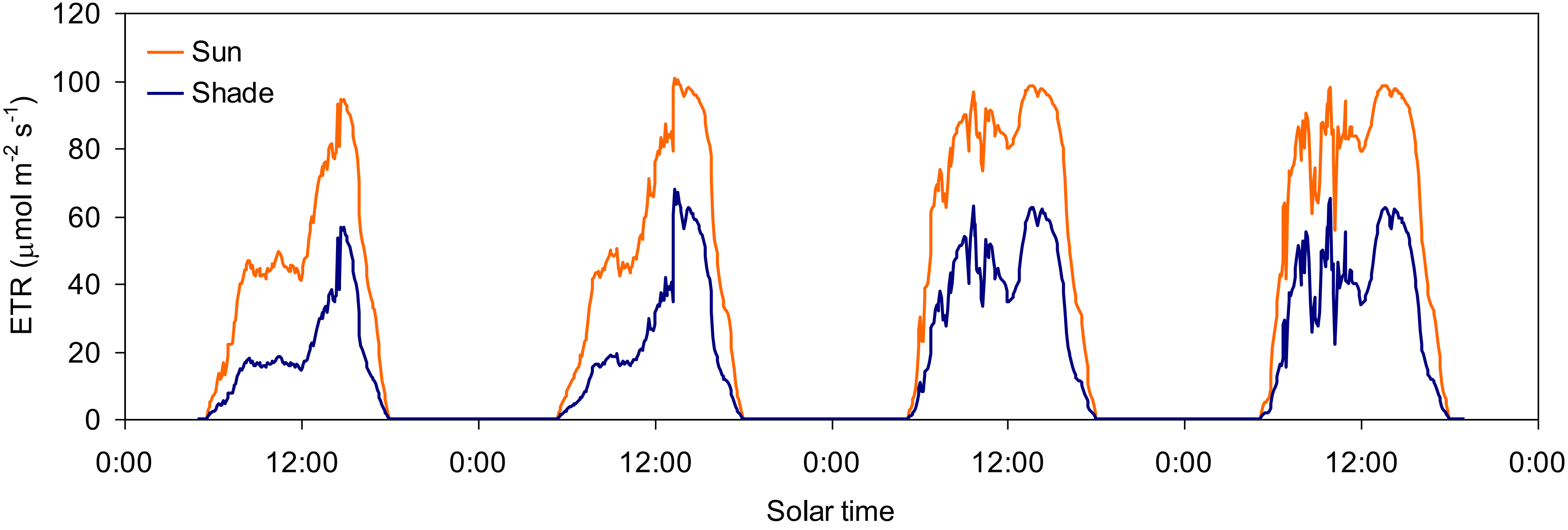

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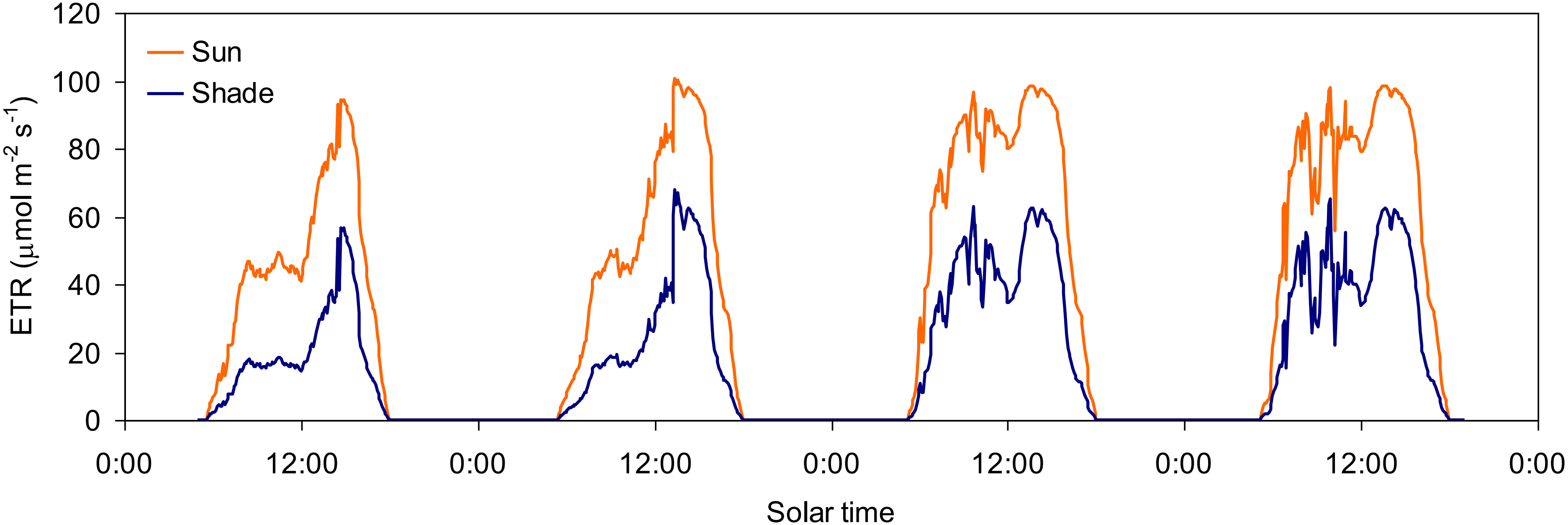
