Hochschule für Forstwirtschaft Rottenburg
Hochschule für Angewandte Wissenschaften

Wuchshüllen in der Forstwirtschaft - (k)ein Ende des Booms?
15 May 2018

Treeshelters : designing the perfect climate?

Christian Dupraz, INRA, France

1985

1988-1992

1995

Various concerns

A key observation : Stem diameter growth unbalanced

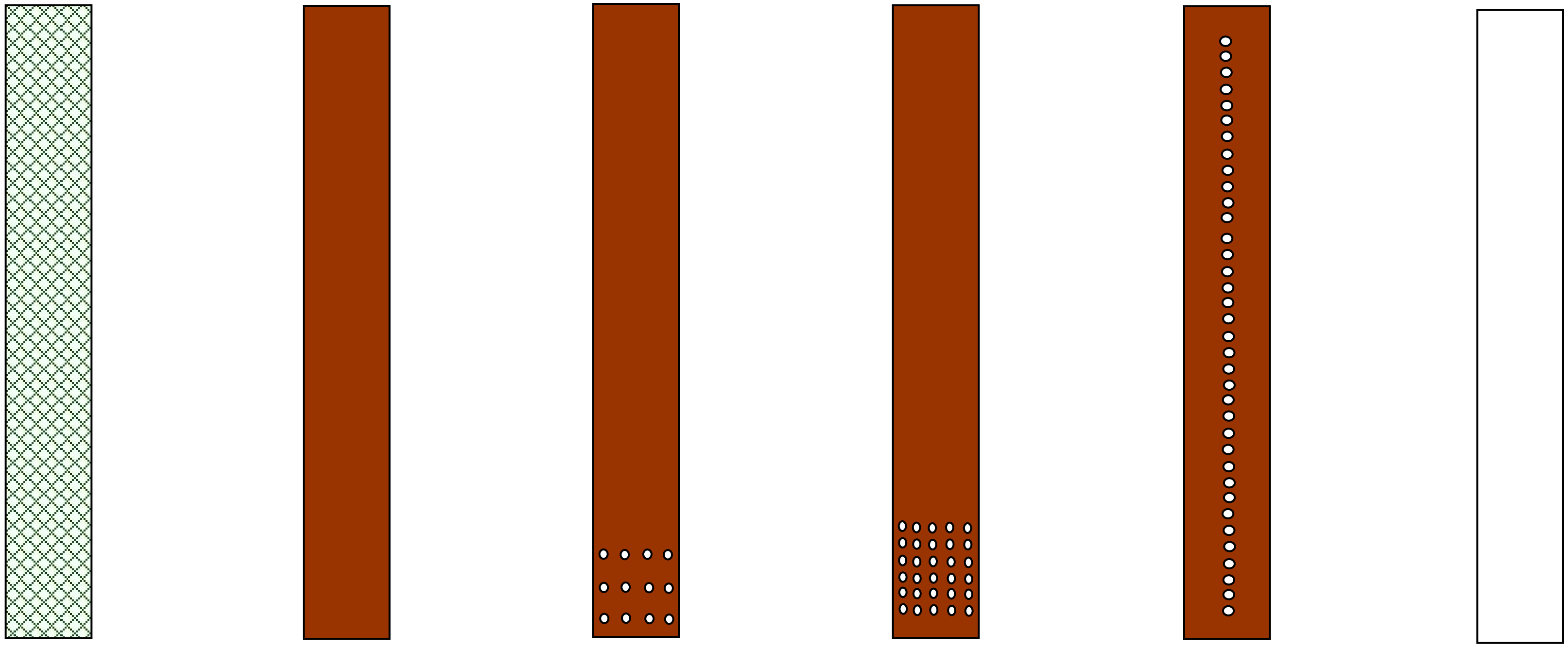
Well, what's wrong with treeshelters ?

Early hypotheses about tree growth in treeshelters

- Main Hypothesis: excess of humidity
- Experiments in 1986 and 1987 (Cornwall & Mid England)
- Perforate tubes to increase ventilation, hence decrease humidity within the treeshelters.
- Disappointing : erratic results on growth

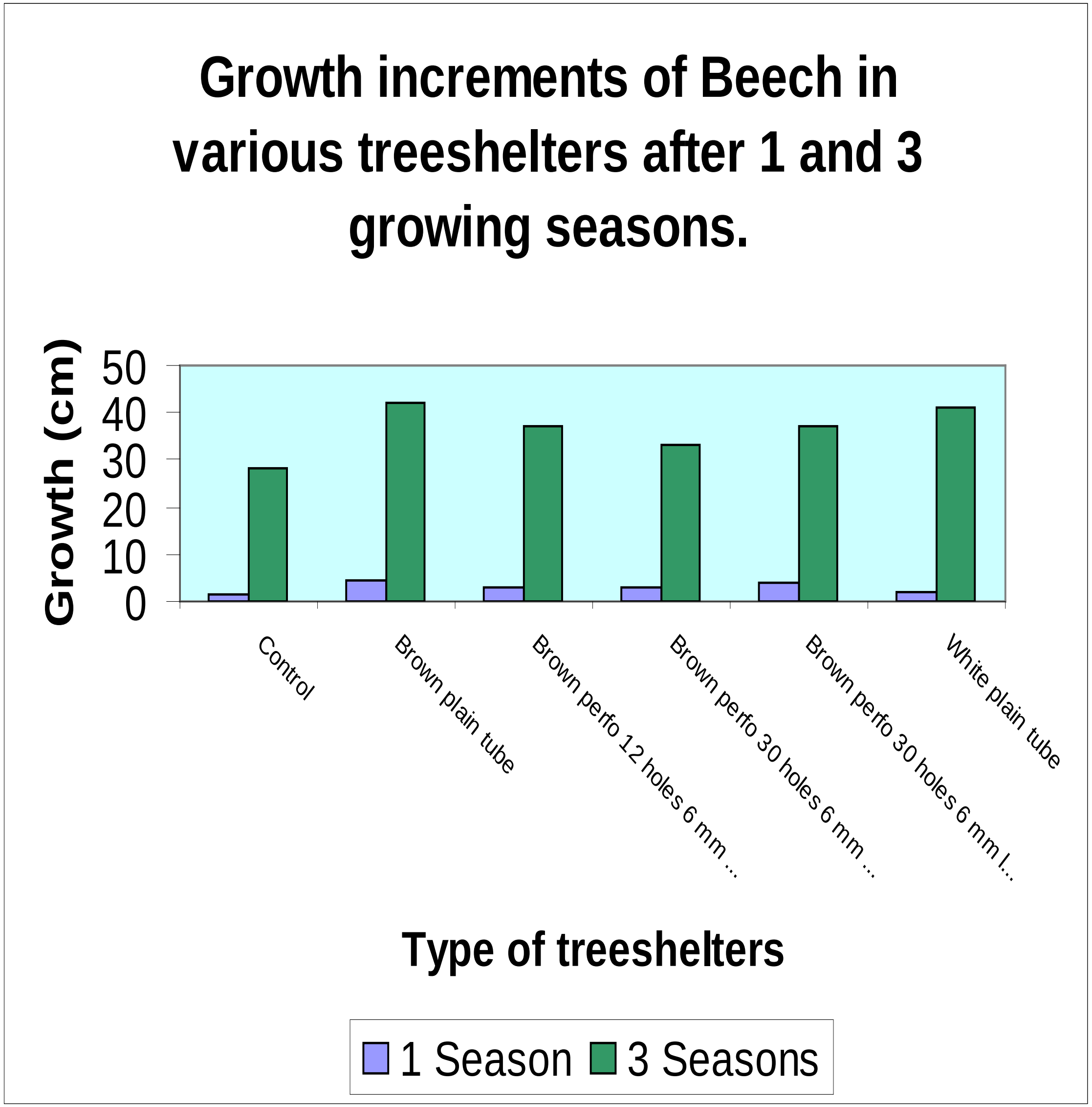
Experiment 1986 Cornwall

1.2 m Treeshelters



Control	**Brown**	**Brown**	**Brown**	**Brown**	**White**
Mesh	**Plain**	**12 holes**	**30 holes**	**30 holes**	**Plain**
Guard		**6 mm**	**6 mm**	**6 mm**	
		Base	**Base**	**Length**	

