Can we optimize feed production in alley cropping systems by adapting grass-herb composition based on distinct shade responses?

First insights from an artificial shade experiment

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Why this experiment?

Optimizing productivity and performance of alley cropping systems?

- Many ways: improved tree-crop combinations, smart & precision design, proper & precision management, ... Acknowledging the (spatial and temporal) heterogeneity

Selection of adapted crop species, varieties and/or mixtures

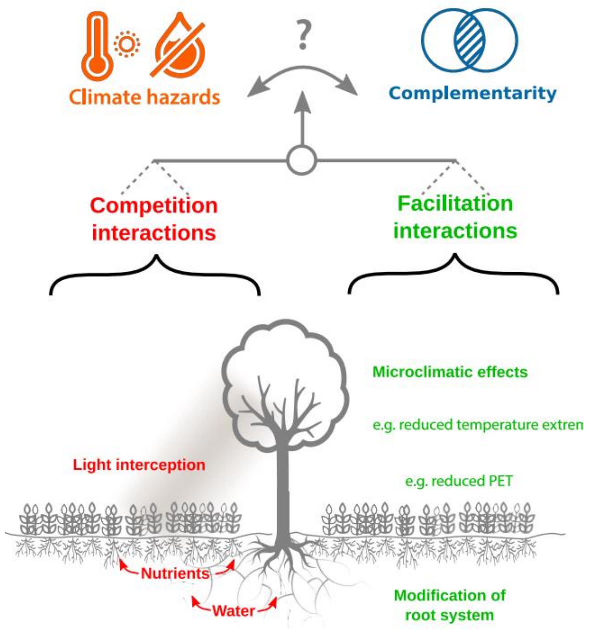
- Specific crops / varieties for specific zones
- Many attributes to be considered…
    - Adaptability to context specific soil conditions
    - Nutrient availability and needs
    - Water availability and needs
    - Pest and disease susceptibility
- **Here: responses to light availability =>** Light likely to be the principal limiting resource for understorey crops in temperate AF systems (Eichhorn et al., 2006; Dufour et al., 2013; Artru et al., 2017)

What do we already know?

- The impacts of shade on crops:
    - Morphological adaptation for maximal light harvesting
    - Lengthening of the growing cycle (not always)
    - Yield losses generally proportional to shade intensity – winter crops less affected
    - Improvement of (grain) quality, i.e. protein content
- The level of light reduction and the period of shading are key factors:
    - Low to moderate PAR reduction often associated with the most relevant morpho-physiological compensations and higher yield
    - Different phenological stages are diversely impacted by shade
- Cumulative rainfall and potential evapotranspiration are key climate moderators
    - Trees have a protective role on crop yield in periods and/or locations with low rainfall and high evapotranspiration (*Panozzo et al. – meta-analysis – soon to be submitted*)

Where do we need more insights?

Based on Blanchet et al. 2019

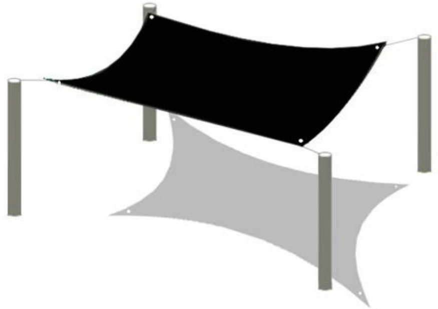


- Tipping points
- The impacts of shade on crops:
  - Which are the the crop varieties most adapted to AF?
  - Which are the key traits for adaptability to agroforestry?

