Water energy and carbon exchanges in young coniferous plantations: effect of the presence of gorses

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IUFRO

Energy, water and carbon exchanges in young coniferous stands in South West of France

Effect of the presence of a layer of gorse

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07 – 15 October 2010 Falls Creek, Victoria & Tarraleah, Tasmania

TRANZFOR INRA Fondation Tuck Enerbio UNIVERSITE BORDEAUX 1 Sciences Technologies

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Introduction

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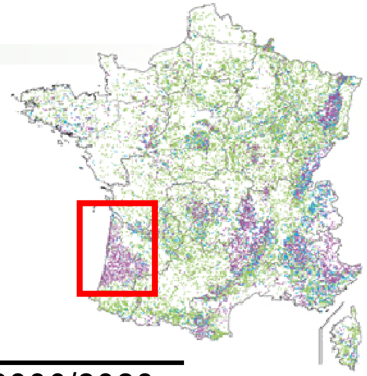

Context

Environmental round table, 2007

Renewable energy production (Mtep)	2006	2020	2006/2020
Heat	**9.7**	**19.7**	**+10.1**
Biomass	8.8	15.0	+6.2
Geothermal energy	0.4	2.3	+1.9
Solar energy	0.00	0.9	+0.9
Waste	0.4	0.9	+0.5
Biogaz	0.00	0.6	+0.5
Electricity	**5.6**	**12.9**	**+7.2**
Hydraulic energy	5.2	5.8	+0.6
Land Wind energy	0.2	3.6	+3.4
Sea Wind energy	0.0	1.4	+1.4
Biomass	0.2	1.4	+1.2
Photovoltaic energy	0.0	0.5	+0.5
Other (geothermal energy, marine energy...)	0.0	0.1	+0.1

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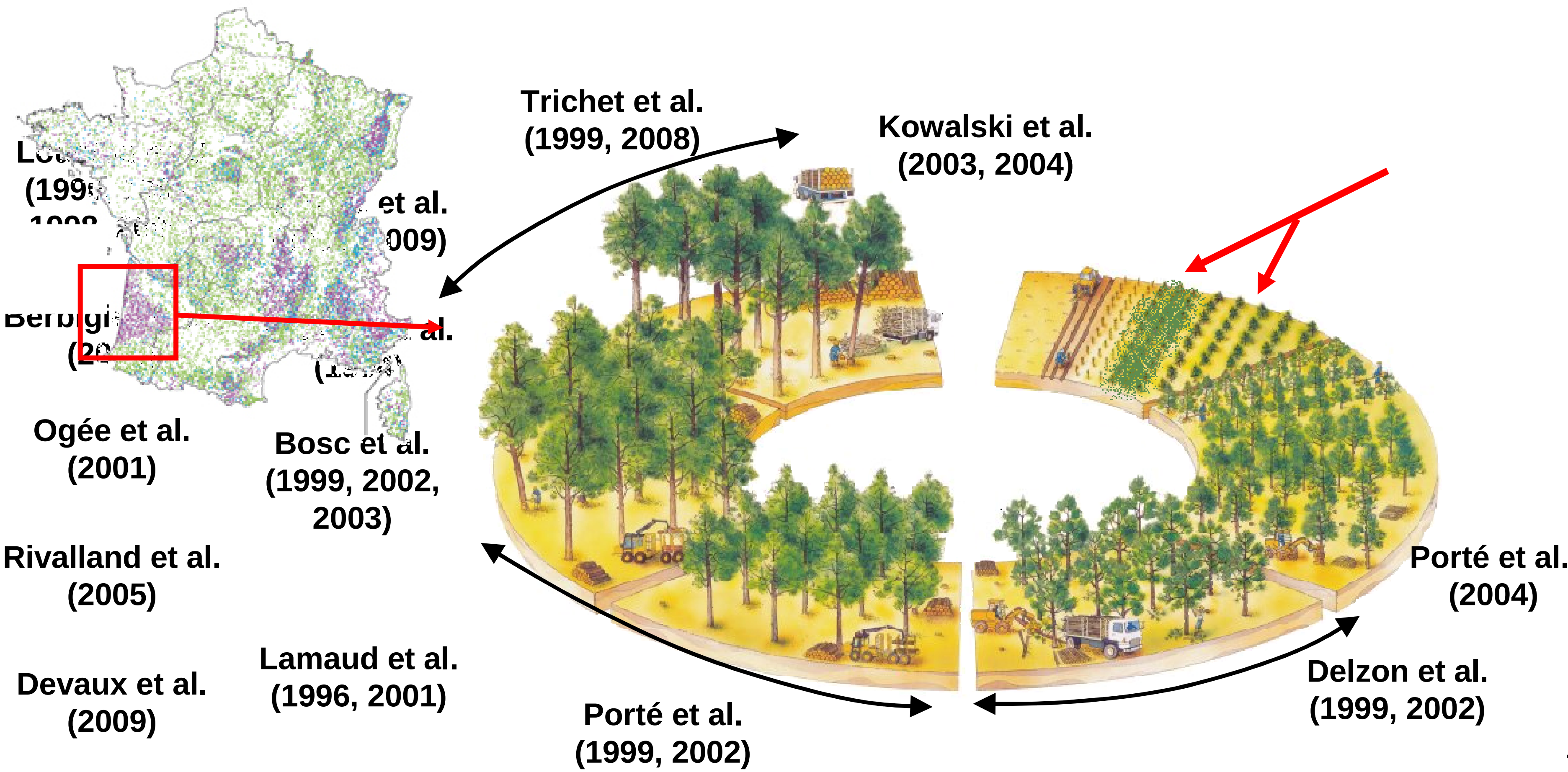
+ 12 Mm^3 in 2012 (ie. 30%)

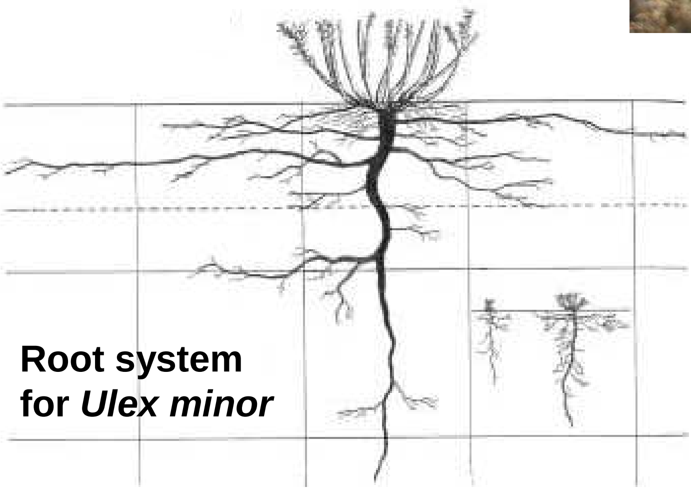
+ 20 Mm^3 in 2020 (ie. 1 Mm^3/yr)

➢ Background around the Landes forest (France).

- The process of cultivation and growth follows a production cycle that extends over a period of 45-50 years (*Lesgourgues et al. 1997).*



- Nitrogen cycle and legume plants input (Fabaceae)



Root system for *Ulex minor*

Intensification of the forest practices

↓

Sustainibility of the forest ecosystem towards the soil fertility, and water resources ?