First ventilated treeshelters



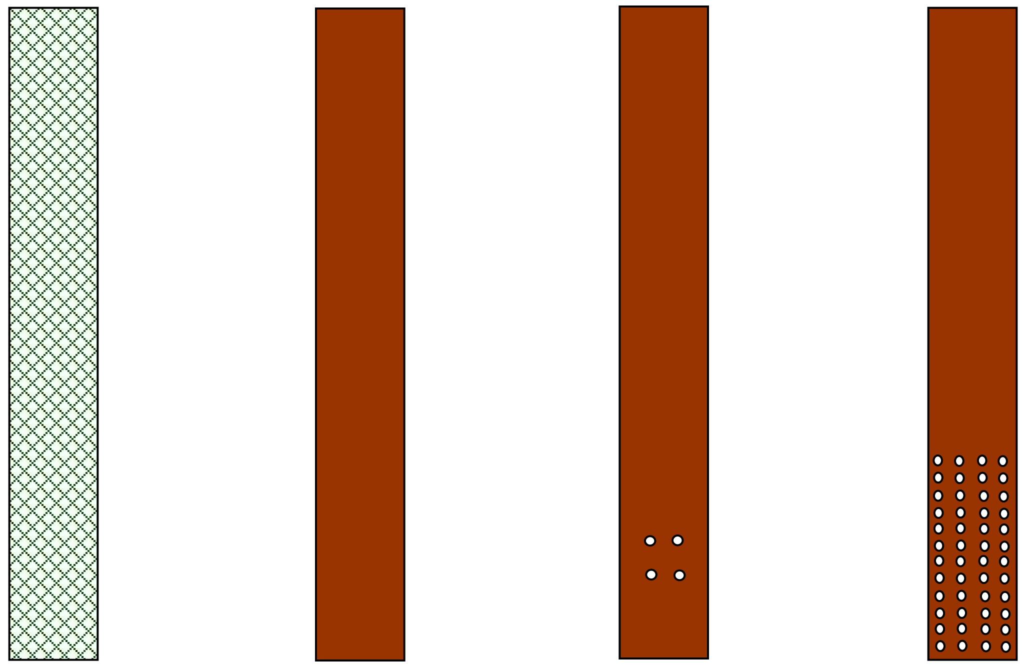
1986 Cornwall

No significant differences bw treeshelters.

1Year: significant difference bw Control (mesh guard) & Treeshelters

Experiment 1987 Cornwall & Mid-England

1.2 m Treeshelters

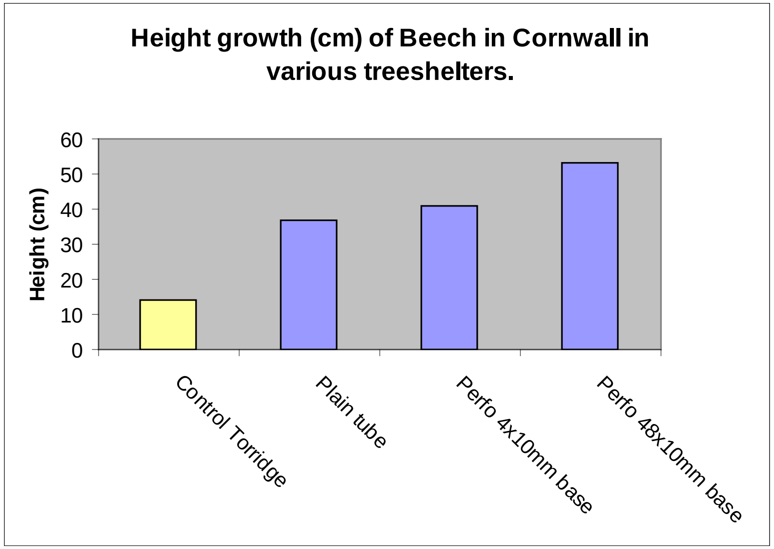


Control	Brown	Brown	Brown
Mesh	Plain	4 holes	48 holes
Guard		10 mm	10 mm
		Base	Base

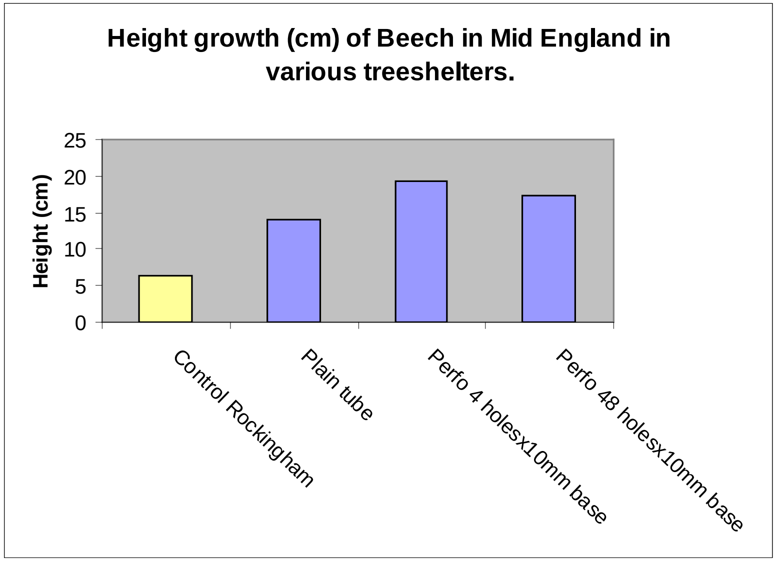
First Ventilated treeshelters

1987 Cornwall and Mid-England– 3 growing seasons

Increased ventilation significantly improved the growth height of Beech.



Good soil



Poor soil

Control: mesh guard

Control: unprotected tree

- But what if….

Height growth was NOT the key issue?

These experiments lack a key combination?

- This was the start of a long investigation

A long story .. in 7 papers

Dupraz, C., 1997. Greenhouse effect shelters for seedlings. Part 1. How trees react. Revue Forestiere Francaise (Nancy) 49, 417-432.

Dupraz, C., 1997. Greenhouse effect shelters for seedlings. Part 2 : Increasing their efficiency by optimized ventilation and greater light exposure. Revue Forestiere Francaise (Nancy) 49, 519-530.

Bergez, J.E., Dupraz, C., 1997. Transpiration rate of Prunus avium L seedlings inside an unventilated tree shelter. Forest Ecology and Management 97, 255-264.

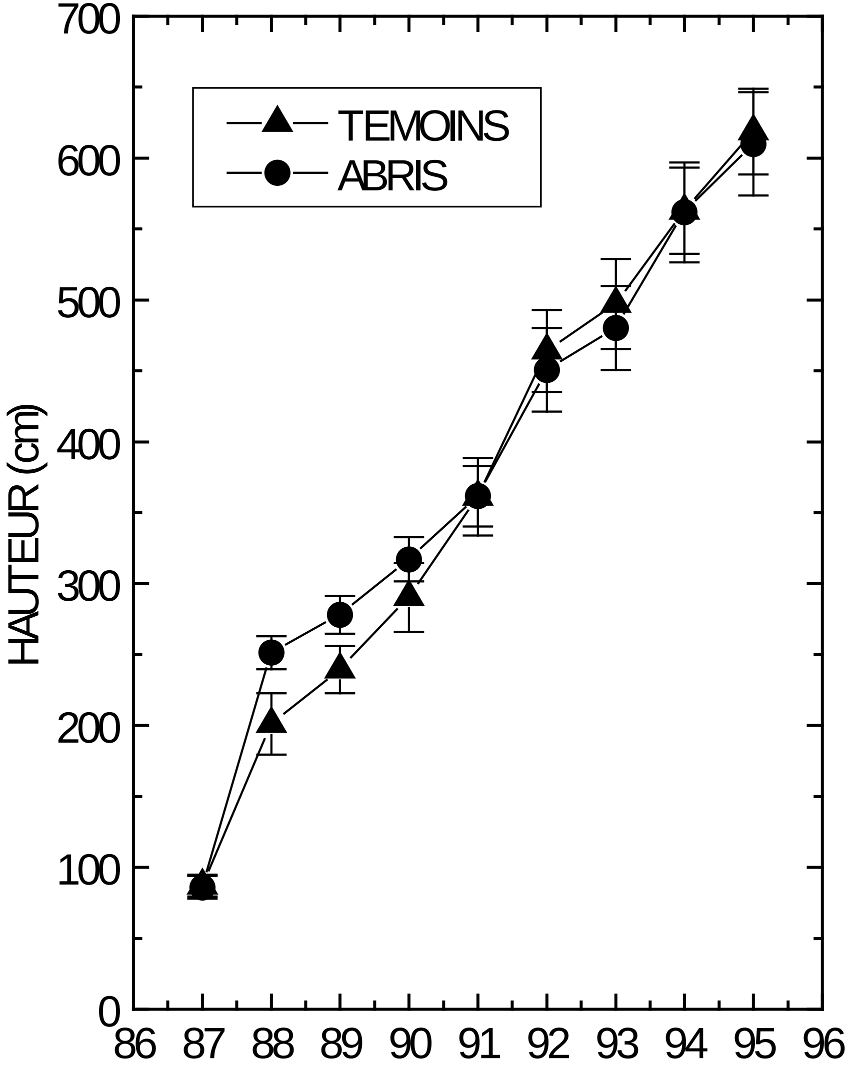
Dupraz, C., Bergez, J.E., 1999. Carbon dioxide limitation of the photosynthesis of Prunus avium L. seedlings inside an unventilated treeshelter. Forest Ecology and Management 119, 89-97.