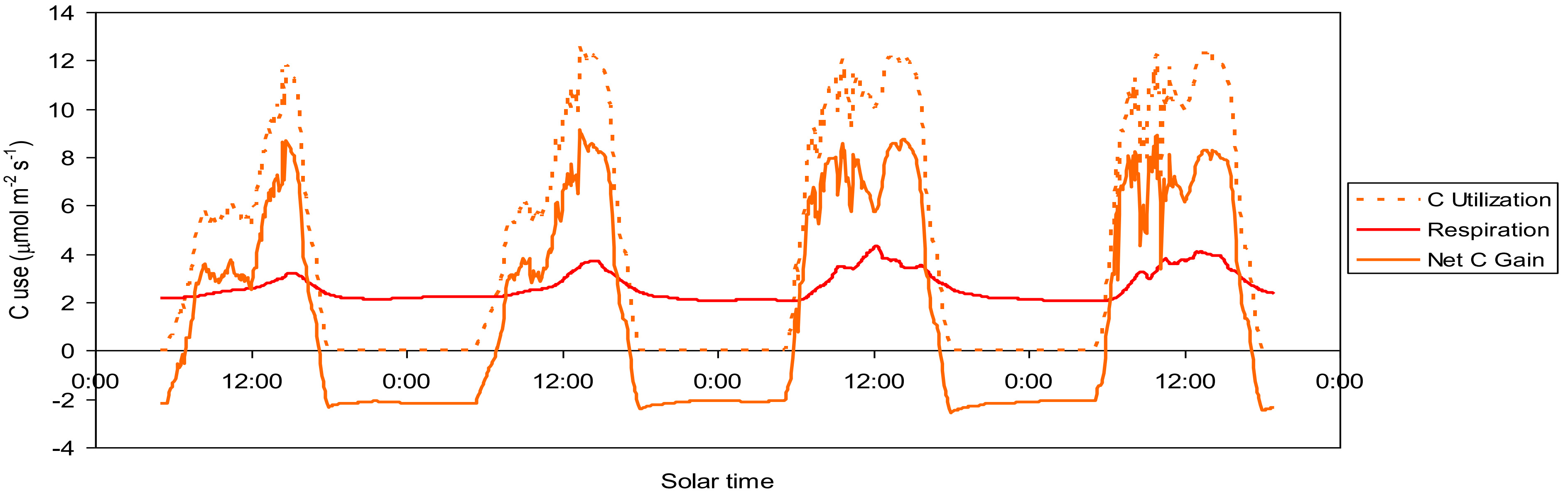
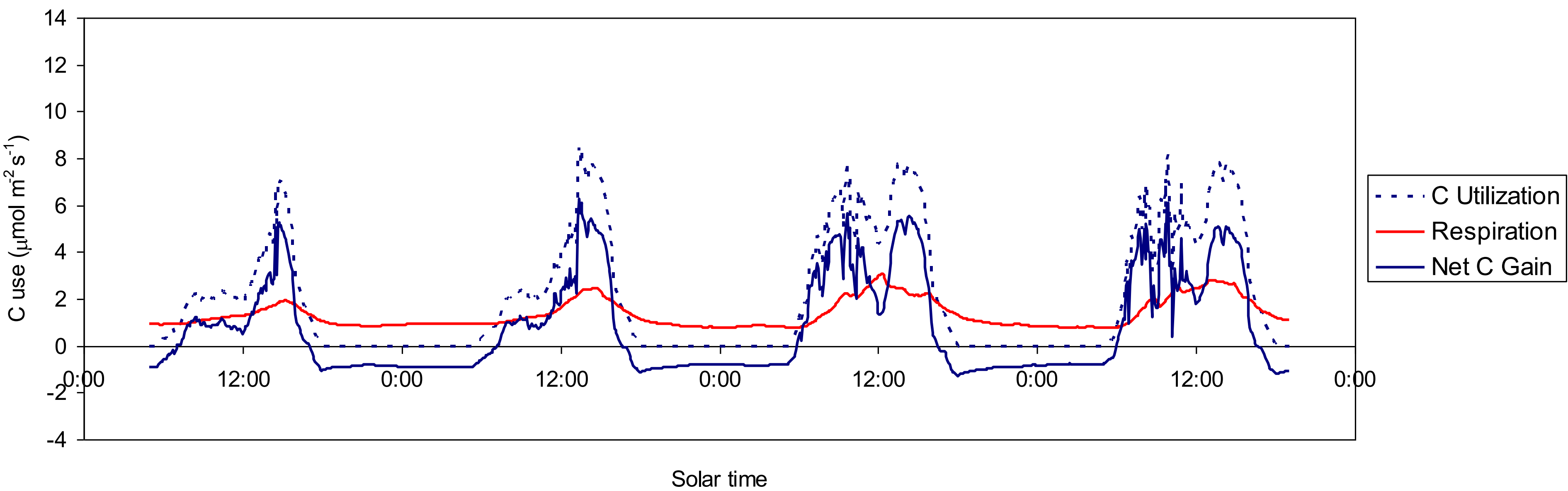


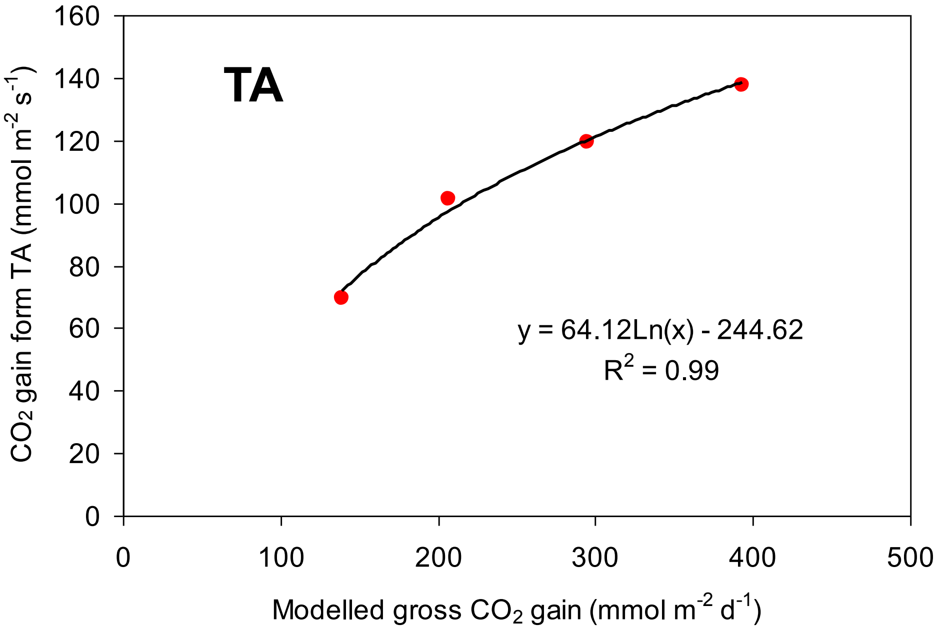