↓

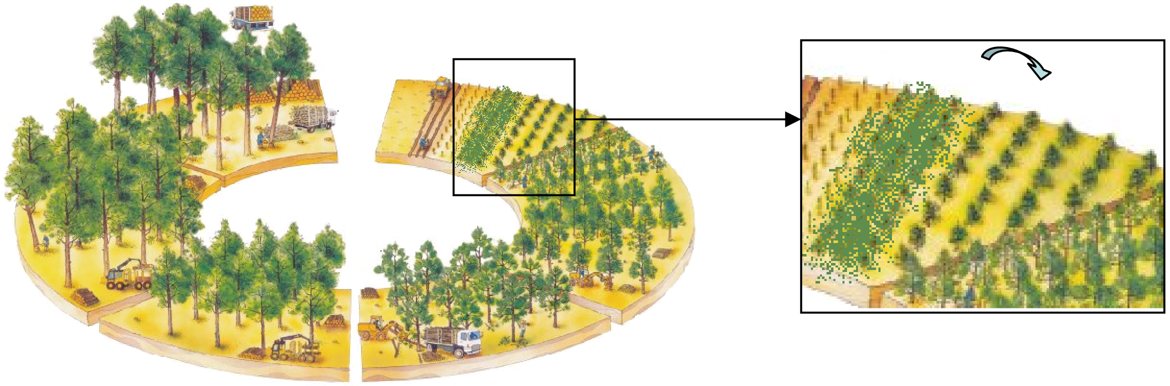
Early stage: presence of species as natural N-fixing shrubs

In the Landes forest: gorses and brooms

Ulex Europeaus, *Ulex Minor* and *Cytisus scoparius*

Heath and Luckwill, 1938, Gloaeguen 1986, Stokes 2002, Augusto et al. 2005, 2010

❑ Main objective



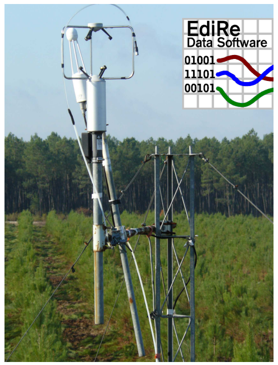
➢ analyse the effects of a the first sylvicultural pratice on the energy, water and carbon **fluxes** from two **young** maritime pine stands: JUNE 2009 – MAY 2010

Material & Method

Material & method

❑ Paired measurements in the two sites

DATA :	CONTROL (C)	WEEDED (W)
Tree species	*Pinus pinaster*, Ait	*Pinus pinaster*, Ait
Age (July 2009)	4 years	5 years
Forest practices	None	1st weeded and depressing in November 2008 2nd weeded in November 2009
Stocking (tree.ha^{-1})	14400	1803
Mean LAI (m^2.m^{-2})	2.62	0.79

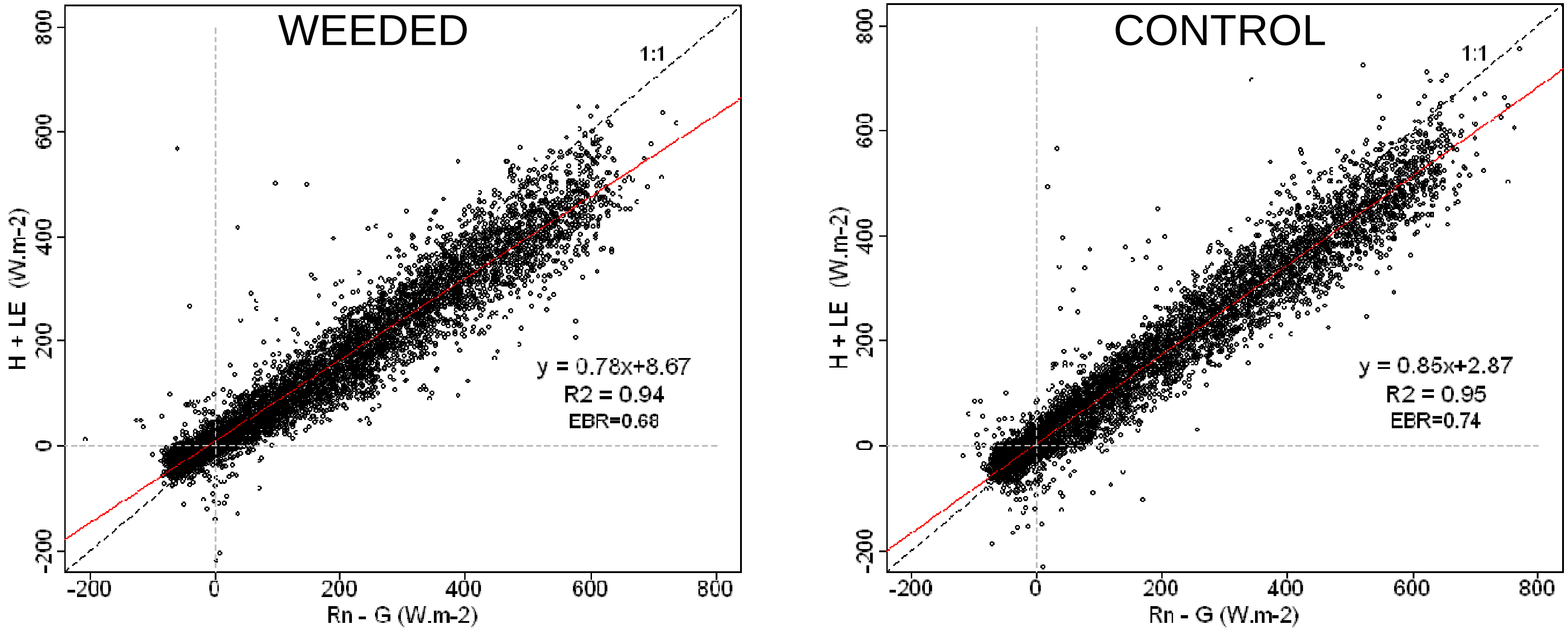


JUNE 2009 – MAY 2010

Results

Energy balance
Water exchanges
Carbon exchanges

Energy balance closure (EBC)