→ Screening of available crop varieties

→ Artificial shading is a relevant experimental tool

- Simultaneously screen a number of varieties in a controled but real life environment
- Test different shade levels in a similar edaphic environment
- Isolate the LIGHT factor from other potential interactions with trees



Artificial shade trial @ ILVO: objective and experimental setup

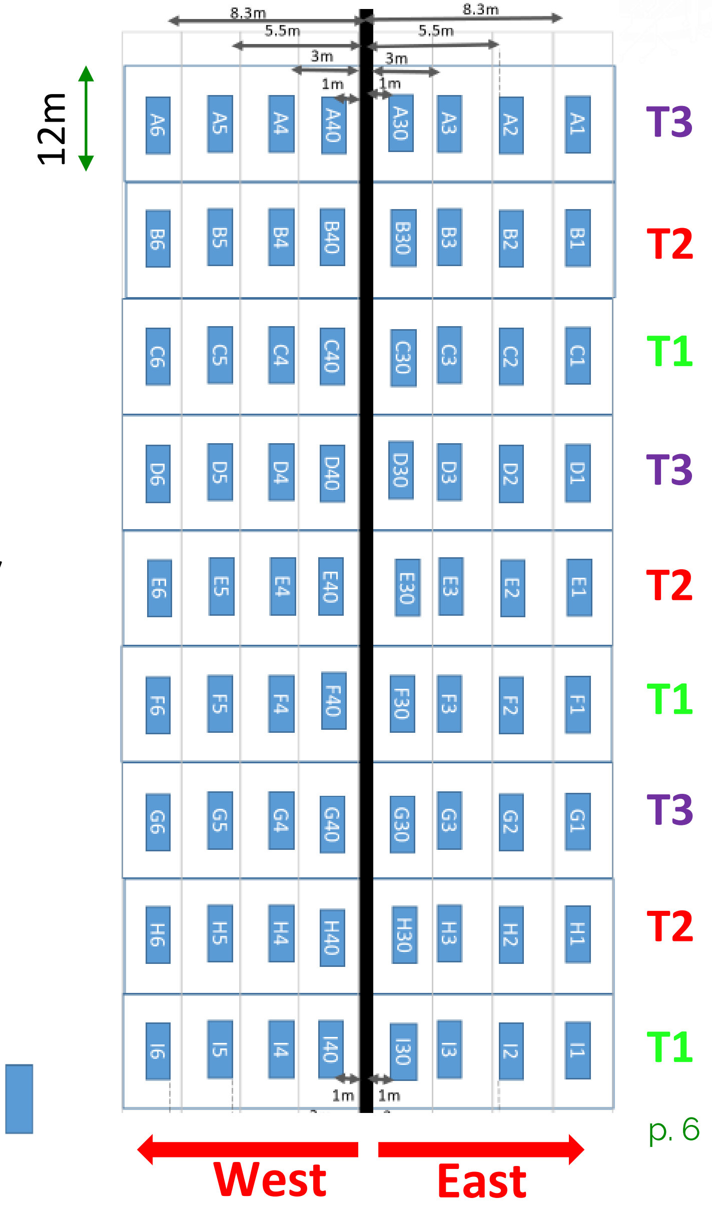
- Screening promising & contrasting crop varieties & mixtures
- Conditions and crop choices representative for Belgian climate & (organic) agriculture
- Artificial shade structure mimicking a mature agroforestry system
- Nets 3m wide at a height of 3.5m
- Nets can be closed in between every two poles in case of extreme weather events



Artificial shade trial @ ILVO: objective and experimental setup

Experimental setup first trial period

- **Crop choice**: Grass-clover(-plantain) mixtures
  - **T1: Lolium perenne + T. pratense**
  - **T2: Festuca arundinacea + Trifolium pratense**
  - **T3: F. arundinacea + T. pratense + Plantago lanceolata**
- Objective:
  - Assessing the impact of shade on crop morphology, yield and quality
  - Interactions with other plot and microclimatic conditions
  - Differences in response between these mixtures?
- 9 shade treatments per crop mixture
  - 8 shade conditions = 4 distances (shade levels) at both sides
  - 1 absolute control = open field



Crop sampling position

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Artificial shade trial @ ILVO: objective and experimental setup

Crop monitoring protocol

- ± Monthly: Leaf Area Index (LAI) – SunScan equipment
- At every mowing moment:
  - Species composition = proportion of different species within mixture
  - Yield = dry biomass/m^2
  - Quality = moisture, crude protein, watersoluble sugars, digestibility, crude fibre, NDF, ADF, ADL

