Comparison of the effects of the thermal radiation from the sky or from an Ecotron walls on the crop temperature

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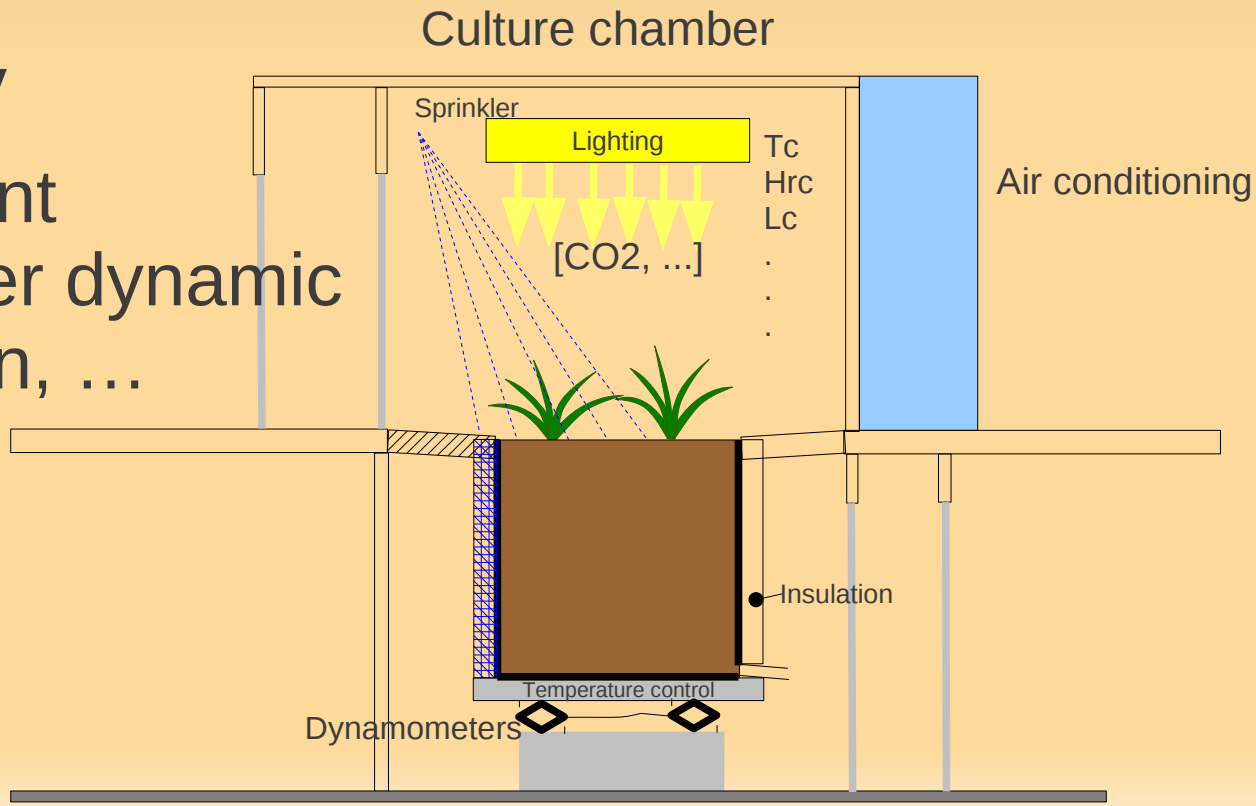
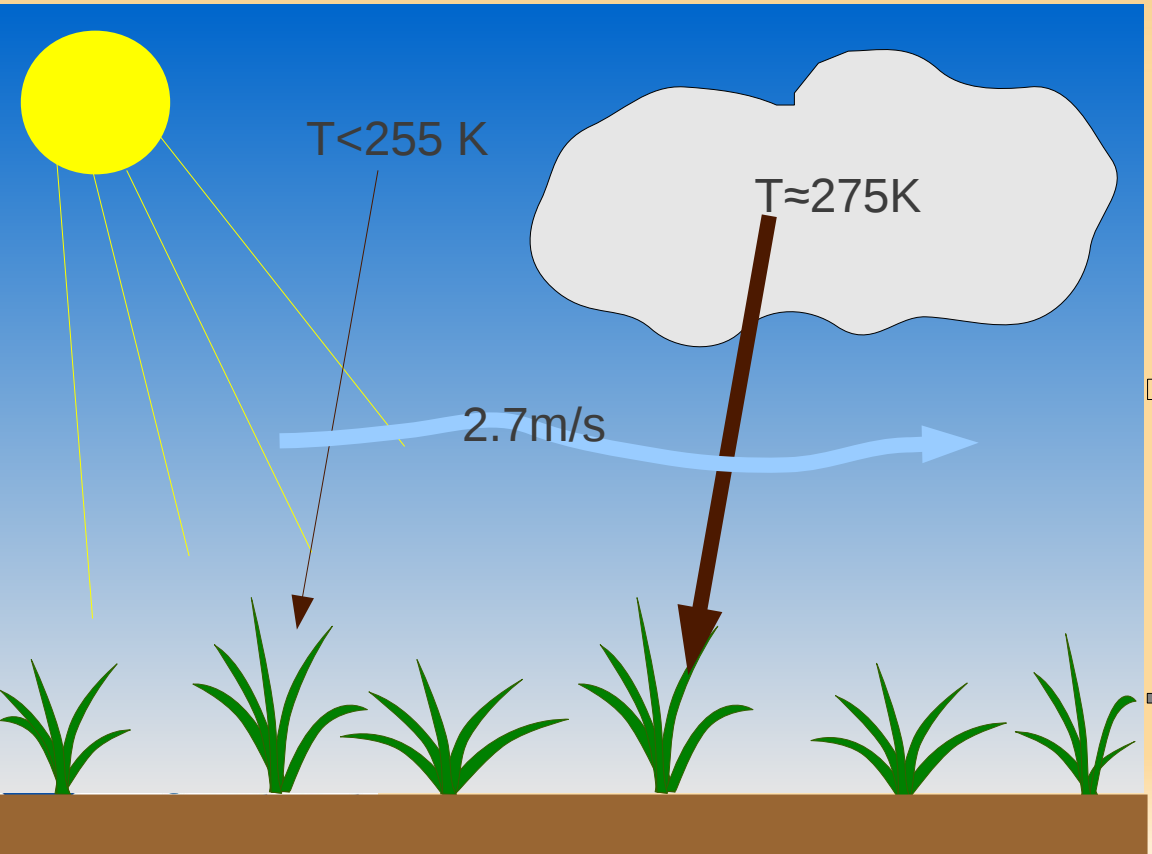
Introduction