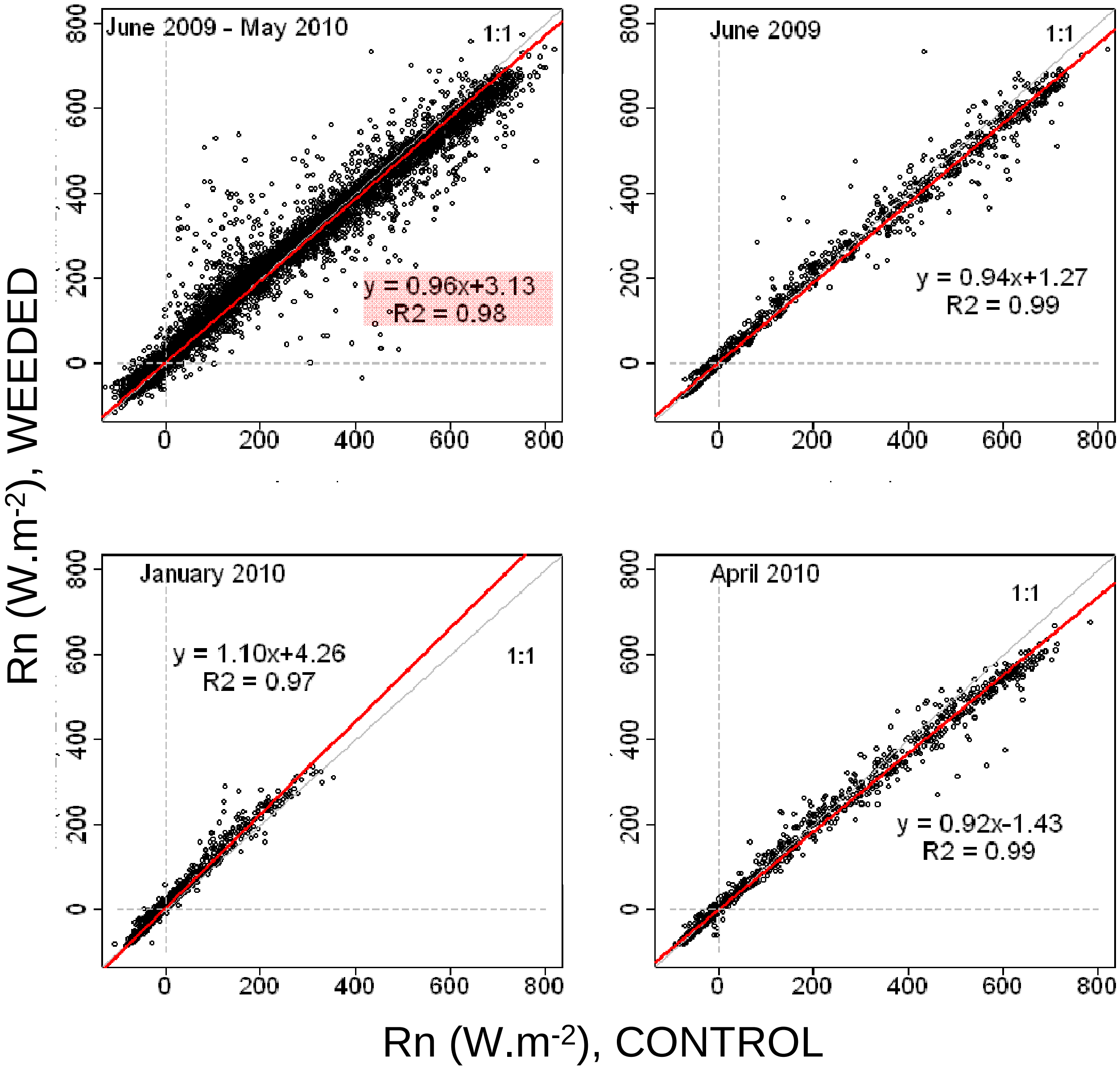


- EBC is better closed on the CONTROL with a slope of 0.78 compared to a slope of 0.85 on WEEDED.

- **Literature:**

Wilson et al 2002 : slope: 0.79 ± 0.01, intercept: 3.7 ± 2.0
Berbigier et al 2001 : slope: 0.86, intercept: 0.007

Energy balance



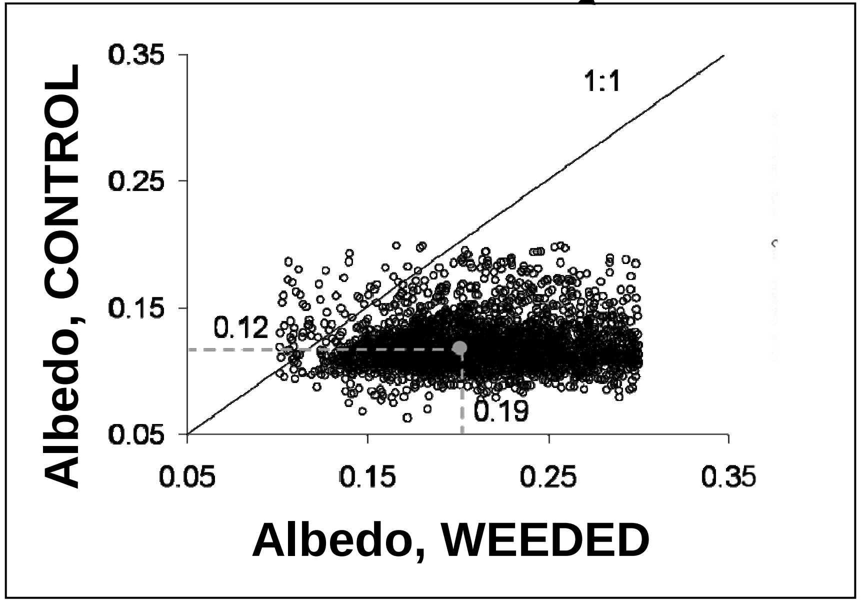
- Annually
  - Rn (W) < Rn (C)
  - Difference of ~4%
- Seasonally
  - High differences from April to July
  - Reversed in winter