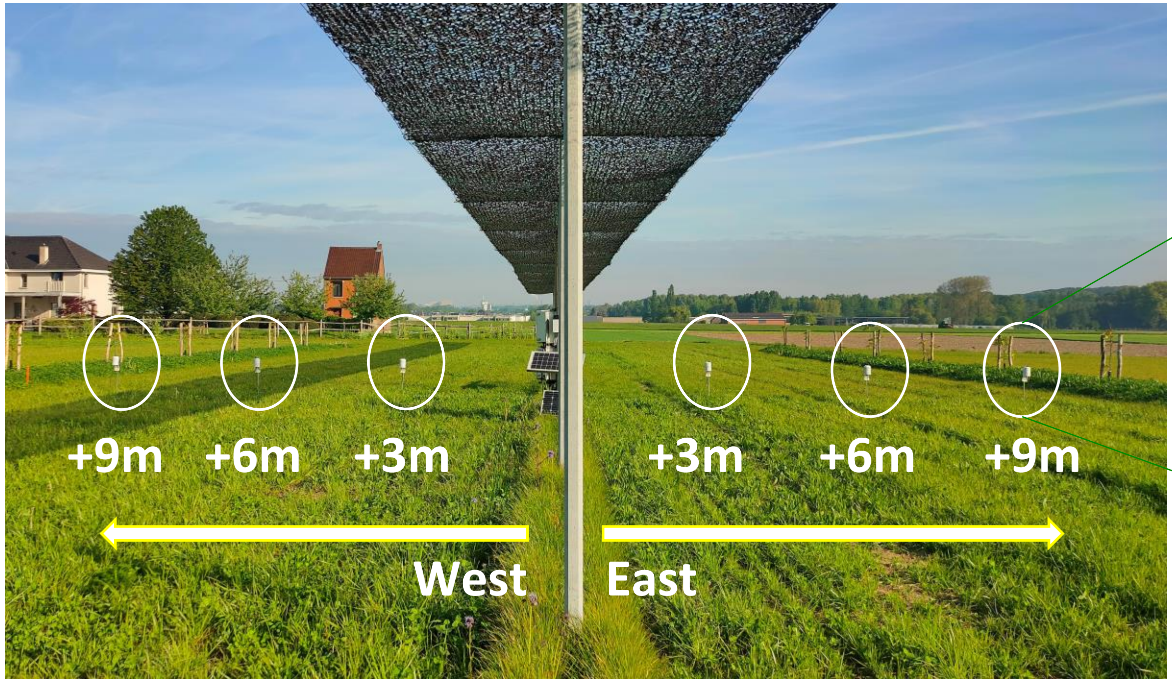
2022: 1/6 4/8 11/10

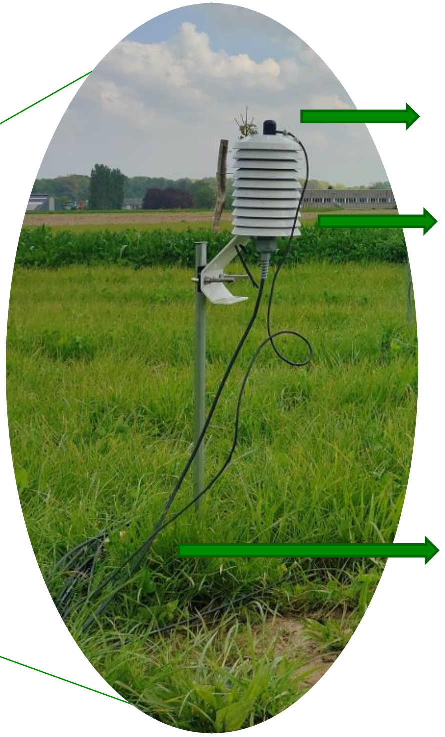
2023: 27/4 13/6 25/7 04/9 23/10

Artificial shade trial @ ILVO: objective and experimental setup

Sensors to assess microclimatic variation

- Impact of the shading structure on microclimatic parameters at different distances
  - Time interval: 10 minutes
  - Data collection via field dataloggers or remote downloading





