MICROCLIMATIC EFFECT OF AGROFORESTRY ON DIURNAL TEMPERATURE CYCLE

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Daytime shade/night mask of trees
Effect of daily temperature range on crop growth

**Garcia et al, 2015**
(wheat in the field with heating tents at night)

**Qiao et al, 2014**
(wheat in growth chambers

- ETS: symmetrically elevated temperature = +3°C day and night
- ETA: asymmetrically elevated temperature = +2.5°C day, +3.5°C night)

**Lobell et al, 2007**
(correlation study between climate data and national wheat yield)

**Fig. 2**

**Fig. 3**

- WARM NIGHTS REDUCE WHEAT AND BARLEY YIELD

- Both asymmetric and symmetric warming increased evapotranspiration, compared to ambient warming.

- The total aboveground biomass and harvest index as affected by elevated CO$_2$ concentration was significantly decreased under elevated temperature conditions.

- The daily temperature range (DTR) had a significant impact on crop yield, with higher DTR values leading to decreased yield.
Effect of climate change on daily temperature range

Easterling et al, 1997
(monthly averaged maximum and minimum temperatures, 1950-1991)

Wang and Dillon, 2014
(hourly temperature records, 1926-2010
black= polar regions, blue=temperate regions, red=tropical regions)
Objectives

- to better characterize the effect of trees on the diurnal temperature cycle
- in order to determine if agroforestry has the potential to alleviate or inversely to aggravate the impact of climate change
Experimental plots
Diurnal Temperature Cycle model

\[
T(t) = T_0 + T_a \times \cos \left( \frac{\pi}{\omega} \times (t - t_m) \right), \text{if } t < t_s
\]

\[
T(t) = (T_0 + \delta_T) + \left[ T_a \times \cos \left( \frac{\pi}{\omega} \times (t_s - t_m) \right) - \delta_T \right] \times e^{-\frac{(t-t_s)}{k}}, \text{if } t \geq t_s
\]

, with \( k = \frac{\omega}{\pi} \left[ \tan^{-1} \left( \frac{\pi}{\omega} \times (t_s - t_m) \right) - \frac{\delta_T}{T_a} \times \sin^{-1} \left( \frac{\pi}{\omega} \times (t_s - t_m) \right) \right] \)

\[
\text{lag} = t_m - t_{\text{sunrise}} - \omega/2
\]
Example of climate series

- radiation during the night
- radiation during the day
- temperature with clear sky
- temperature with covered sky
- rain
Effect of agroforestry on air temperature

2015

2016

Difference in air temperature Agroforestry - Full sun

- cloudy day
- clear day
- cloudy night
- clear night

mean cloudy
mean clear

mean before budbreak
mean after budbreak
Effect of agroforestry on the parameters of the DTC model

T0 (°C)

Ta (°C)

deltaT (°C)

tm (hour)

ts (hour)

lag (hour)
Discussion

- Significant effect of agroforestry on air temperature
  - AF < FS during day, AF > FS during night
- the main effect of the trees was through the modification of the radiative transfers of energy
- simple linear relationships are not sufficient to predict the DTC in AF from the temperature in FS
- potential to limit the risk of heat stress by reducing the amplitude of the daily increase of temperature
- increases the risk of yield loss due to insufficiently cold nights