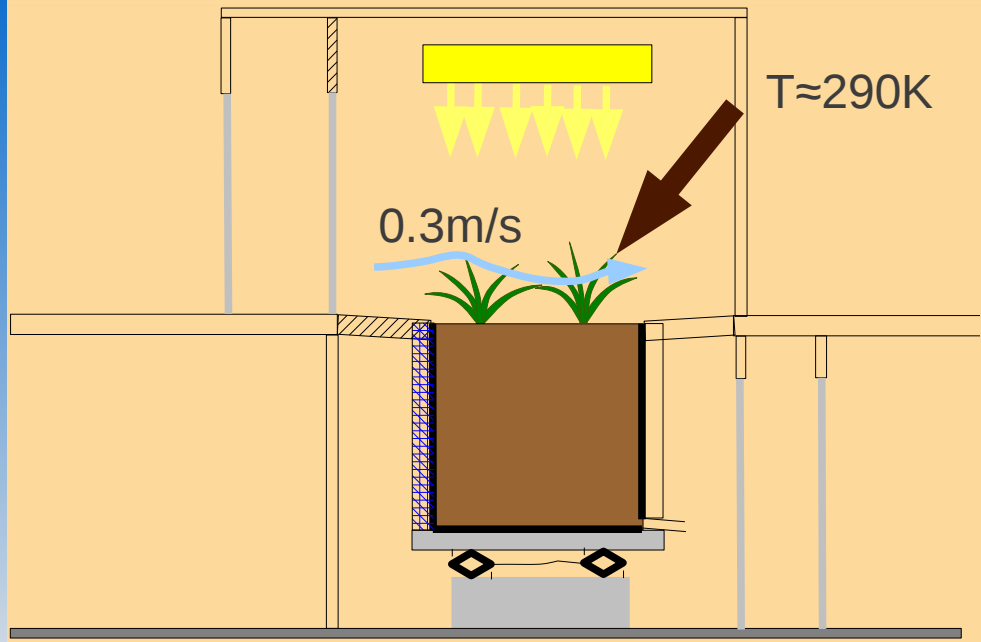
- Planned Ecotron in GxABT
  - Culture chamber with controlled atmosphere, light, precipitation
  - Lysimetric facility
  - Monitoring of plant growth, soil, water dynamic gas concentration, …



Introduction

- Two uncontrolled variables :
  - Environmental thermal radiation
  - Wind speed (2.7 m/s *vs* 0.3 m/s)