Light intensity (PAR) (80 cm ↑)

Air humidity (70 cm ↑)

Air temperature (70 cm ↑)

Soil water content (0-30 cm ↓)

Soil temperature (0-10 cm ↓)

Soil water potential (10 cm ↓)

Getting more out of the data

- Mixed approach for a better connection of the microclimatic data with the crop data

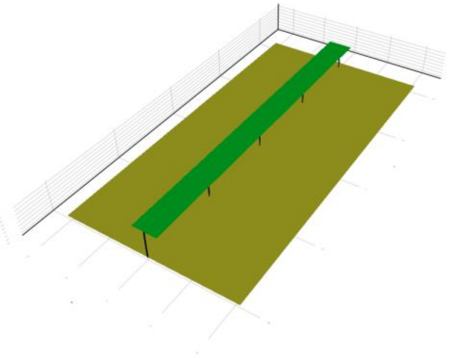
Reference input data

Point sensors

- Missing time points:
  - Intermediate harvests
  - Sensor failure
- Limited spatial resolution

3D model

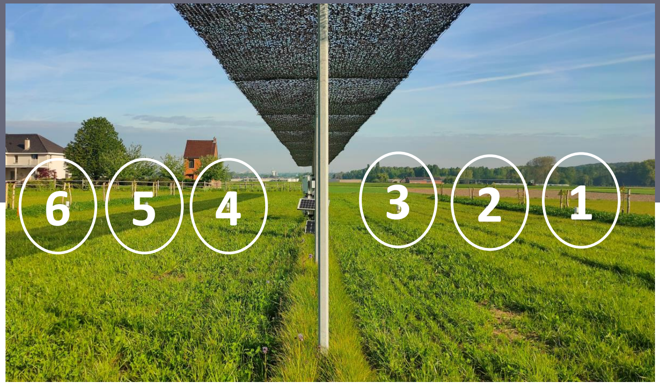
julia

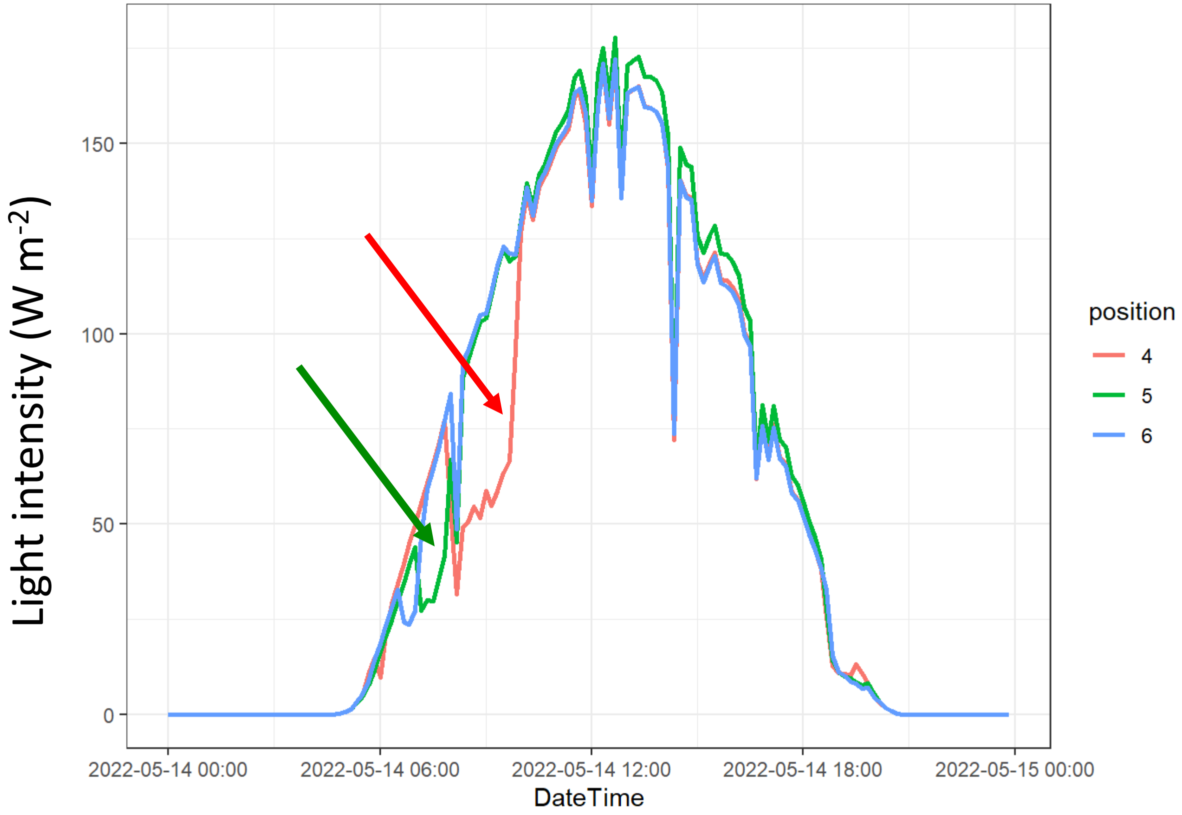


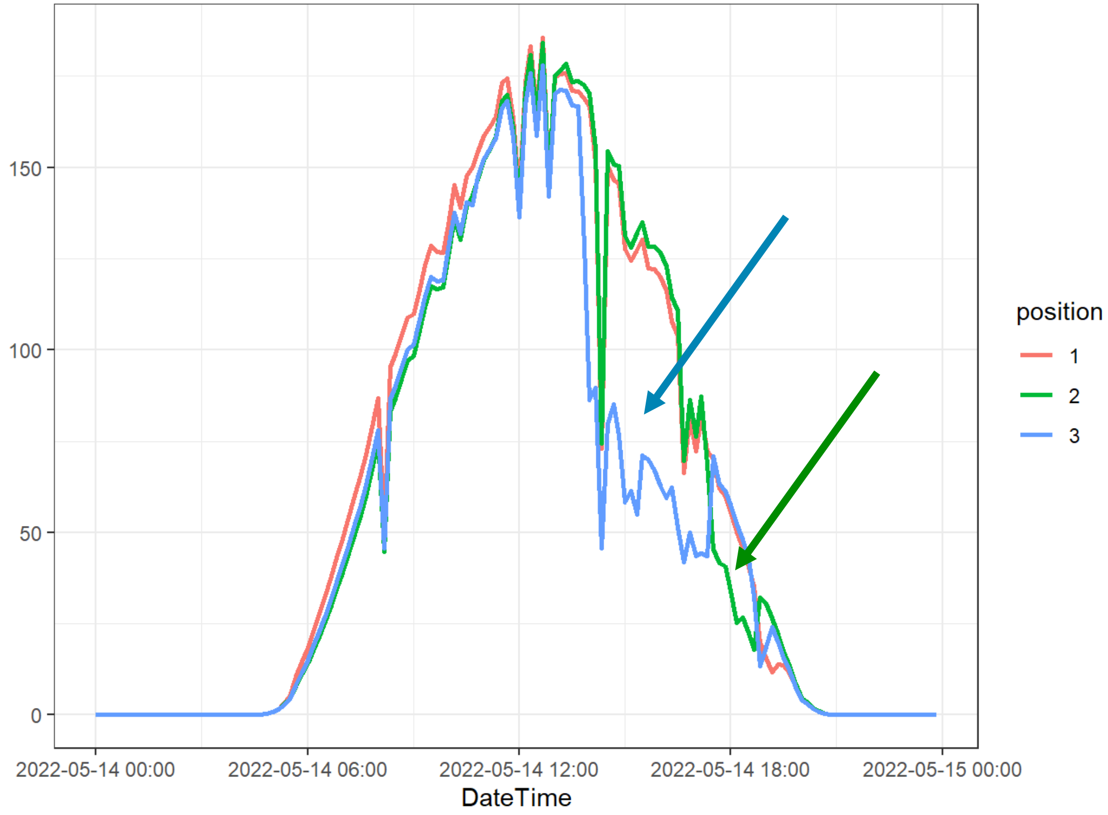
Full spatial and temporal coverage output data