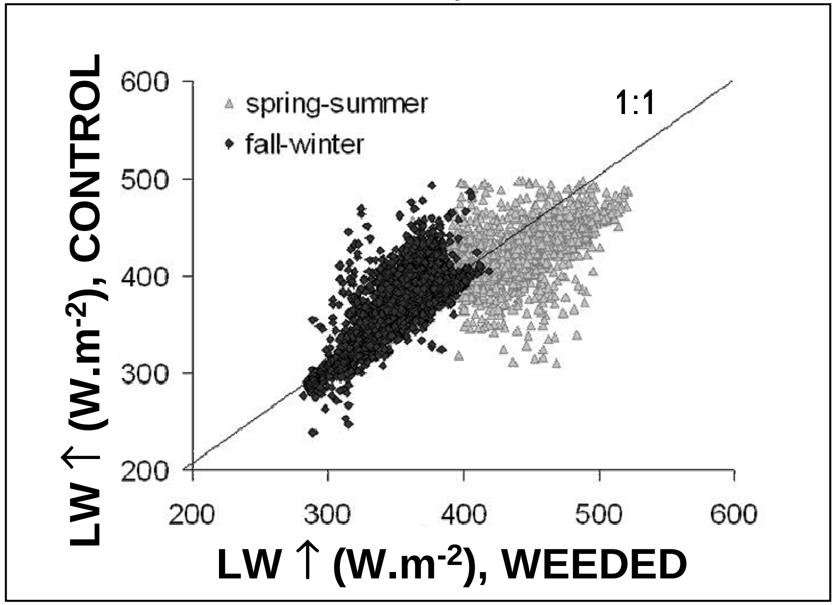
Results


W


C

$$Rn = Rg - aRg + LW\downarrow - LW\uparrow$$





Effect of albedo is compensated by the effect of LW ↑

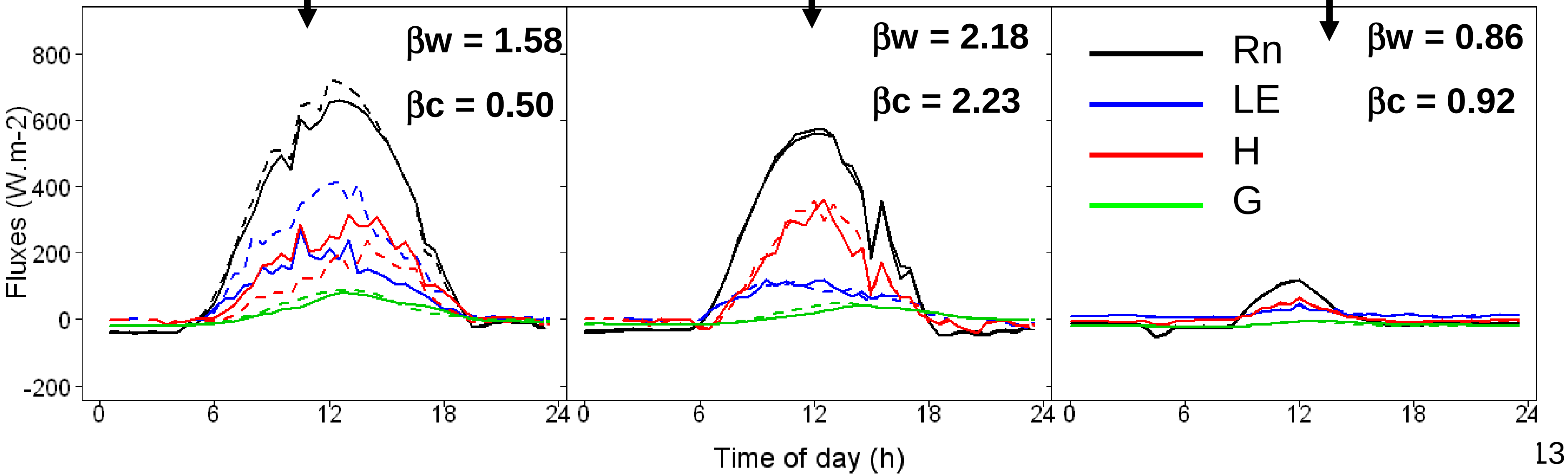
Results

❑ Partionning of the energy fluxes

growth drought winter

CONTROL

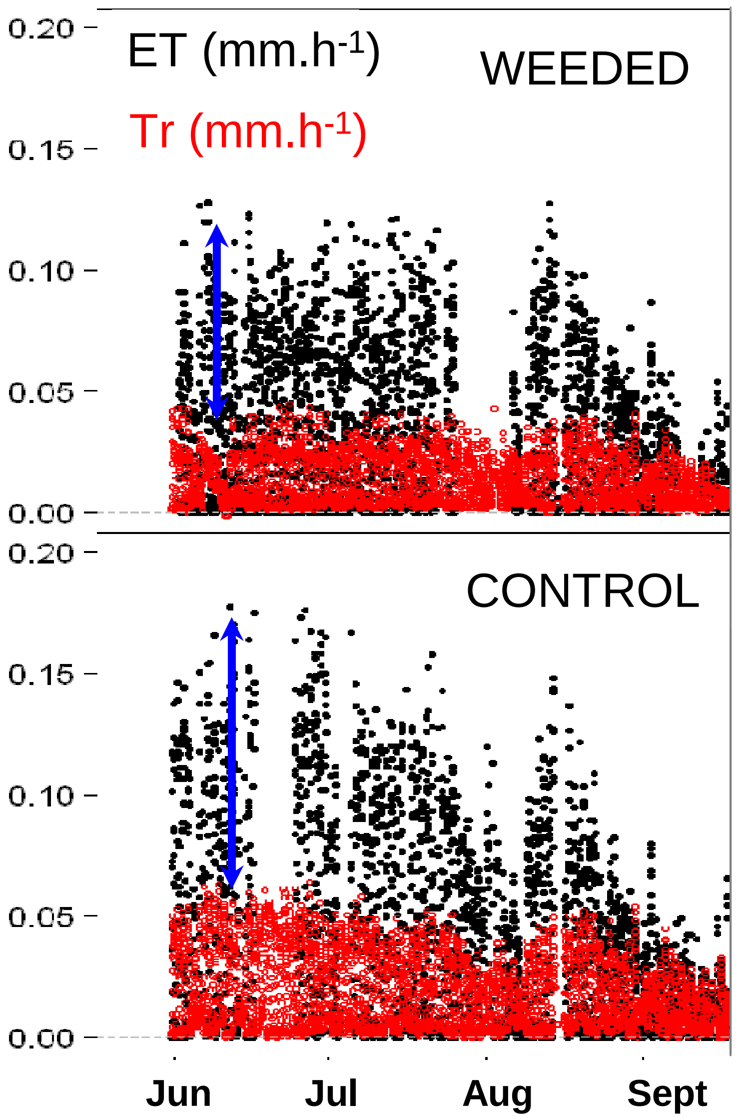
WEEDED



Results

❑ Water balance

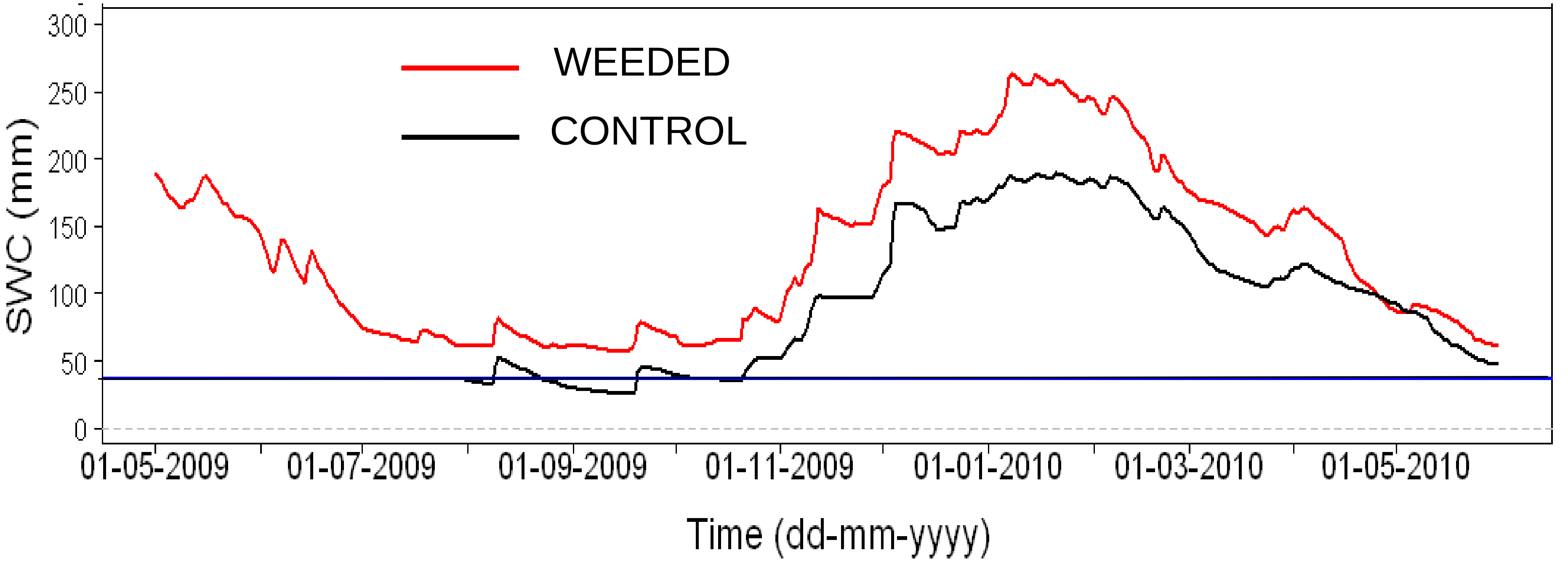
➢ Partitionning between evapotranspiration (ET) and transpiration (Tr)



- **Total ET** comparison:
  - Growing season: ET (C) = **1.5** ET (W)
  - Drought: ET (C) = ET (W)
- **Pine Tr** comparison:
  - Growing season: Tr (C) = **1.5** Tr (W)
  - Drought: Tr (C) = **1.5** Tr (W)
- **(ET – Tr)** comparison:
  - Growing season: Higher on the control plot
  - Drought: Similar