Bergez, J.E., Dupraz, C., 2000. Effect of ventilation on growth of Prunus avium seedlings grown in treeshelters. Agricultural and Forest Meteorology 104, 199-214.

Coutand, C., Dupraz, C., Jaouen, G., Ploquin, S., Adam, B., 2008. Mechanical Stimuli Regulate the Allocation of Biomass in Trees: Demonstration with Young Prunus avium Trees. Ann Bot 101, 1421-1432.

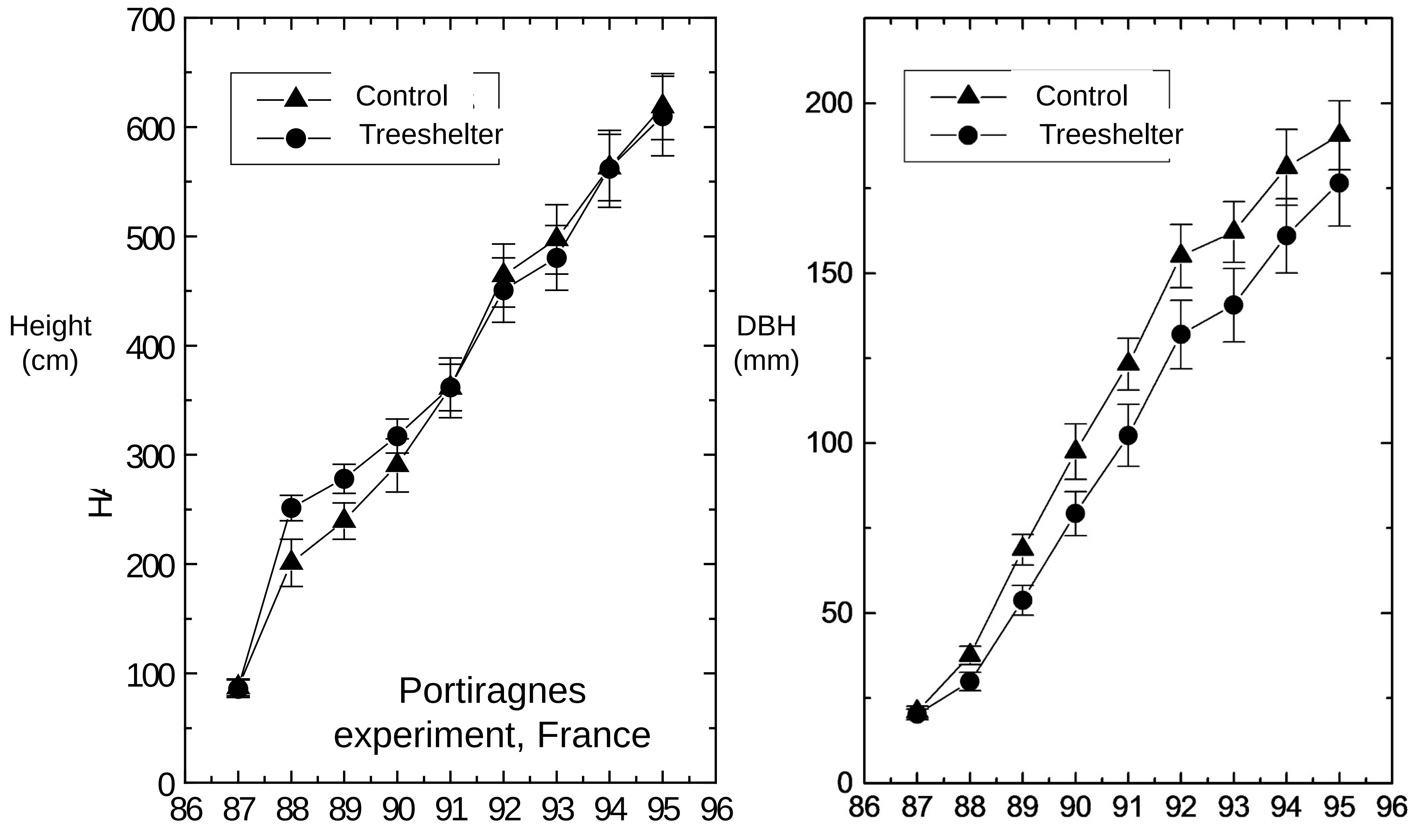
Bergez, J.-E., Dupraz, C., 2009. Radiation and thermal microclimate in tree shelter. Agricultural and Forest Meteorology 149, 179-186.

Long-term experiments on hybrid walnut trees



Standard unventilated brown 1.8 m tall treeshelters

Long-term experiments on hybrid walnut trees



Standard unventilated brown 1.8 m tall treeshelters

Key finding 1

Early DBH growth more important than early height growth

Impact of treeshelters on the root/shoot balance

Année	Auteur	Site	Essence	Proportion de biomasse souterraine	
				Témoins	Abrités
1988	Dupraz, données inédites	Montpellier, conteneurs	Merisier Noyer commun Noyer noir Noyer hybride	48 75 79 73	33 54 67 64
1989	Bergez, 1993	Montpellier, conteneurs	Merisier Noyers hybrides	60 85	33 66
1990	Bergez, 1993	Montpellier, conteneurs	Merisier	57	42
1991	Bergez, 1993	Montpellier, pleine terre	Merisier Noyer commun	65 83	38 64
1991	Cemagref données inédites	Montoldre, (Allier) pleine terre	Merisier Noyer commun	65 82	39 70
1992	Balandier et al, 1995	Montoldre (Allier) pleine terre	Merisier Noyer commun	51 79	35 59

Moyenne	Merisier Noyers	58 79	37 63

Abris de 120 cm, standards (non ventilés)