First results

Typical light pattern







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First results

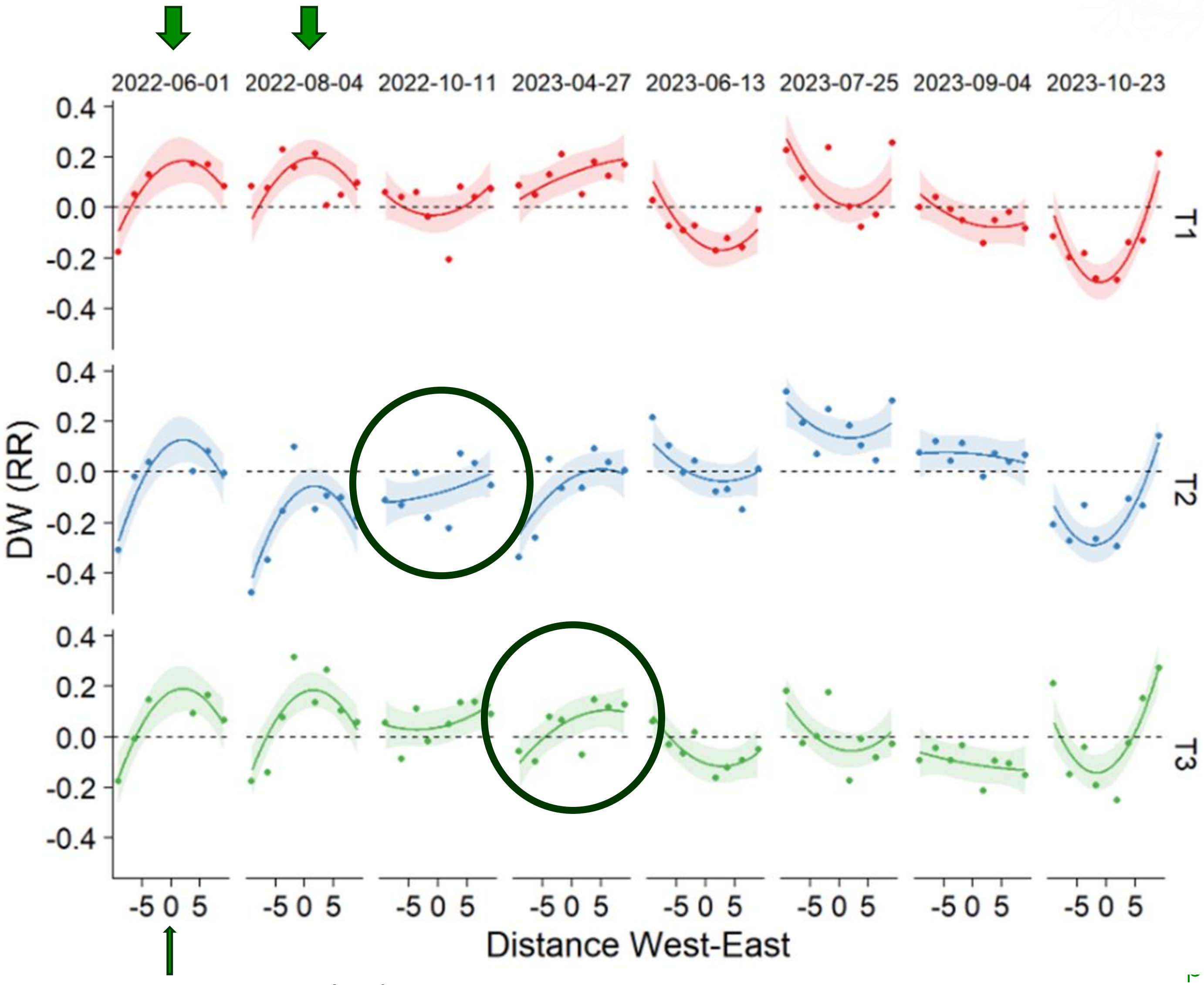
Biomass (DW)