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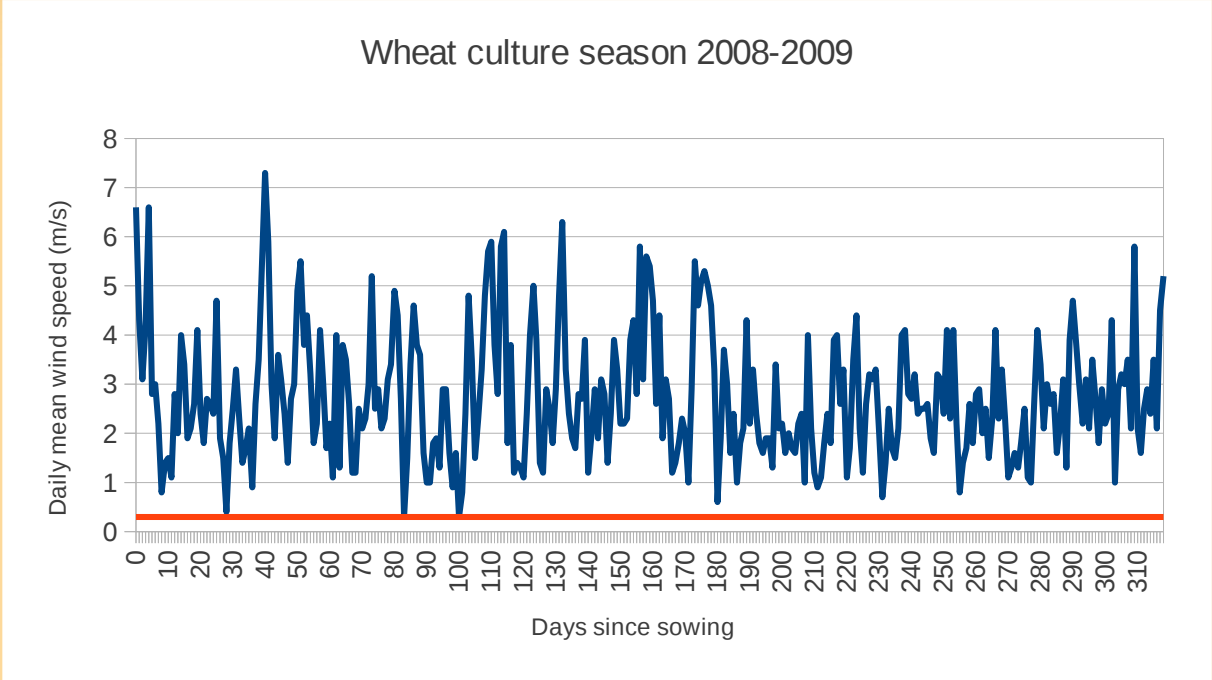

Introduction

- Two uncontrolled variables :
  - Environmental thermal radiation
  - Wind speed (2.7 m/s vs 0.3 m/s)
- How are these two variables affecting the crop temperature, ET, LAI and yield ?
- 3 simulations :
  - Field
  - Ecotron (with modified thermal radiation but normal wind)
  - Ecotron-wind (with both thermal radiation and wind modified)

Method

- The ”STICS” crop simulation model was used and modified
- STICS has a daily time-step
- Takes the soil conditions, the crop system and the climate as inputs
- Computes many parameters such as the
  - radiation balance, insulation fraction, crop temperature
  - LAI, crop dry matter and grain yield

Method

- For the field model, (STICS) the long wave radiation balance (R_{LW}) was computed by using Brutsaert's formula (MJ/m²/d) :

$$R_{LW} = 4.9\,10^{-9}\left(T_c\right)^4\left(1-\varepsilon_a\right)$$

With

  - T_c the crop temperature computed by using the energy balance, function of net radiation, air temperature, wind speed, ET, soil heat
  - ε_a the emissivity of the atmosphere function of the air vapour pressure, the crop temperature, and the insulation fraction computed by using Angström's formula.

Method

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$$R_{LW} = 4.9\,10^{-9}\left(T_c\right)^4\left(1-\varepsilon_a\right)$$

- For the Ecotron models, R_{LW} was given by

$$R_{LW} = 4.9\,10^{-9}\left(\left(T_c\right)^4-\left(T_a\right)^4\right)\approx 0$$

With T_a the temperature of the *air*.