20% shift of the total biomass to the aboveground biomass in treeshelters

Key finding 2

Root deficit with treeshelters

1997

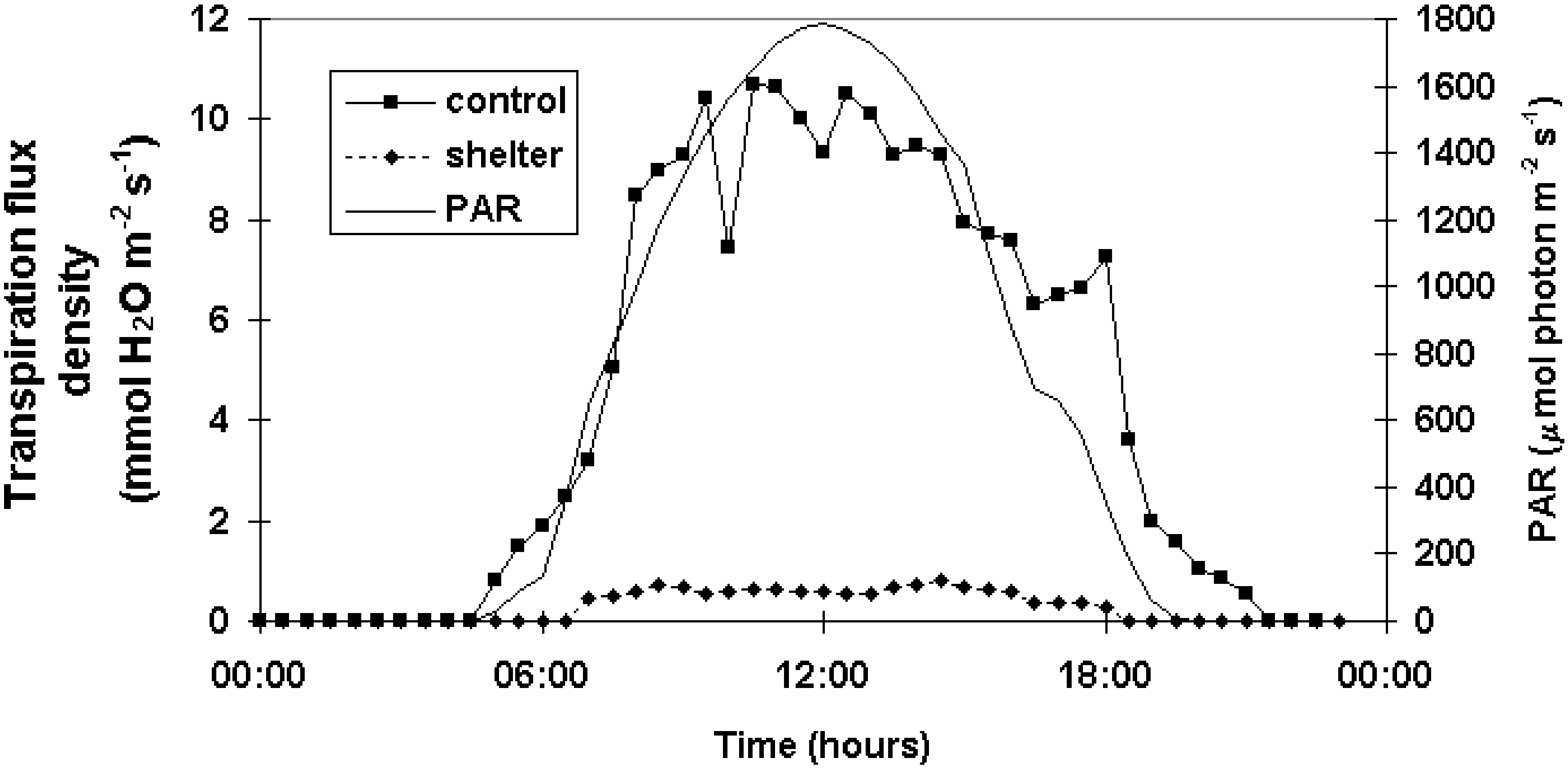
ELSEVIER

Forest Ecology and Management 97 (1997) 255–264

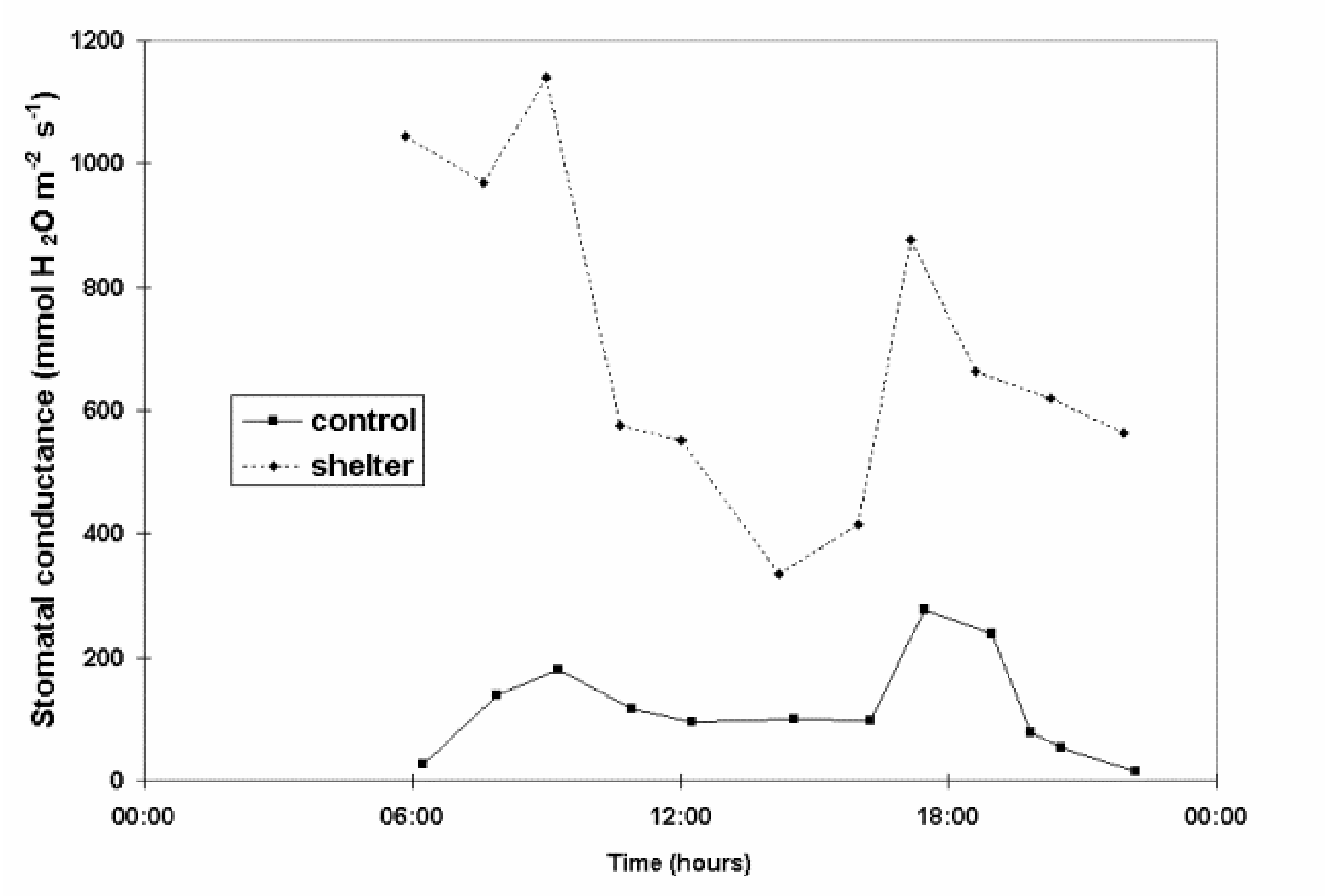
Forest Ecology and Management

Transpiration rate of *Prunus avium* L. seedlings inside an unventilated treeshelter