- 2 growing seasons – 8 mowing moments

R = **biomass DW**

$$RR = ln\left(\frac{Response_{AF}}{Response_{C}}\right)$$

- Yield improvements close to the shade structure when high temperatures and dry conditions (e.g. June & August 2022)
- Afternoon shade (east side) more favorable than morning shade (west)
- More direct insights in responses to microclimatic differences after modeling
- Then also look into differences between treatments



0 = center = most shade

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Do I have some time left?

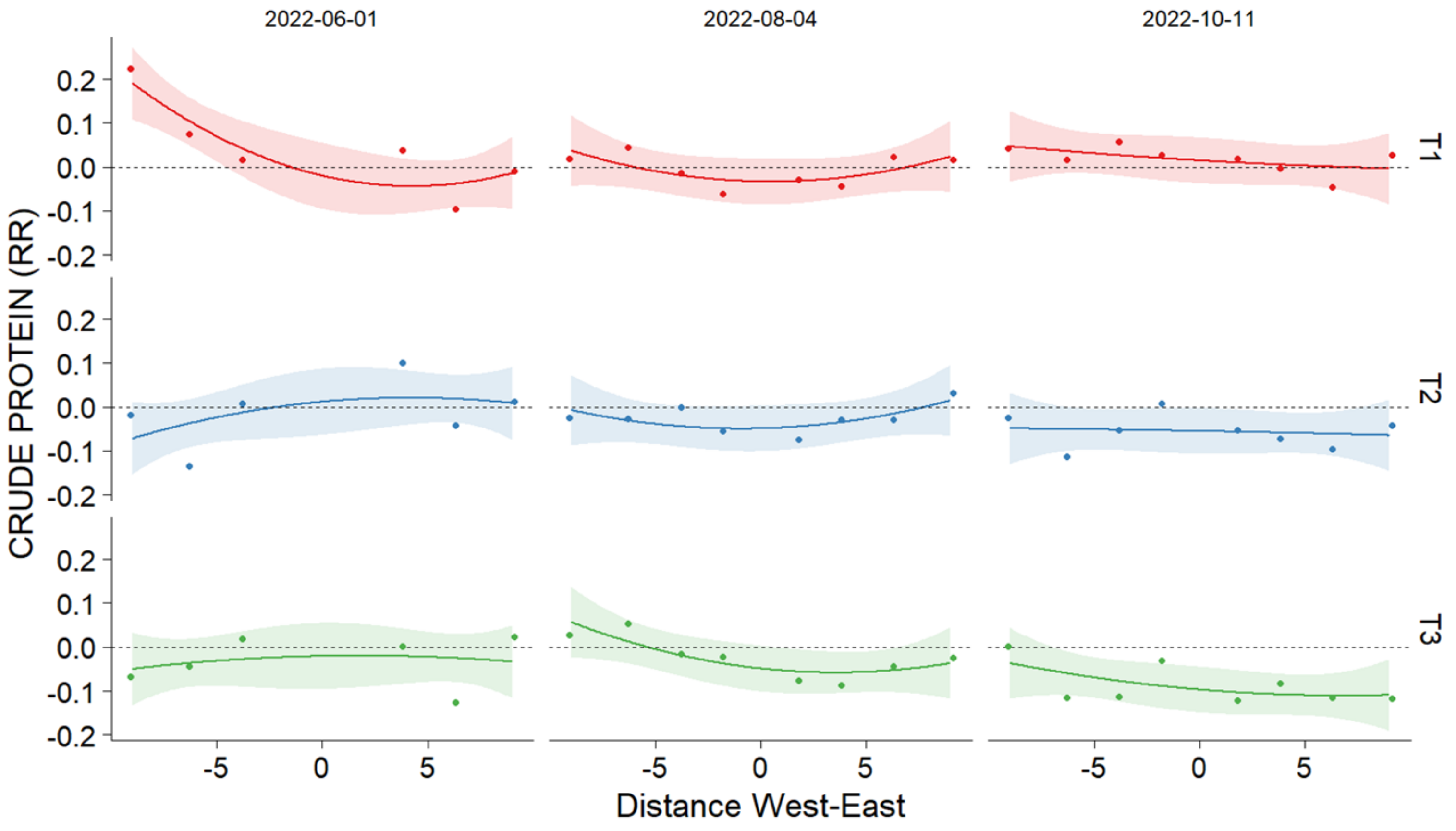
Crop quality – crude protein

- 1 growing season – 3 mowing moments

- Lower variations across distances
- Lower variations vs. C
- Opposite trend vs. biomass DW --> some positive variations vs. C on the western side (morning shade)

R = **crude protein**