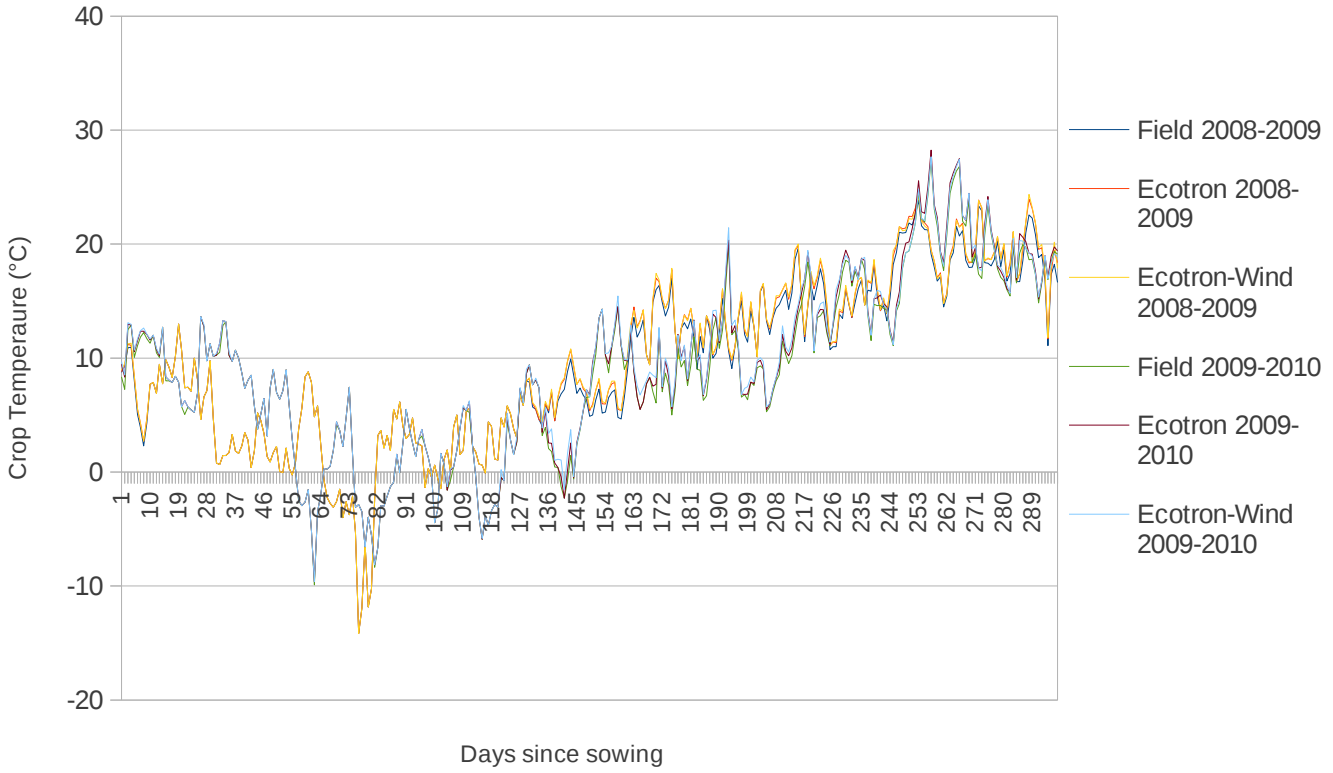
Input Data and validation

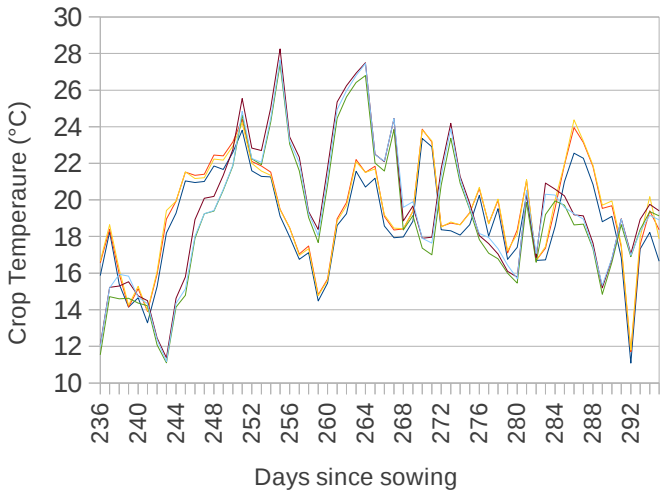
- Climatic data were from crop seasons 2008-2009 and 2009-2010
- The model crop was wheat
- The field model was validated with field measurements
- For the Ecotron-wind data, the wind speed was constant : 0.3 m/s
- The Ecotron models were not (yet) validated

Results

- Effect on the crop temperature :