Carbon use in the light was estimated assuminga a stoichiometry of 8 e$^-$ per mole C

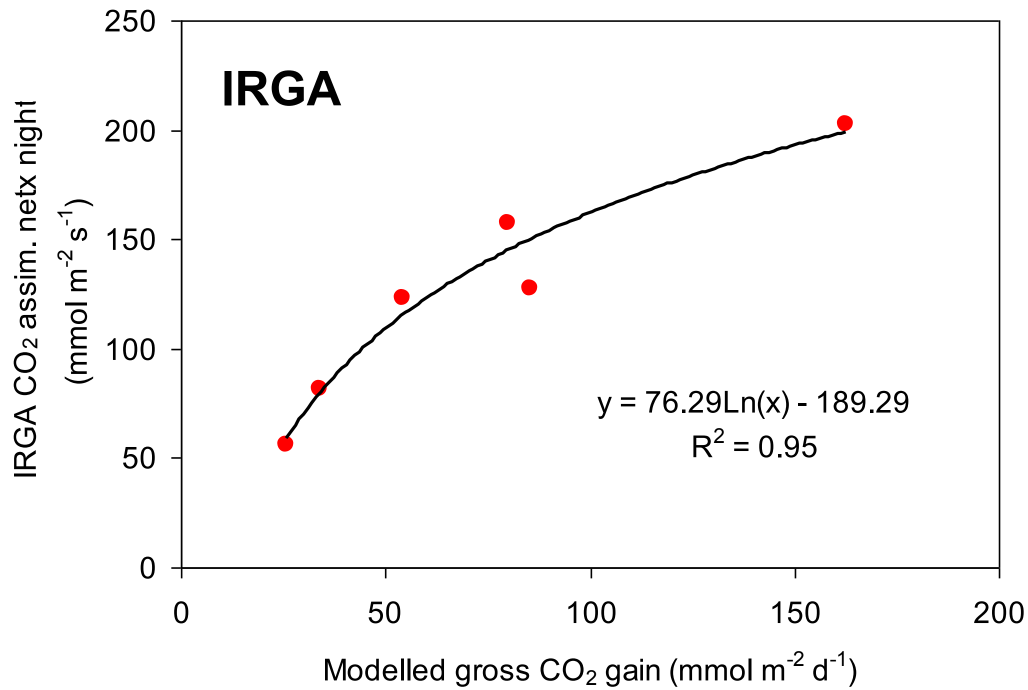
# Results: Simulations: Carbon (C) use



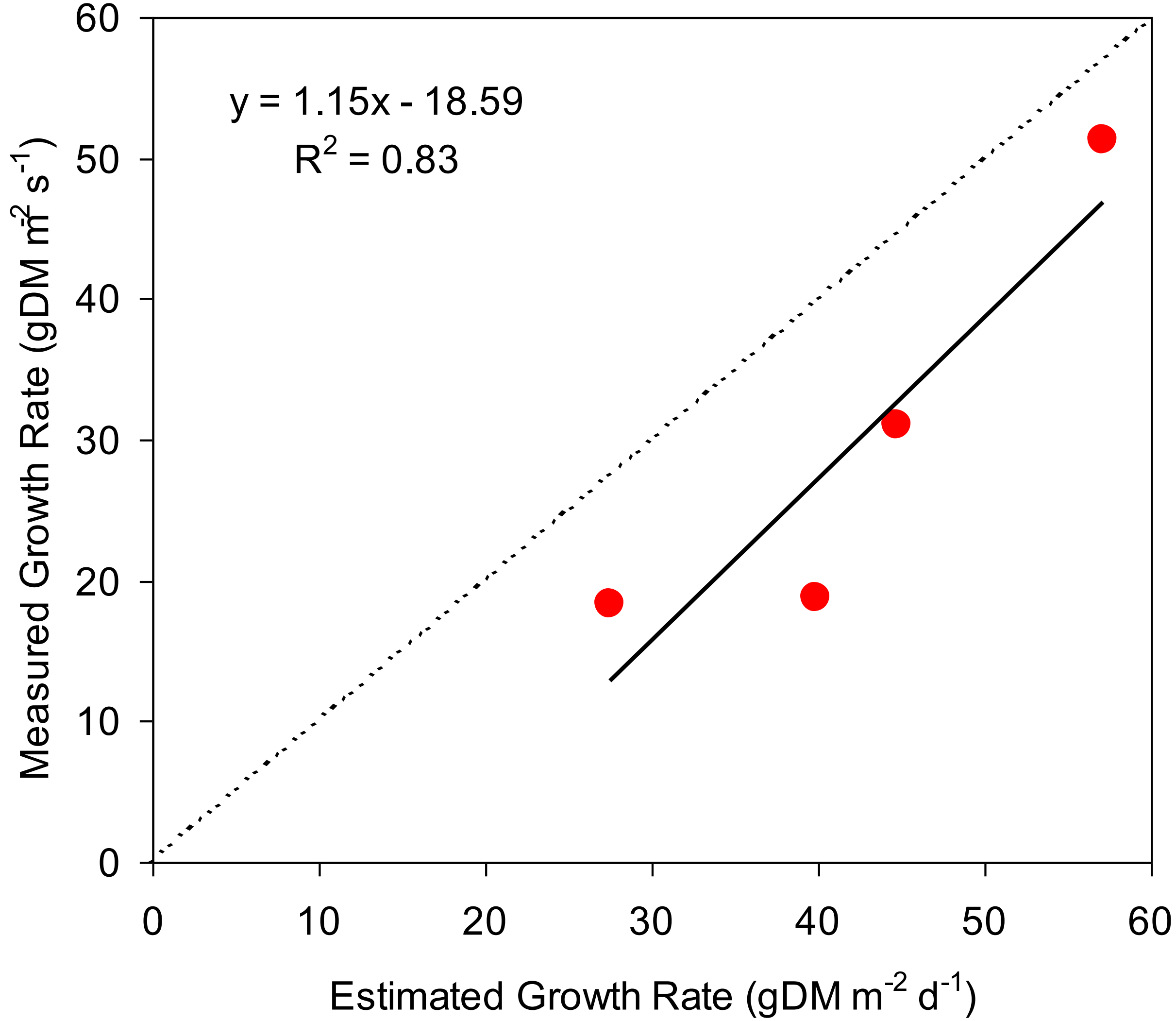
# Results: ¿How does the model compare to IRGA and TA?




- Model overestimates for high PAR availability!
- Sink feedback down-regulation?