Vegetation layer is more sensitive to drought

➢ Soil water content (0-80cm)



SWC higher in the weeded plot due to:

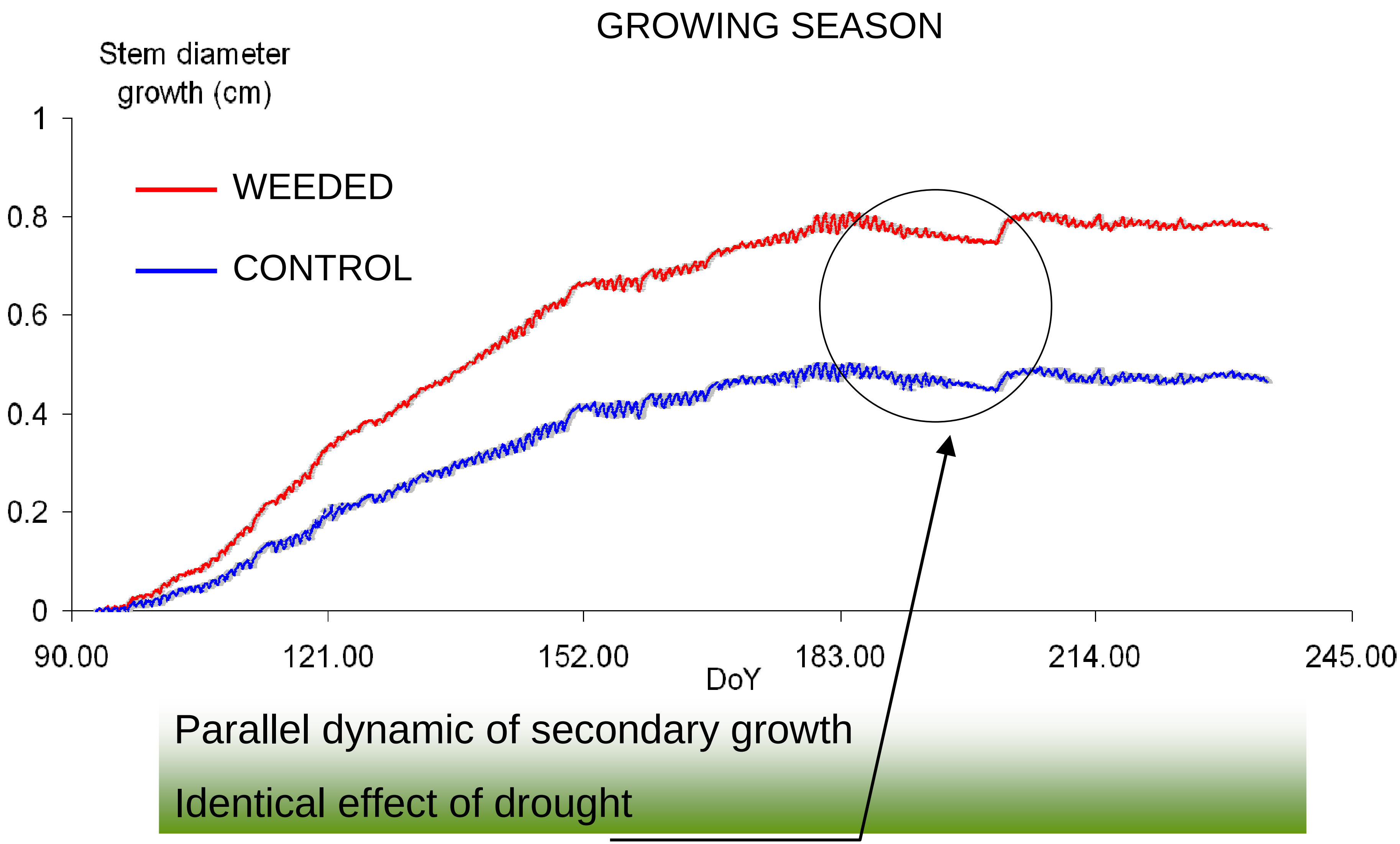
- lesser ET
  - weaker rainfall interception
  - lesser transpiration