°C	Ecotron – Field	Ecotron-Wind – Field
Average	0.5	0.6
Max	1.7	2.5

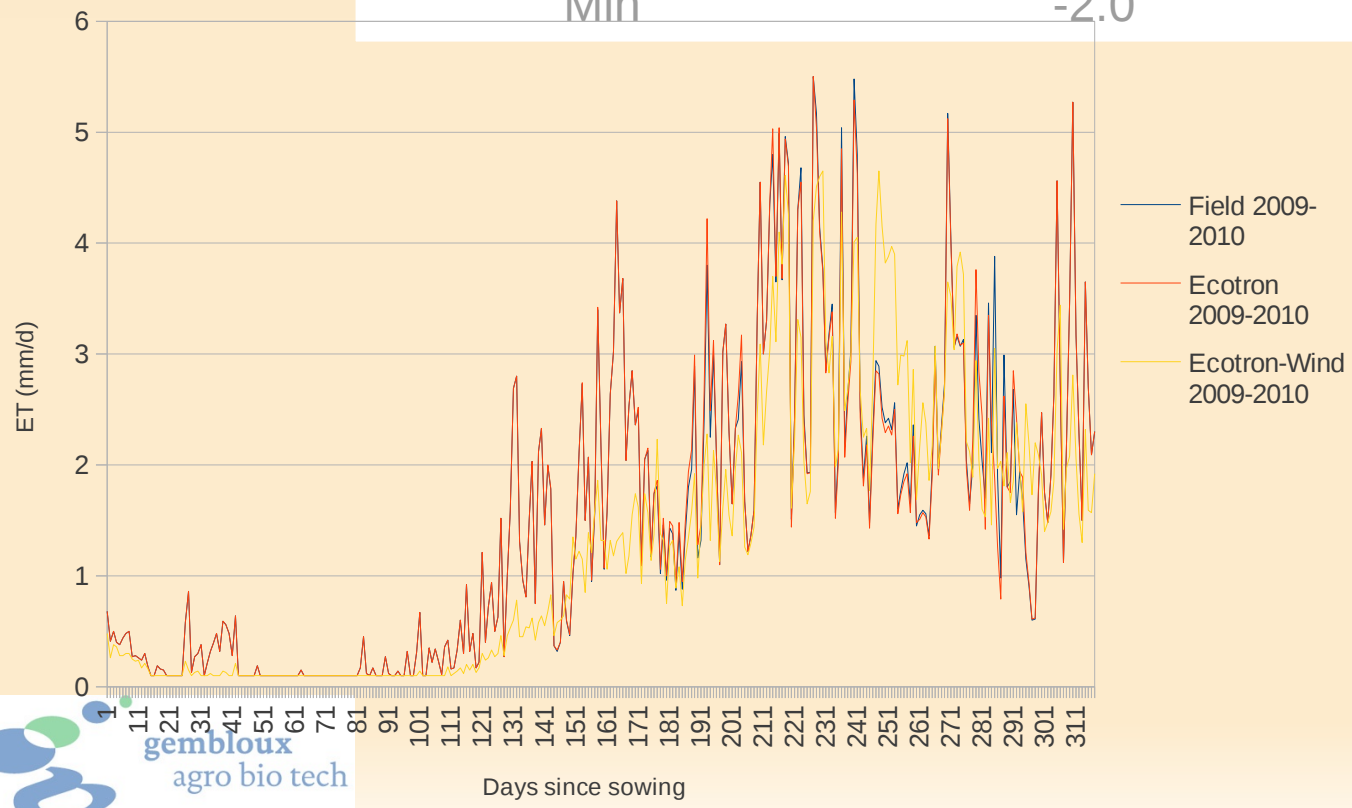




Results

- Effect on the Evapo-transpiration :

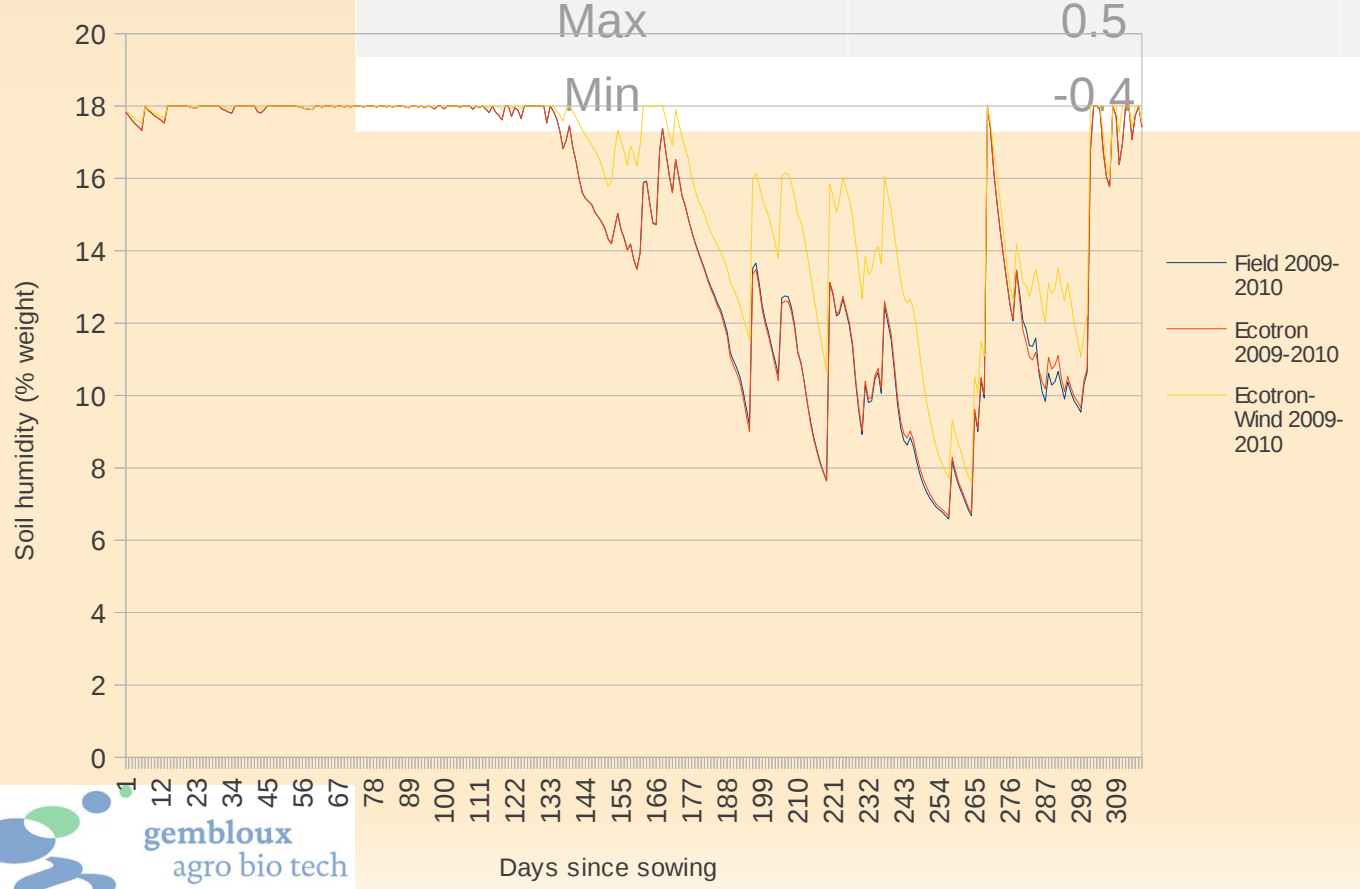
mm/d	Ecotron – Field	Ecotron-Wind – Field
Average	0.0	-0.2
Max	0.6	1.2
Min	-2.0	-3.1