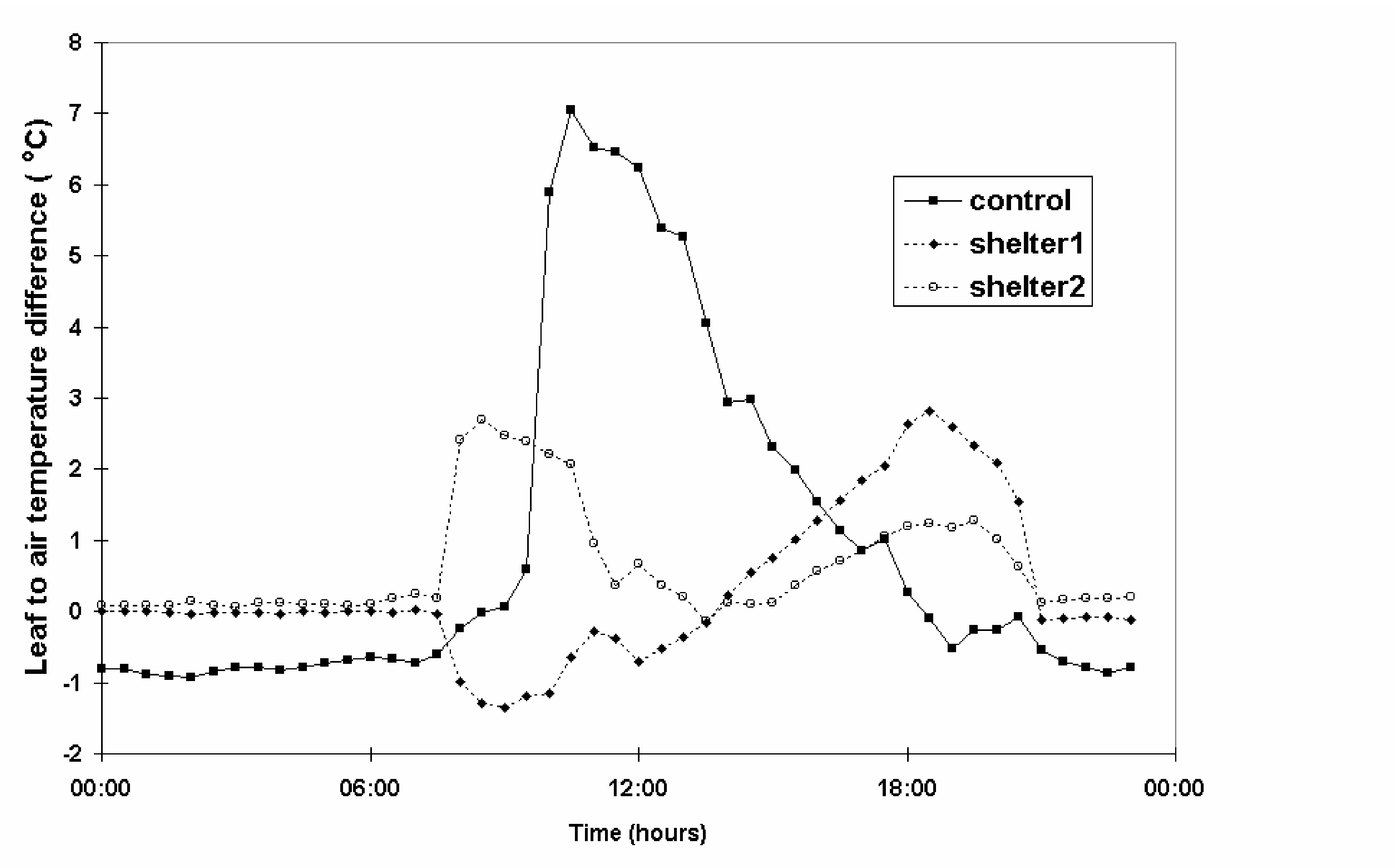
J.-E. Bergez [1], C. Dupraz *



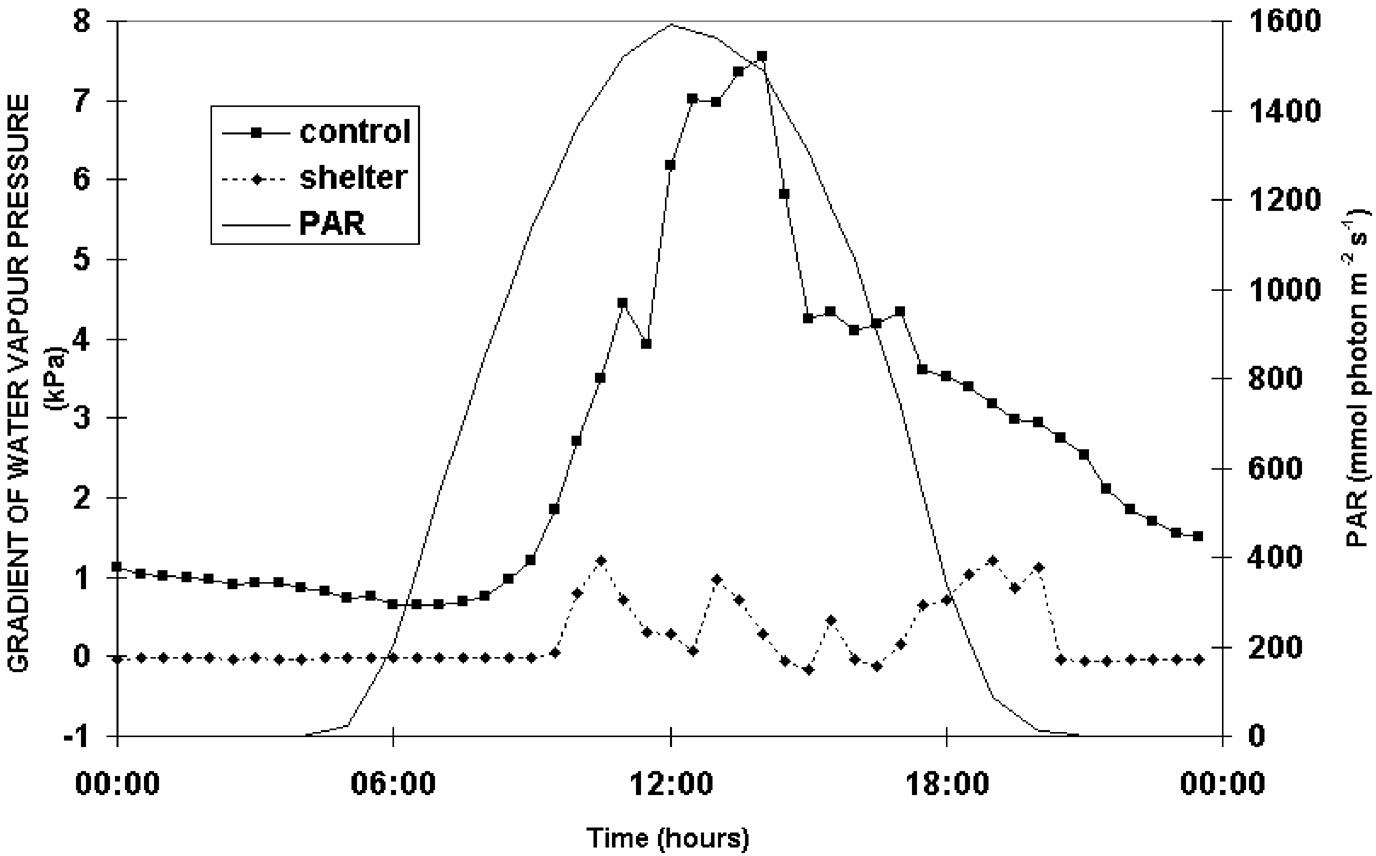
Trees in treeshelters… save a lot of water!