Results

- Simultaneous water stress

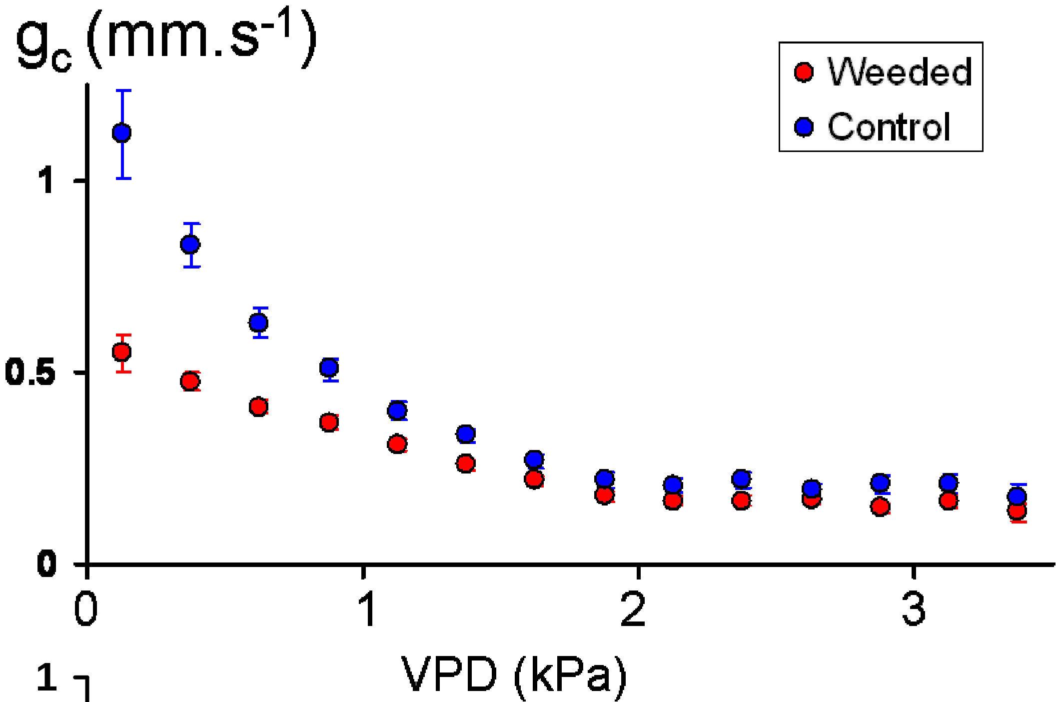

W


C



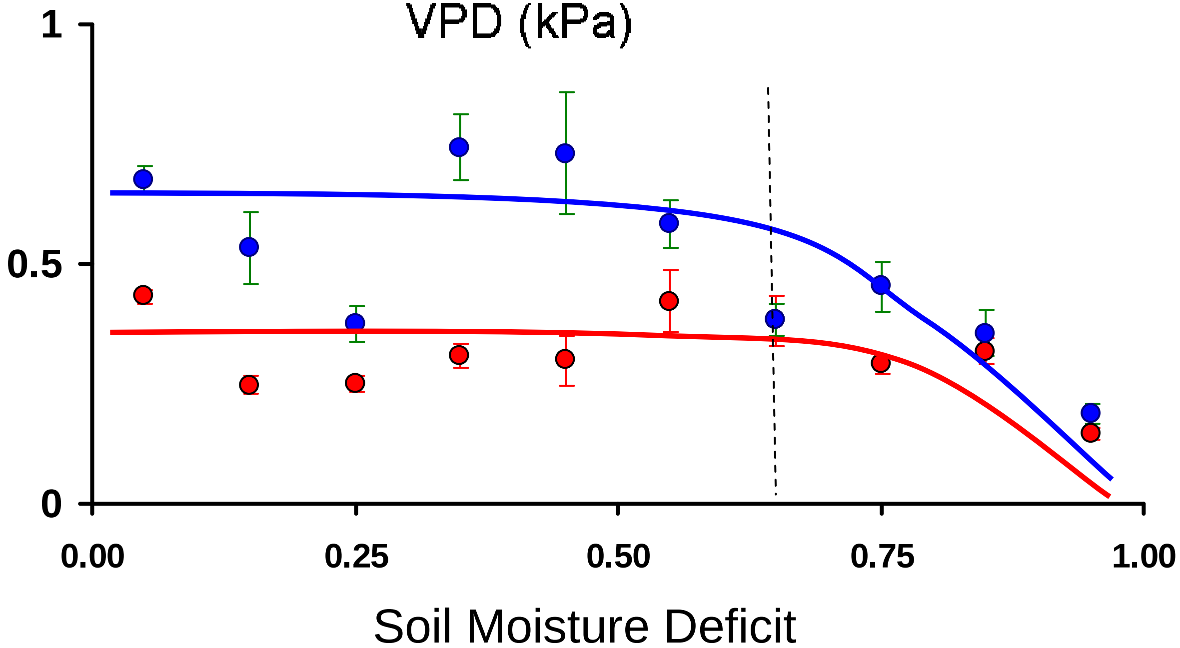
Parallel dynamic of secondary growth

Identical effect of drought



Higher gc on the control plot at low VPD

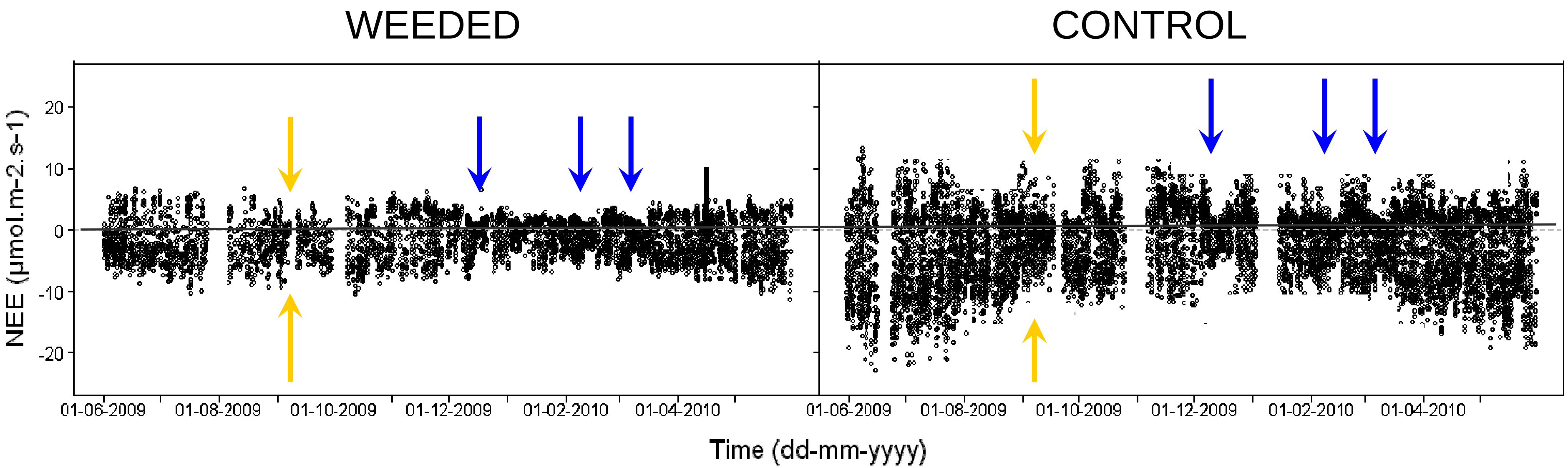
Abrupt response of gc to an increase of VPD



(mm)	C	W
Field capacity	135	135
Wilting point	25	55
Holding capacity	110	80

❑ Carbon fluxes

➢ Temporal evolution of NEE (filtered data)



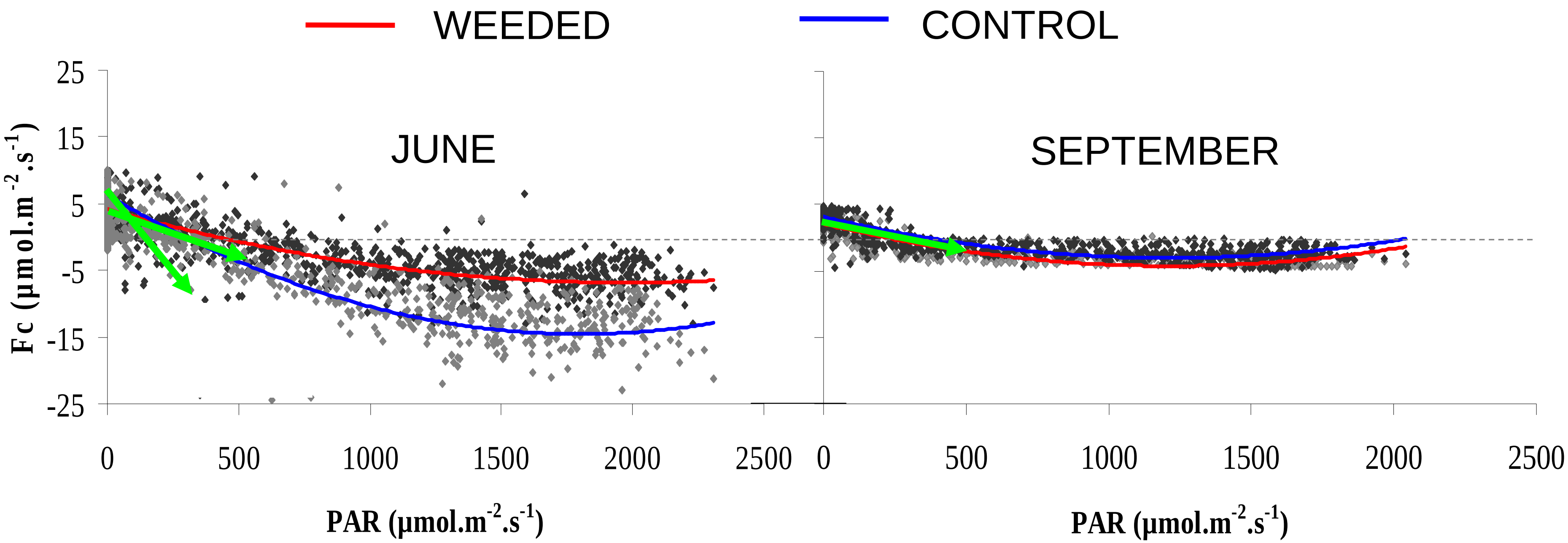
Dynamic of the fluxes more pronounced on the control plot, with higher values

Dry and warm events: high reduction of the fluxes on the control plot

Dry and cold events : high reduction of the fluxes, for both realesed and fixed carbon