Results

- Effect on the Soil humidity :

% weight	Ecotron – Field	Ecotron-Wind – Field
Average	0.0	2.1
Max	0.5	4.1
Min	-0.4	0



The 2009-2010 crop season presented a water stress

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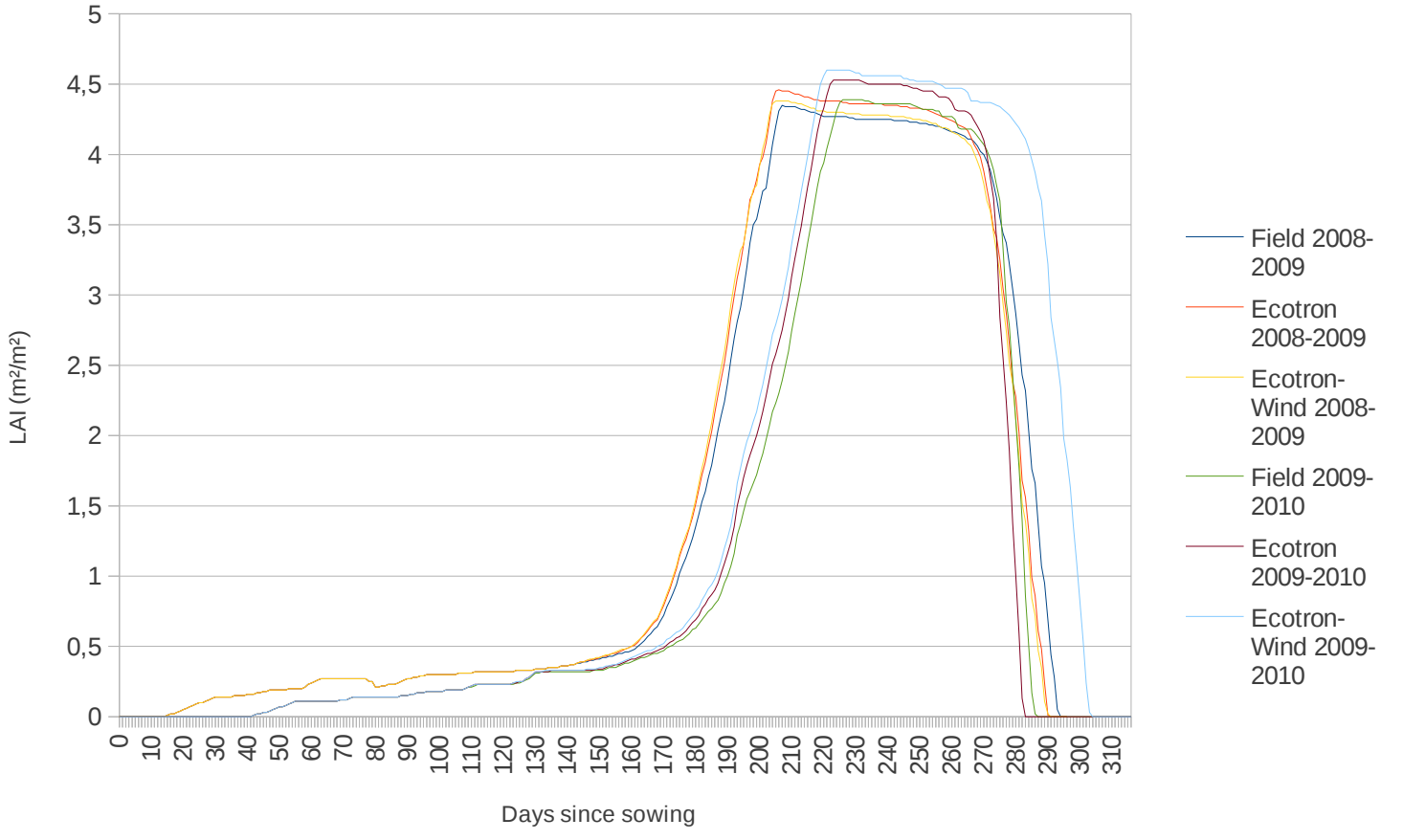
Results