While their stomata are wide open

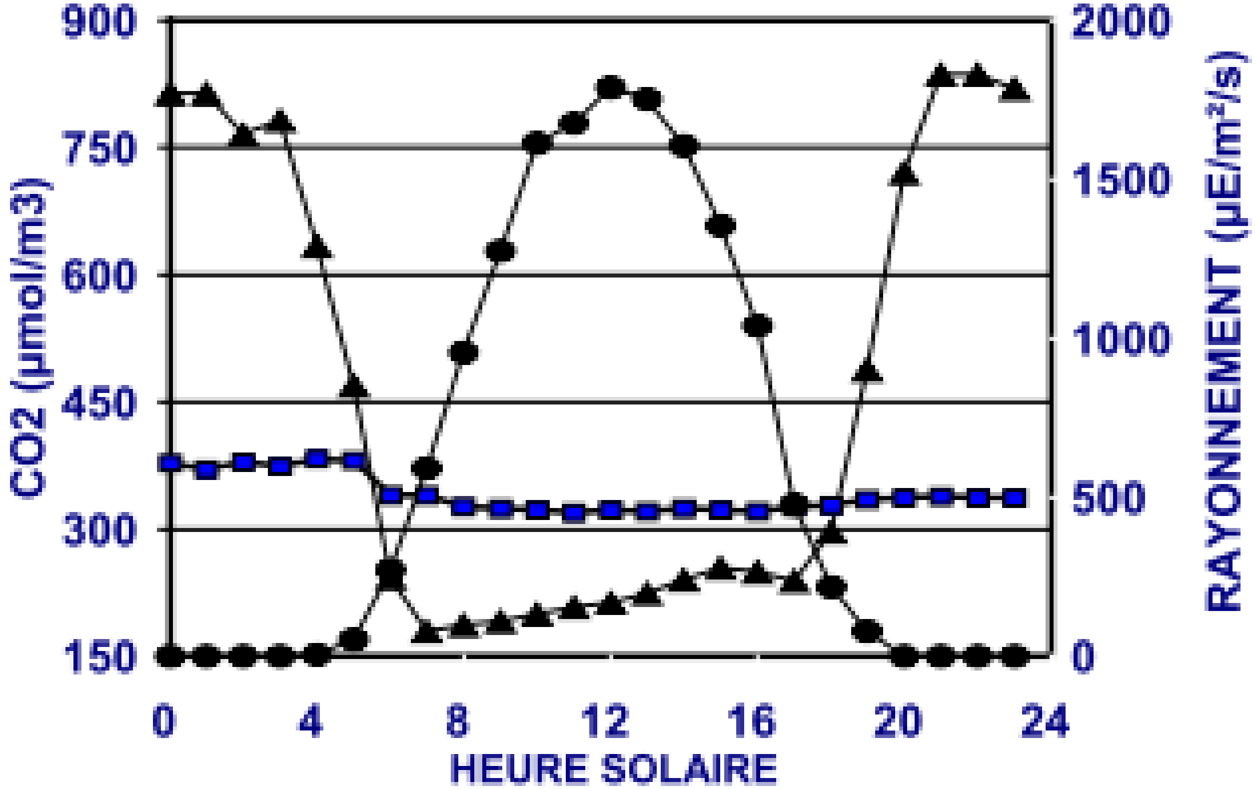


Tree Leaf temperature very close to air temperature in treeshelters



Very small VPD in treeshelters

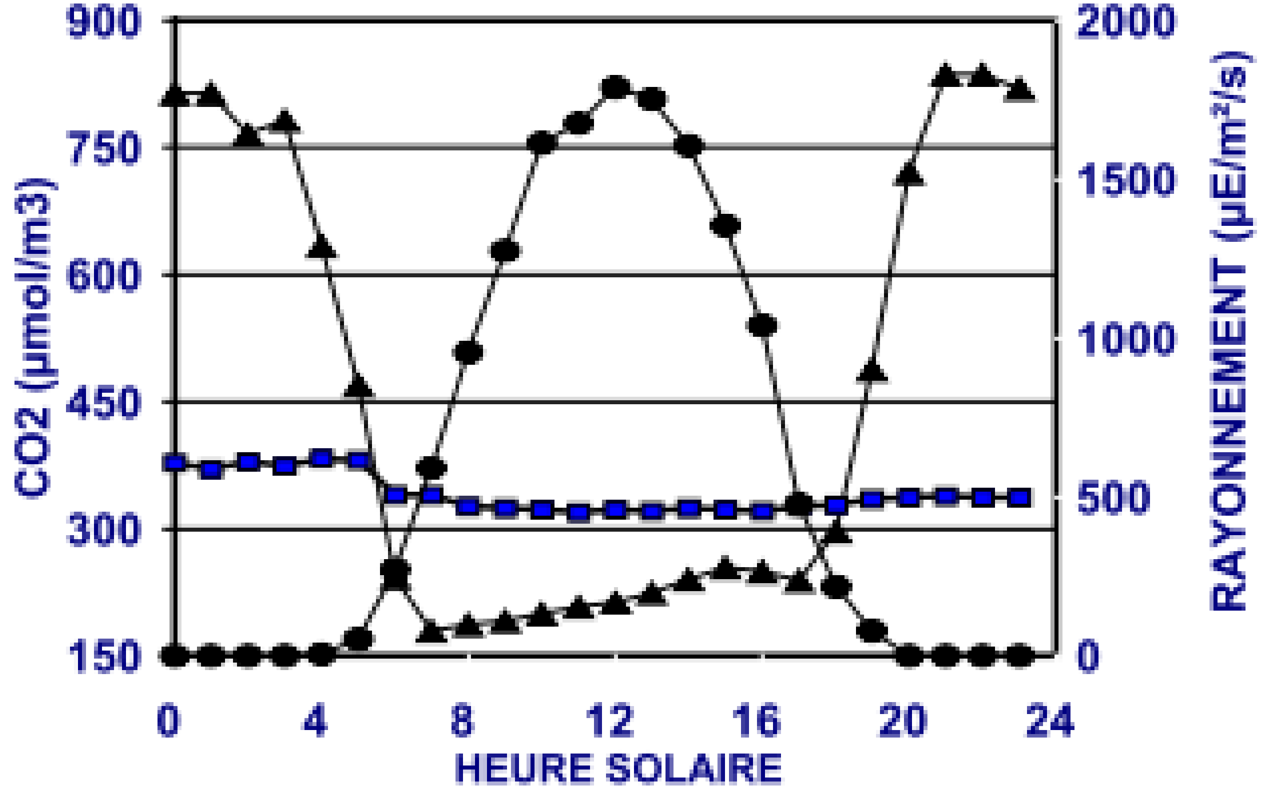
But the key finding is :