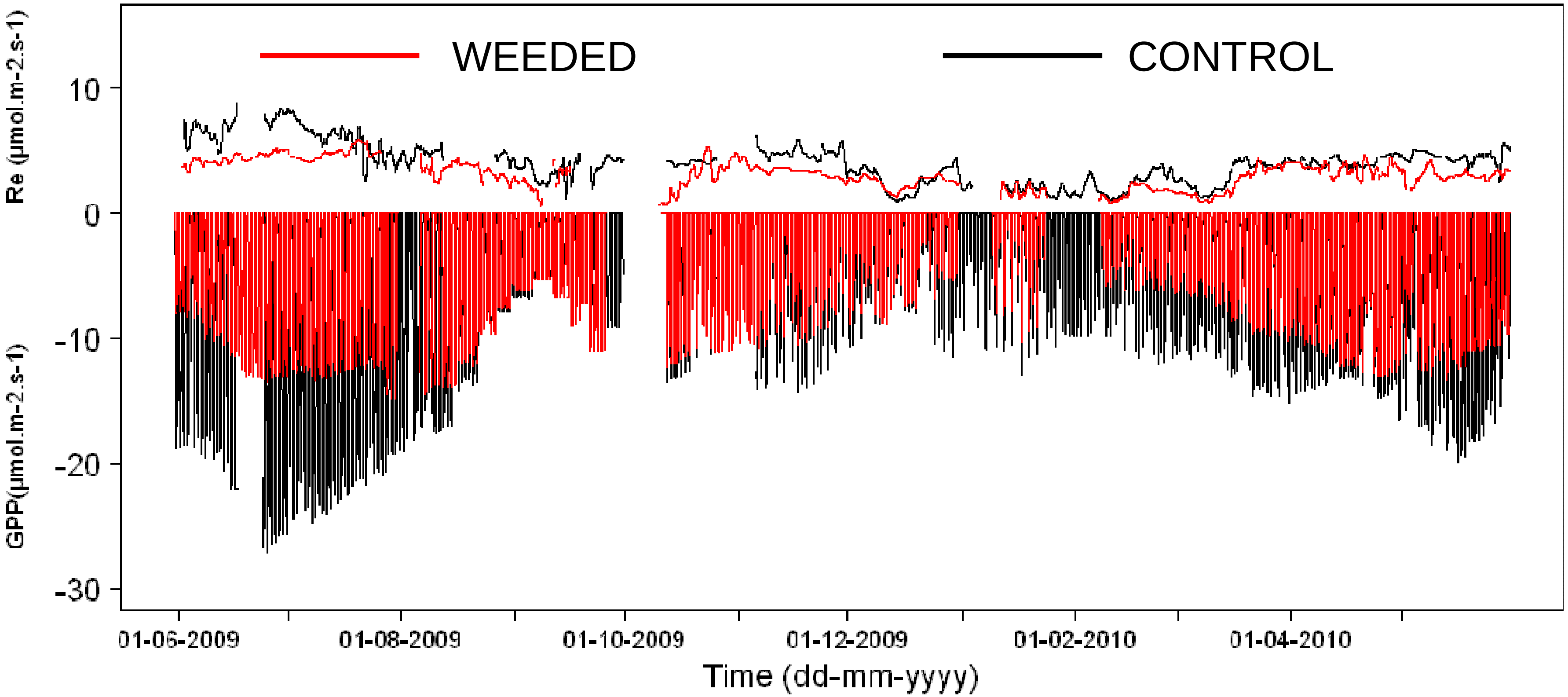
➢ Partitionning between GPP and Re

$$NEE = \frac{a_1 PAR}{a_2 + PAR} + R_{ref}.Q_{10}^{(\frac{T_{SURF}-15}{10})}$$



Higher respiration	Same respiration
Higher carbon assimilation	Same carbon assimilation
Higher LUE	Same LUE

➢ Partitionning between GPP and Re



GPP and Re higher in the control plot, with a earlier decreasing in GPP

Is this earlier decrease in GPP during the drought linked to the layer vegetation?

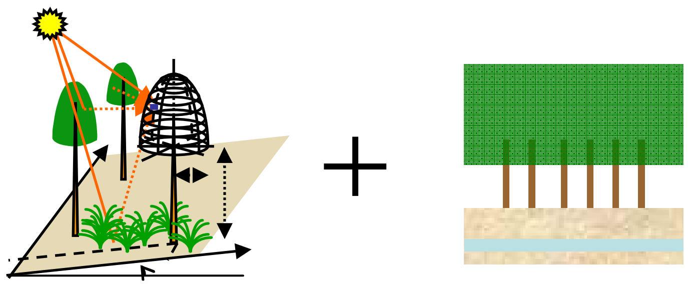

Conclusion and prospects

Effects of weeding and thinning

- on radiative balance:
  - Slight decreasing of the available energy (4%)
  - Reducing of latent heat flux but few change in sensible heat

- on hydrological processes and carbon fluxes:
  - No attenuation of the summer drought since effects on transpiration on tree growth look **identical**.
  - Dynamic of the ET and GPP on the control plot is more important and react **faster** to dry conditions: attributed to **the dynamic a the gorse layer**

- Next step:



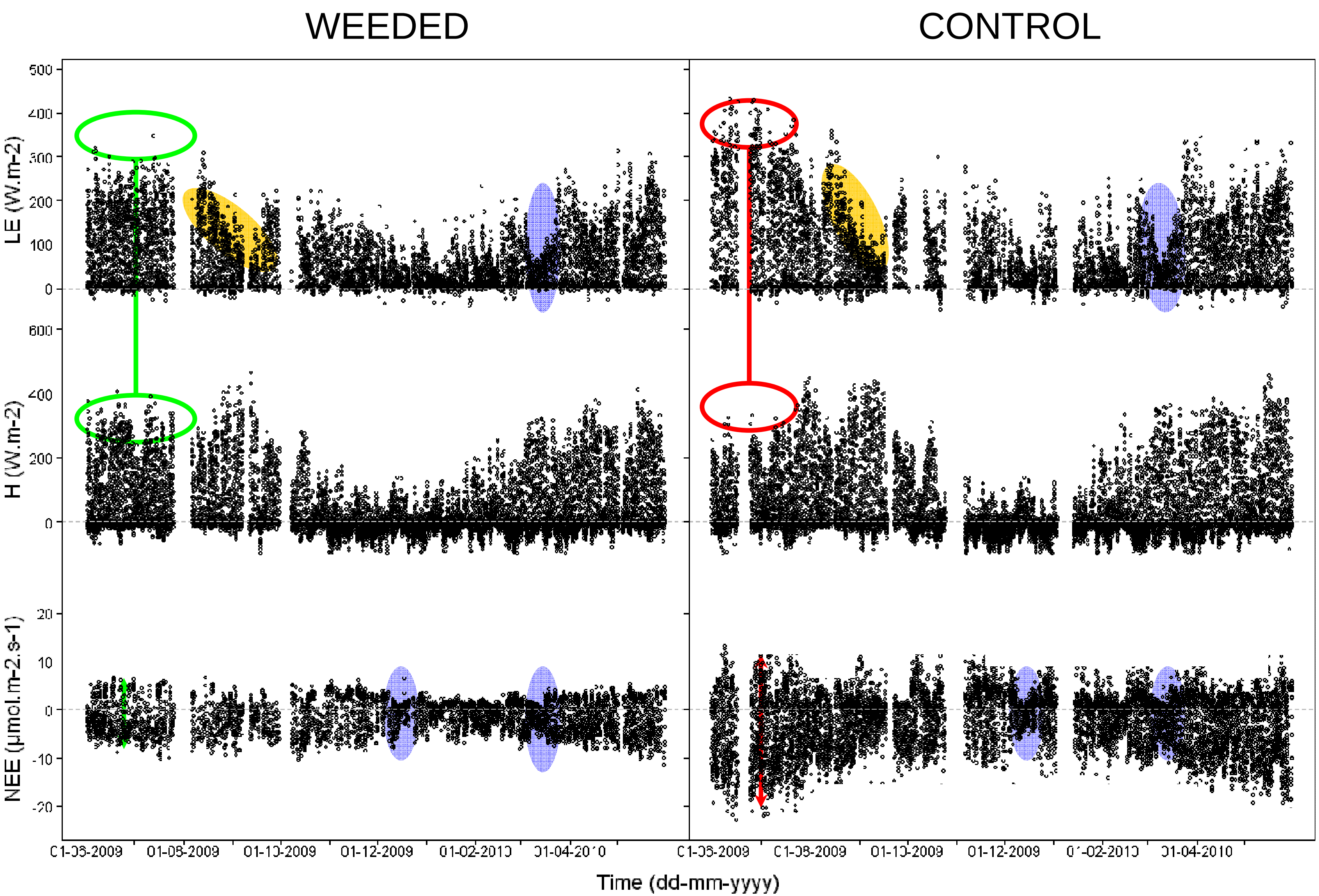
  - **Modelling**: using a 3D- model (Maestra, Wang, 1989, Medlyn, 1997): better representation of the understorey layer in young stand.