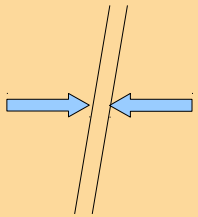
- Effect on the crop development (extreme values)

	Ecotron – Field	Ecotron-Wind – Field
LAI (m^2/m^2)	0.14	0.21
Dry matter (%)	-0.18	6.0
Yield (T/ha)	-0.15	3.3

Results

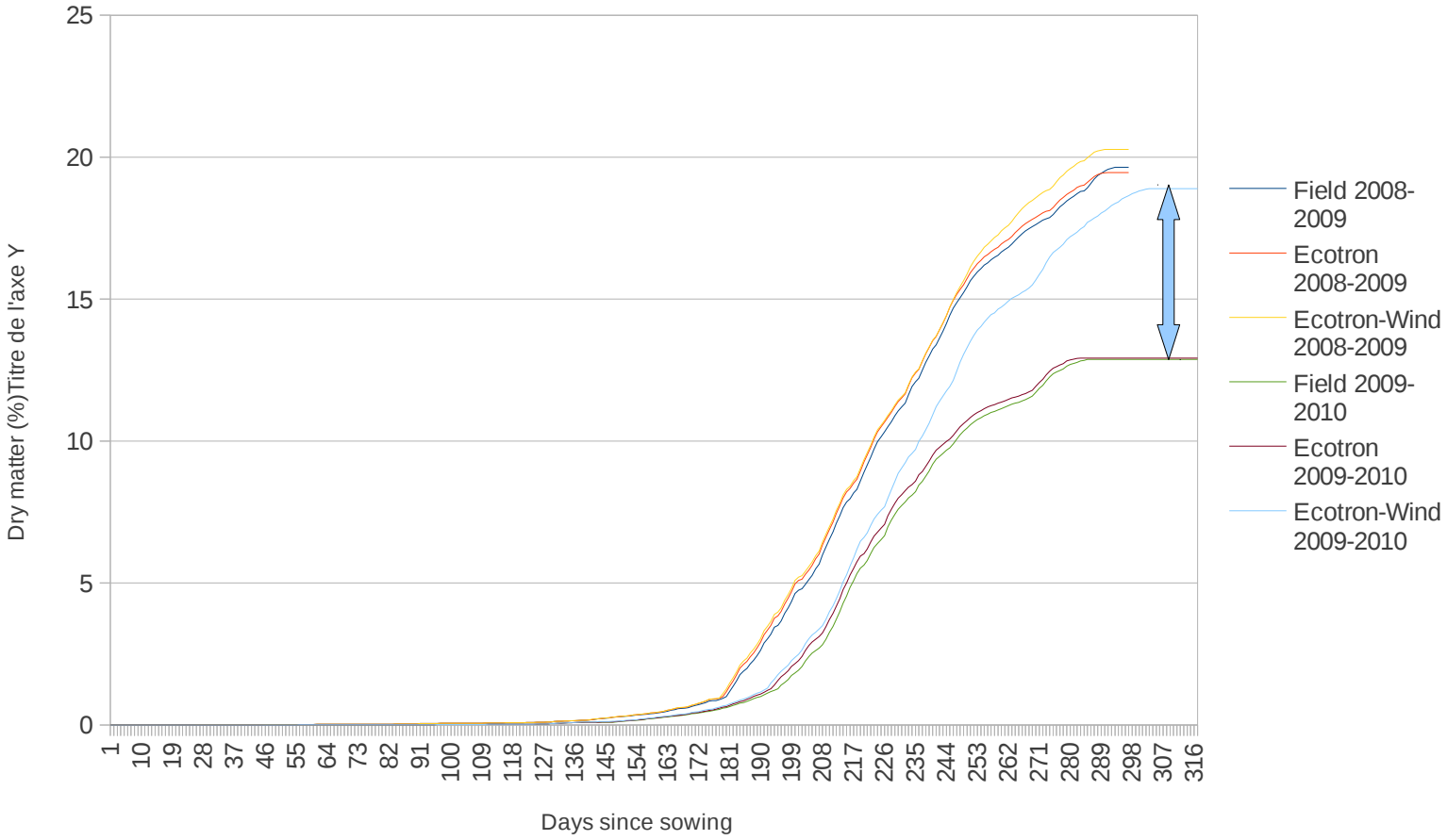
- Effect on the LAI
  - LAI ”advance” up to 6 days during growing
  - LAI ”extension” up to 14 days during senescence