$$RR = ln\left(\frac{Response_{AF}}{Response_{C}}\right)$$



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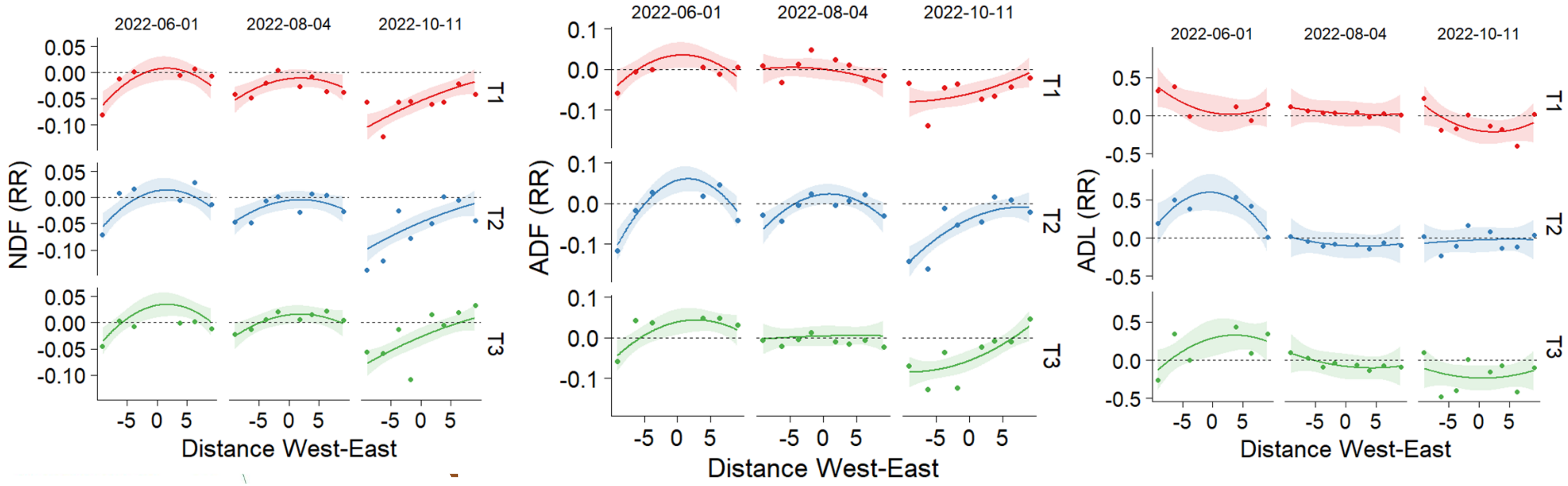
Do I STILL have some time left?

Crop quality – NDF, ADF, ADL

- 1 growing season – 3 mowing moments
- Larger variations vs. Crude protein
- Slightly better close to the shade structure (especially ADF & ADL) under drought conditions (June and august 2022)
- Afternoon shade (east side) tendentially better vs. morning shade (west), similarly to biomass DW

R = **NDF, ADF, ADL**

$$RR = ln\left(\frac{Response_{AF}}{Response_{C}}\right)$$



Thank you for your attention

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This project has received funding from the European Union's Horizon Europe research and innovation programme.

Grant agreement: 101059794

Co-funded by the European Union

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