Thanks for your attention

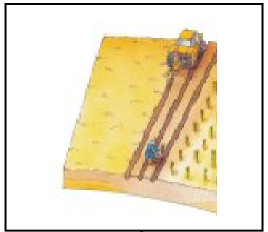
Acknowledgment: Denis Loustau and Eric Lamaud

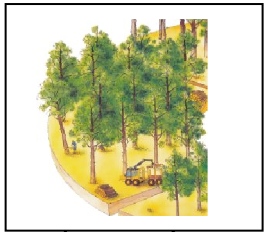
Michel Sartore, Didier Garrigou, Pierre Trichet, Fréderic Bernier, Jean-Luc Denou, Jean Michel Beau, Salles commune

❑ Temporal evolution of the fluxes (filtered data)



Annual ecosystem fluxes



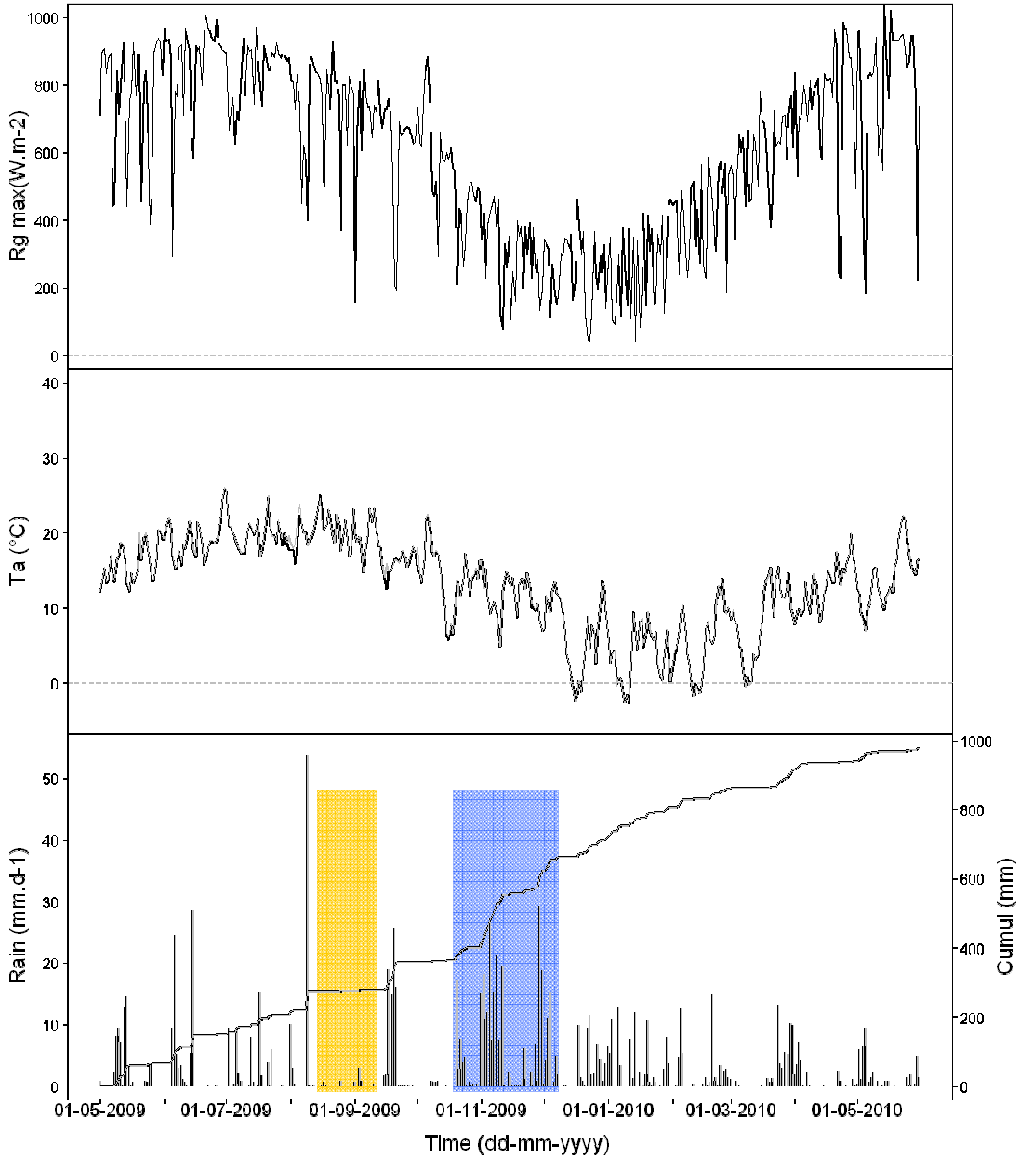


Annual exchange	Bilos (age = 0)	Bray (age = 28)	Bray (age = 31)
NEE carbon ($gC\,m^{-2}$)	290	−575	−498
GPP ($gC\,m^{-2}$)	727	2255	2025
TER ($gC\,m^{-2}$)	996	1680*	1527
PPFD ($mol\,m^{-2}$)	9227	9296	9308
R_n ($MJ\,m^{-2}$)	1956	3006	2746
T_{air} (°C)	13.2	15.0*	13.4
H ($MJ\,m^{-2}$)	928	620	515
LE ($MJ\,m^{-2}$)	895	1592	1491
Evaporation (mm)	358	666	624
Precipitation (mm)	875	930	515†

Kowalski et al. 2003

Results

- Meteorological characteristics: June 2009 - May 2010



- Annually:
  - Mean annual T= 12.4 ℃
    13℃ (1950-2000 average)
  - Annual P= 936 mm
    977 mm (1950-2000 average)

- Particular events:
  - **Drought**
    - P = 7mm (10/08 - 16/09)
    - SWC < 50 mm (**0-80cm**)
  - **Storms**
    - P = **222 mm** (November)