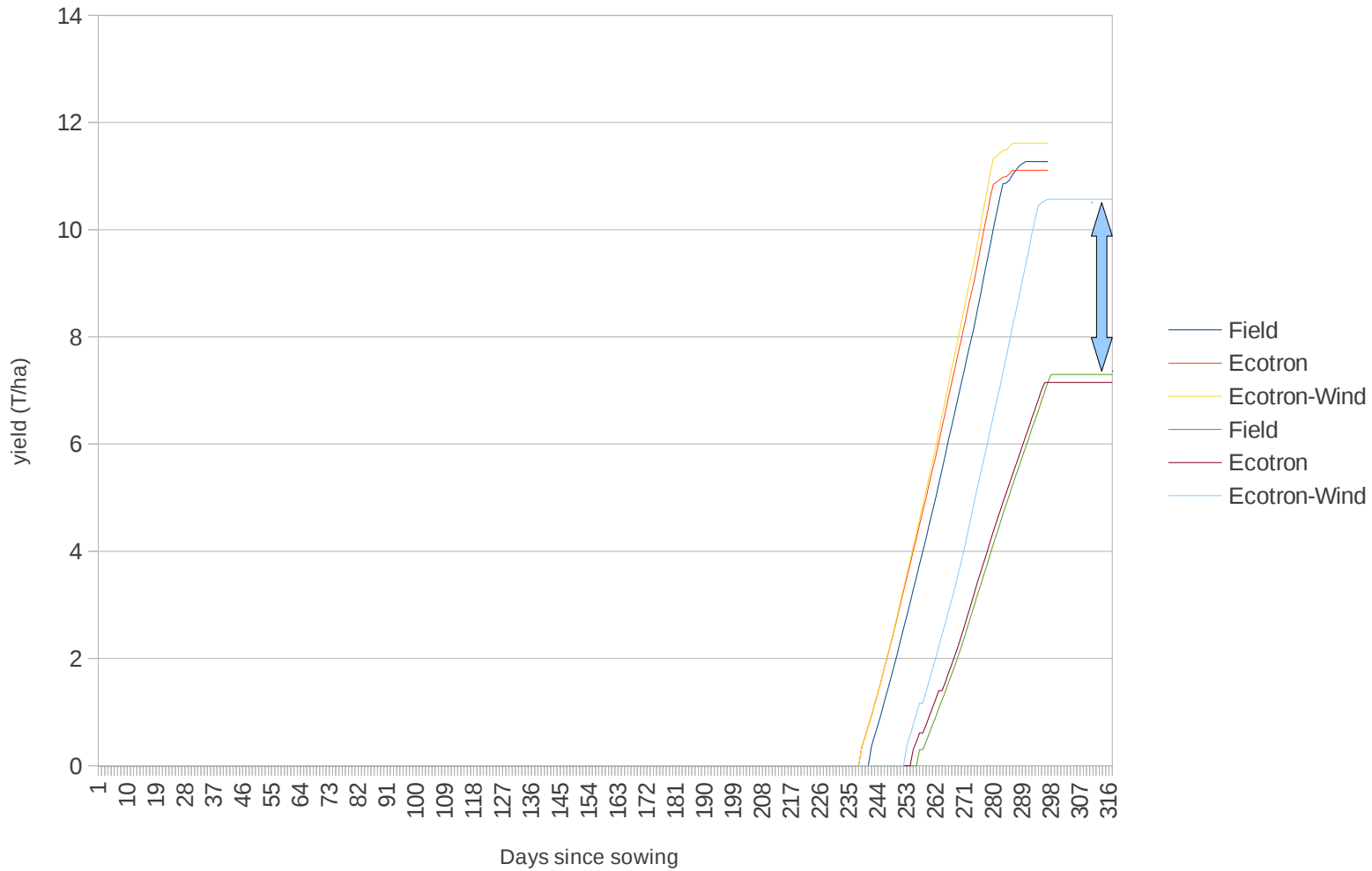
Results

- Effect on the dry matter



Results

- Effect on the yield



Conclusion

- The model showed that the effect of wall radiation compared to the atmosphere radiation induce a moderate temperature rise of about 0.5°C
- This was small compared to the interannual variations
- This induced a few days advance in crop development
- No significant effect on the yield was observed
- The effect of this variable might be ignored (?)

Conclusion

- The model showed that the lower wind speed induced a small temperature rise
- It would reduce the evapo-transpiration
- The lower wind speed in the Ecotron could reduce the water stress and there by enhance significantly the yield
- This problem may not be ignored

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Thank you for your attention

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