# Results: ¿How does the model compare to actual growth?



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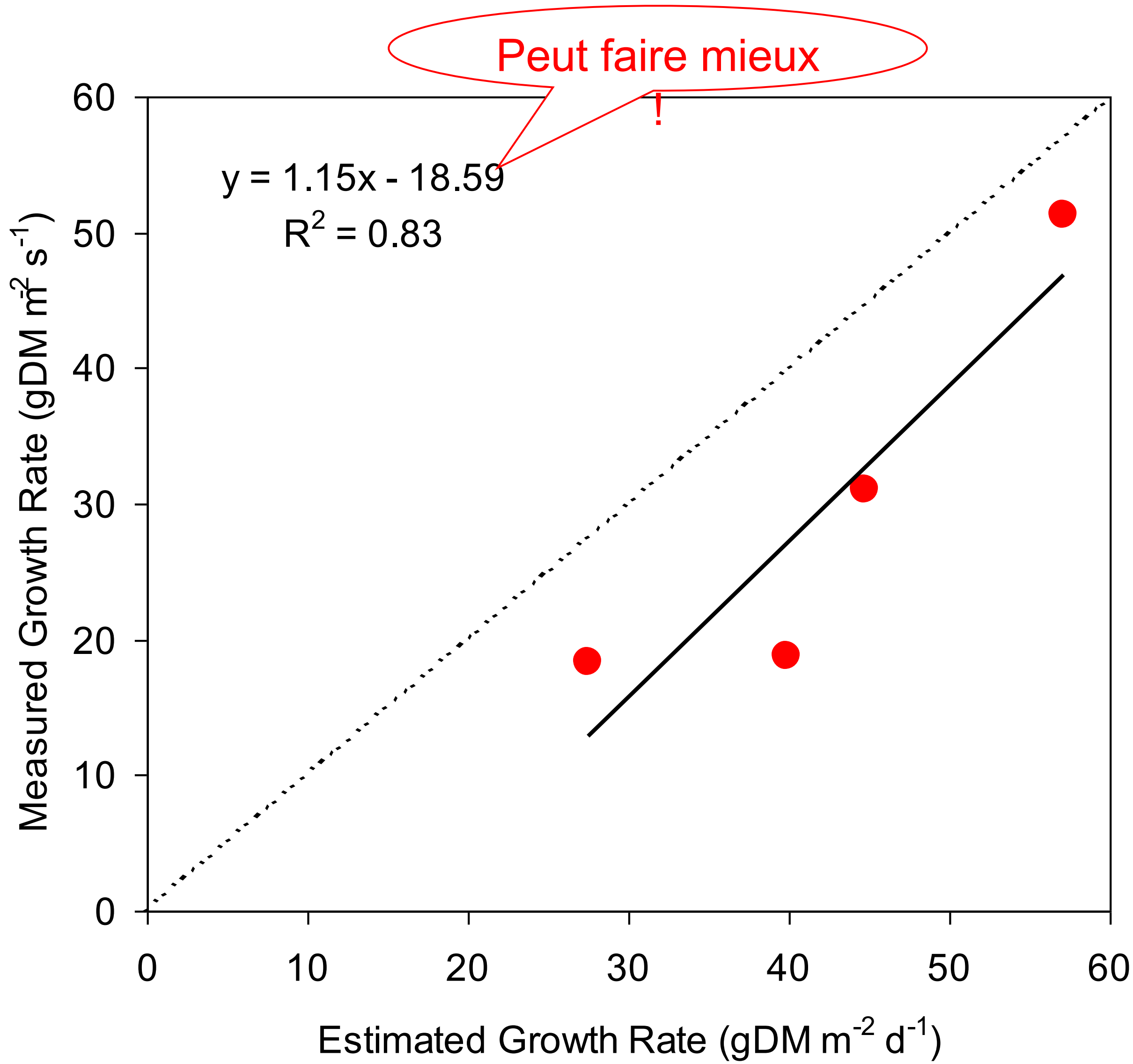

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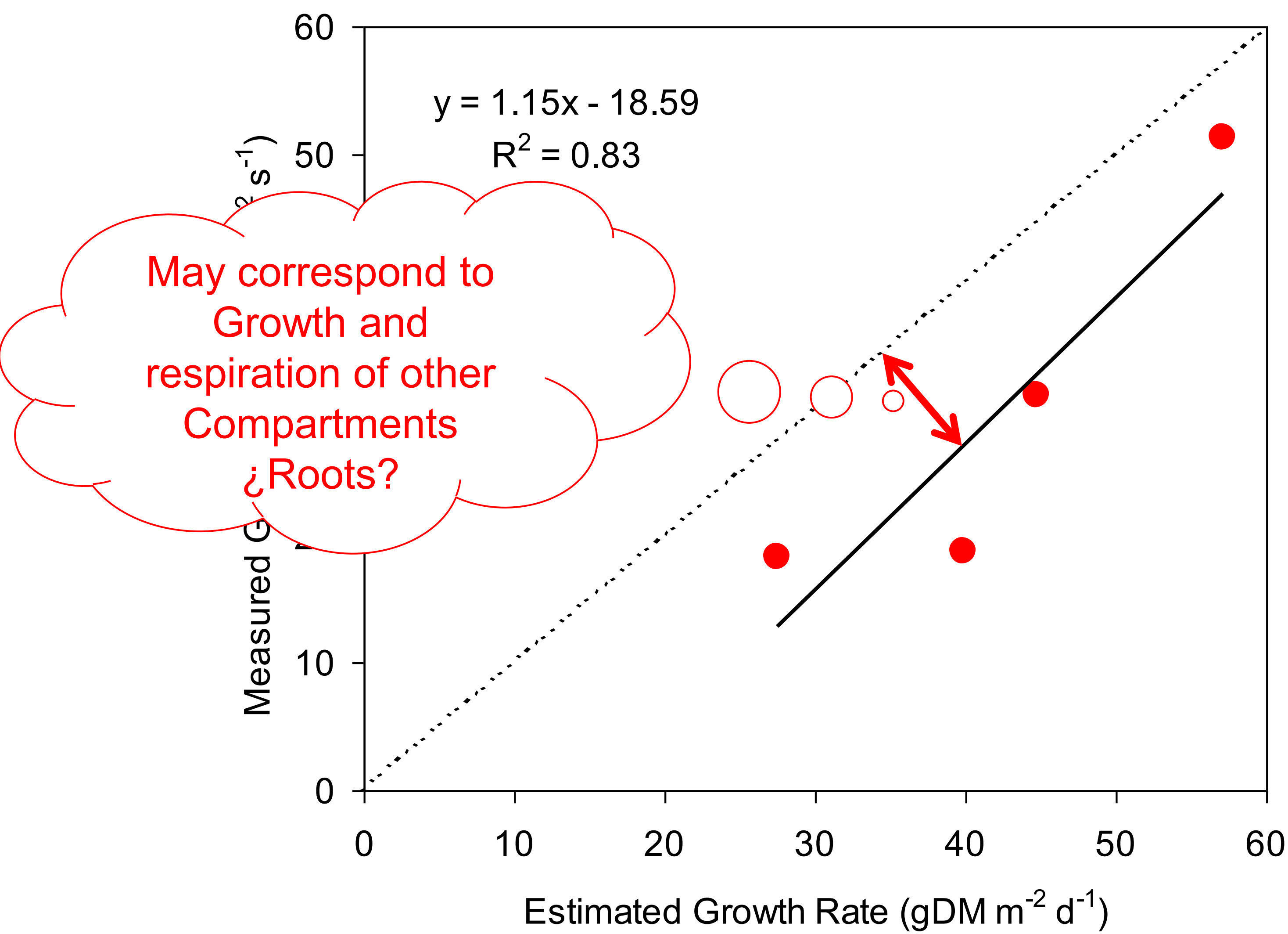

# Concluding Remarks:

- TA and IRGA estimation of carbon assimilation (CA) are comparable.
- Model reasonably predicts CA and growth but tends to overestimate:
    - Sink feedback inhibition?
    - Lack of accouniting for bellow ground biomass?
- Chlorophyll fluorescence light response curves may be a “easy” tool for screening for LUE (25 min/curve).
- Our results need to be tested over longer periods and under “real” conditions.


Víctor Muñoz
Ça c'est moi aux cheveux courts…
David Arancibia
Francisco Alfaro
GRACIAS!