CO_2 inside treeshelter — CO_2 outside — Radiation

Unventilated treeshelter with a wild cherry tree

But the key finding is : extremely fast Air CO_2 depletion



CO_2 inside treeshelter — CO_2 outside — Radiation

Unventilated treeshelter with a wild cherry tree

Key finding 3

Photosynthesis
impeded by lack of CO_2

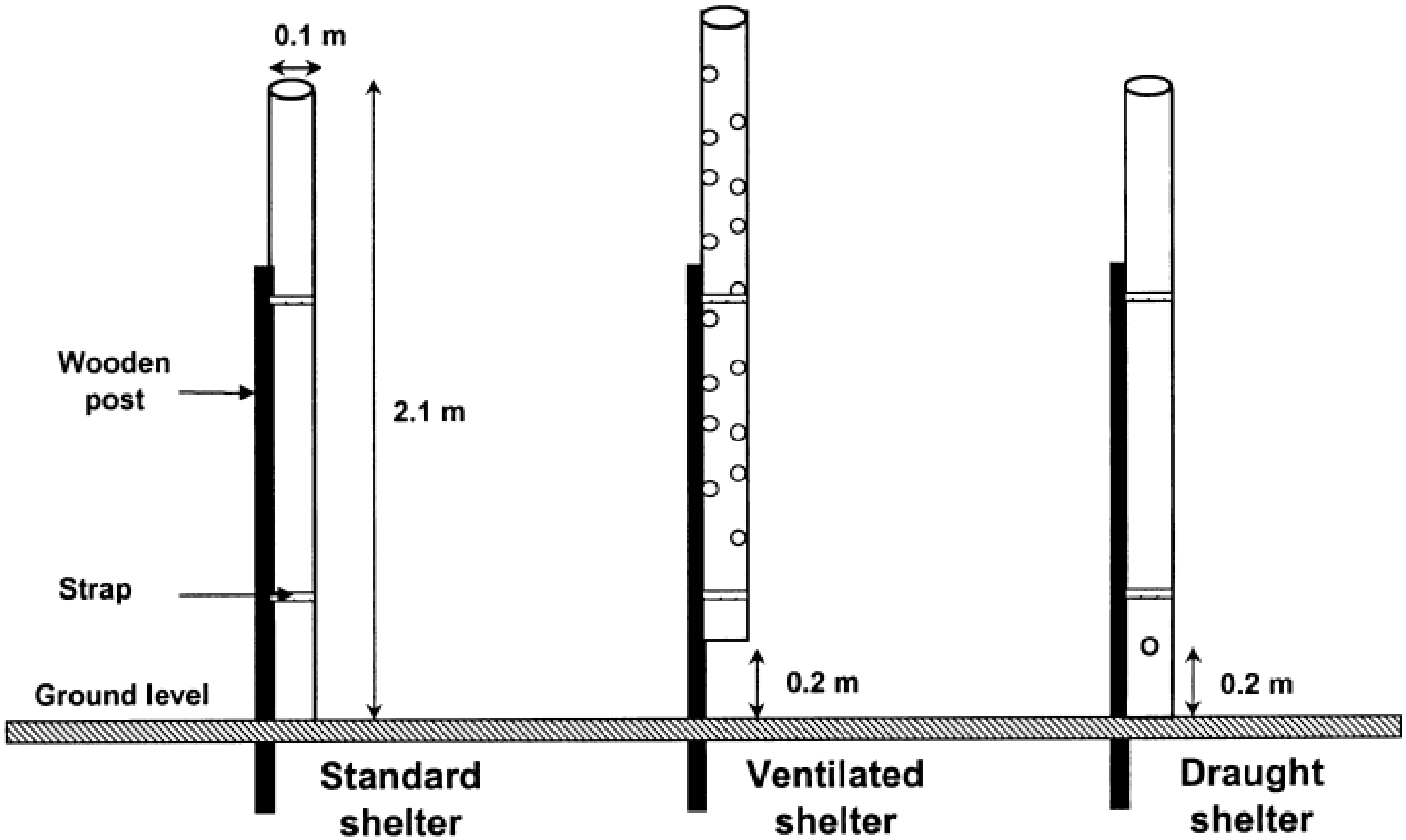
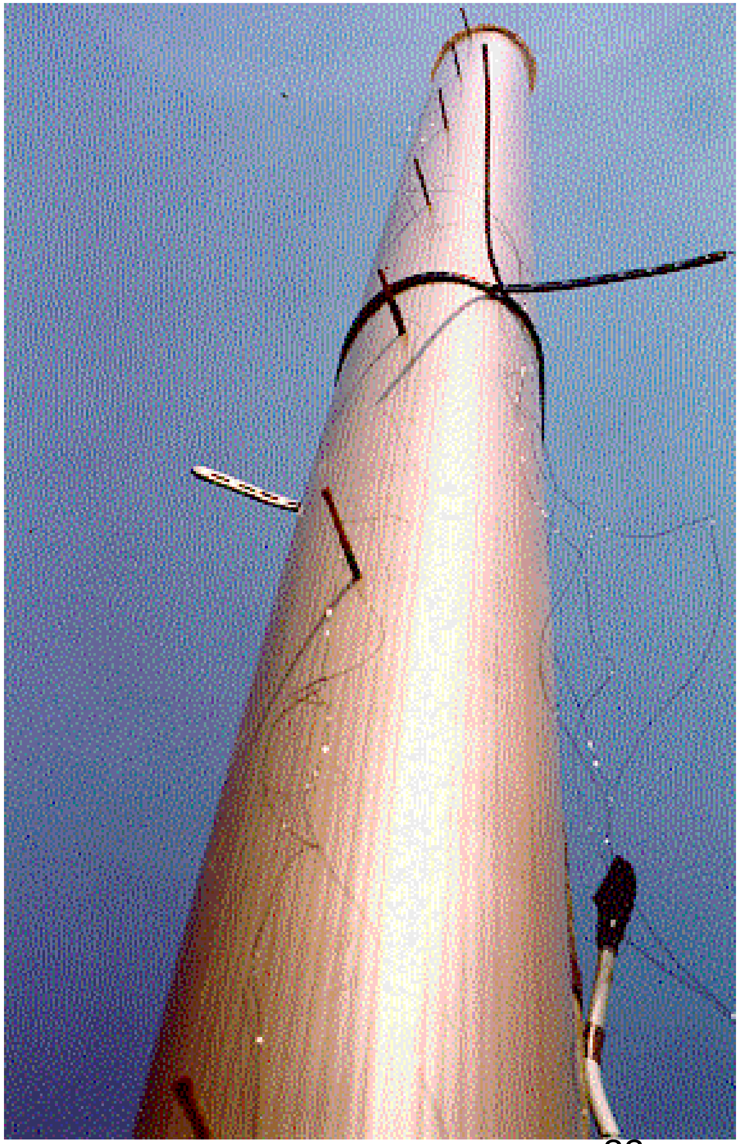
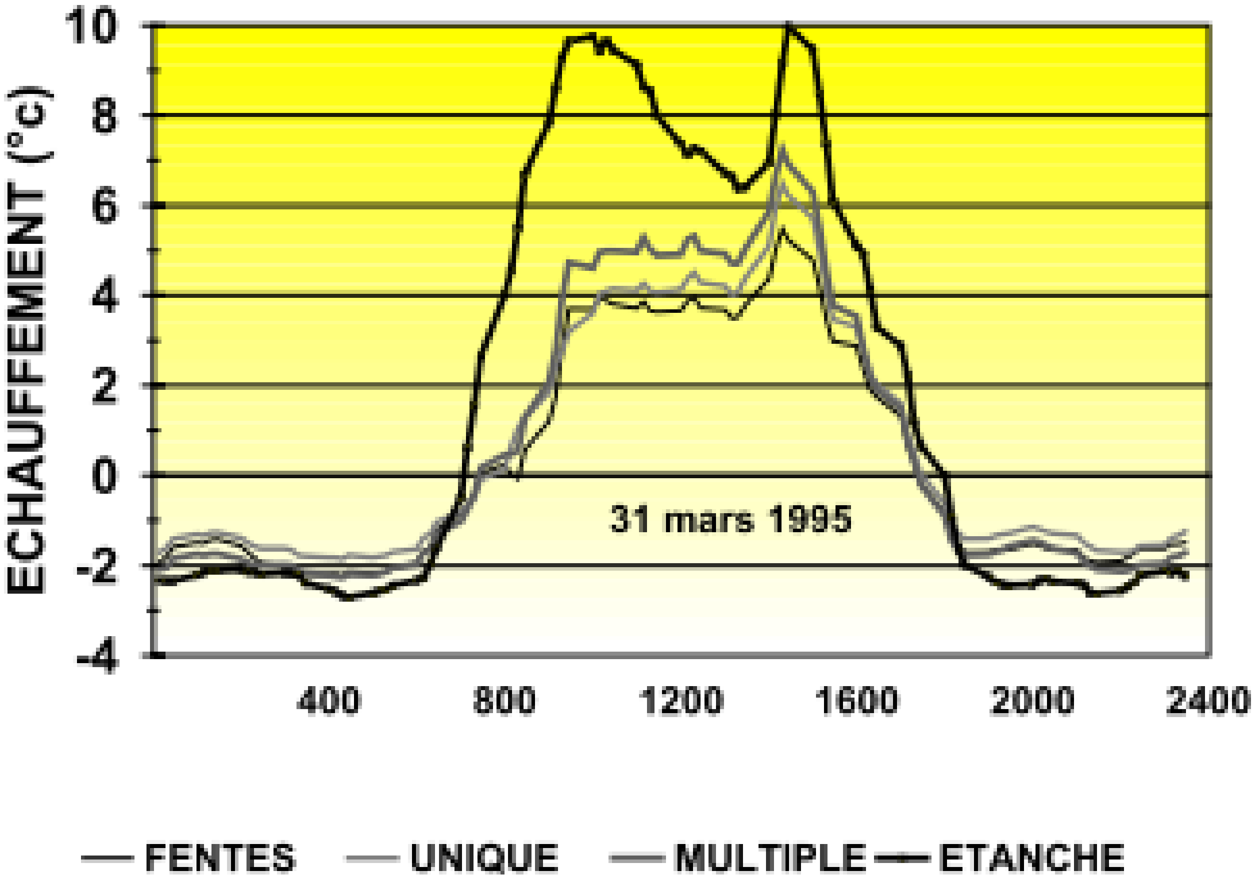


Fig. 1. Design and set-up of the treeshelters used in experiments A, B and C.

Photo 1 : Dispositif expérimental de Notre-Dame de Londres (Hérault) sur merisier : comparaison de différentes modalités d'abris-serres modifiés en luminosité et aération sur la croissance des arbres

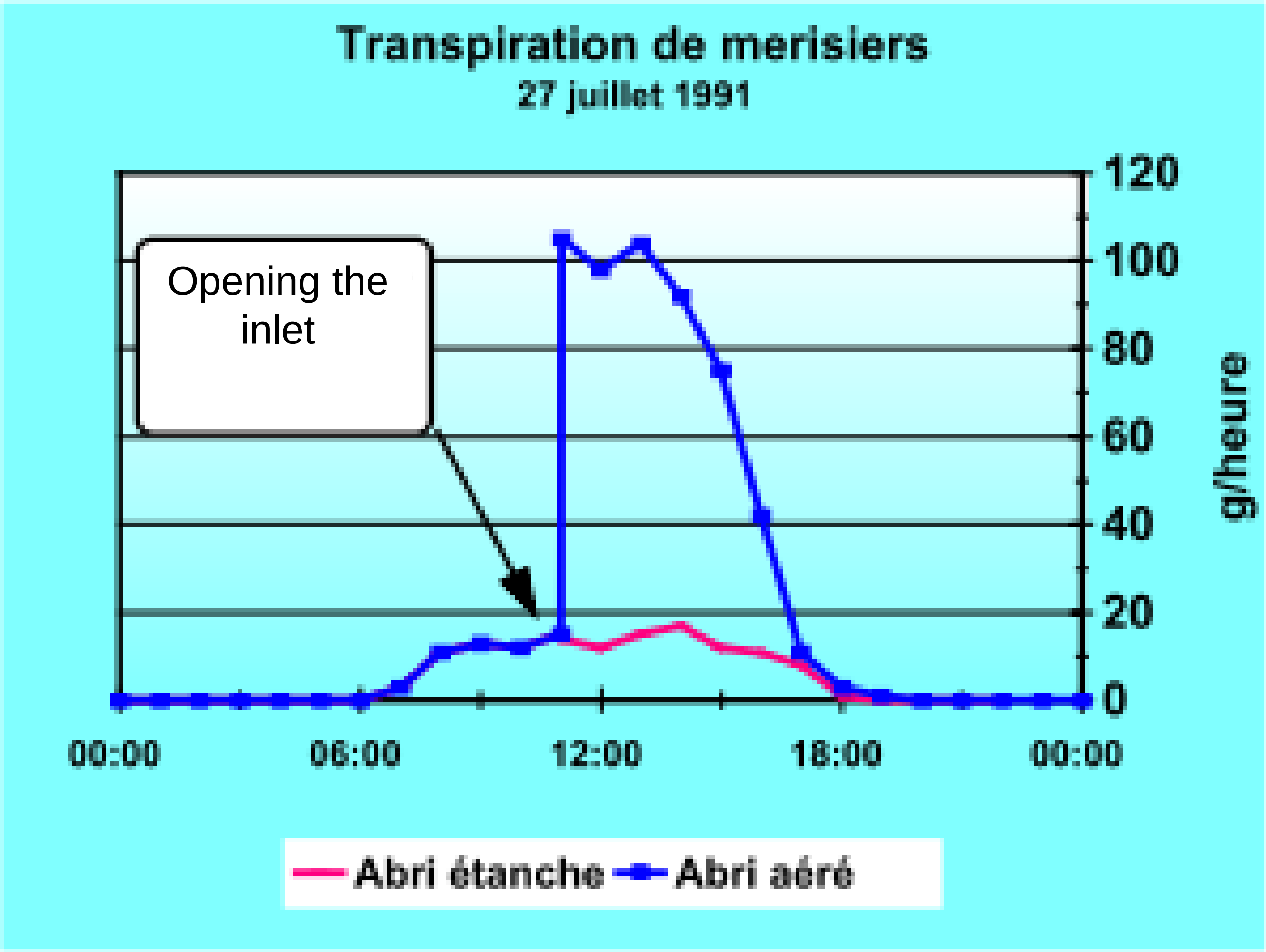


Air temperature cooling by the chimney effect



Les températures sont mesurées à 80 cm de hauteur dans les abris

Tree transpiration stimulation by the chimney effect



Improved photosynthesis at low radiation levels in treeshelters

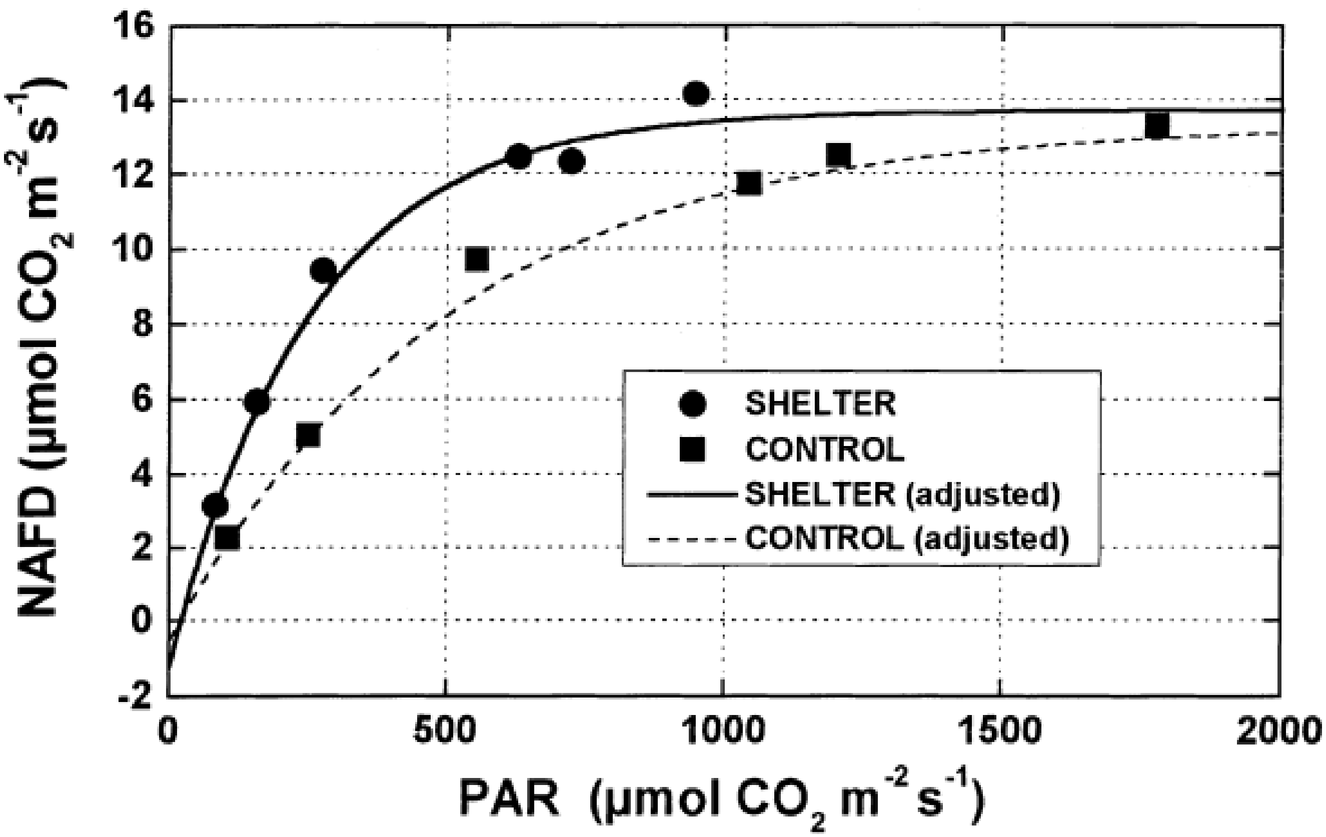


Fig. 5. Net assimilation flux density of *Prunus avium* leaves versus available radiation for sheltered and control trees. Day: 4 July; Air temperature: 26.5°C; Relative humidity: 38%; $[CO_2]$: 360 µl l^{-1}.

Tree photosynthesis stimulation by the chimney effect

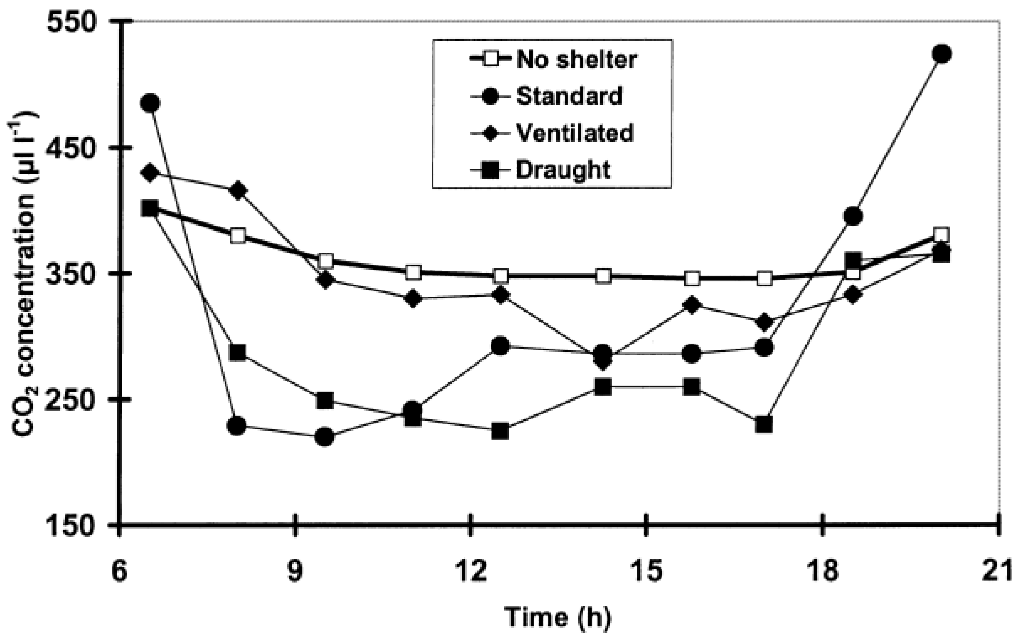


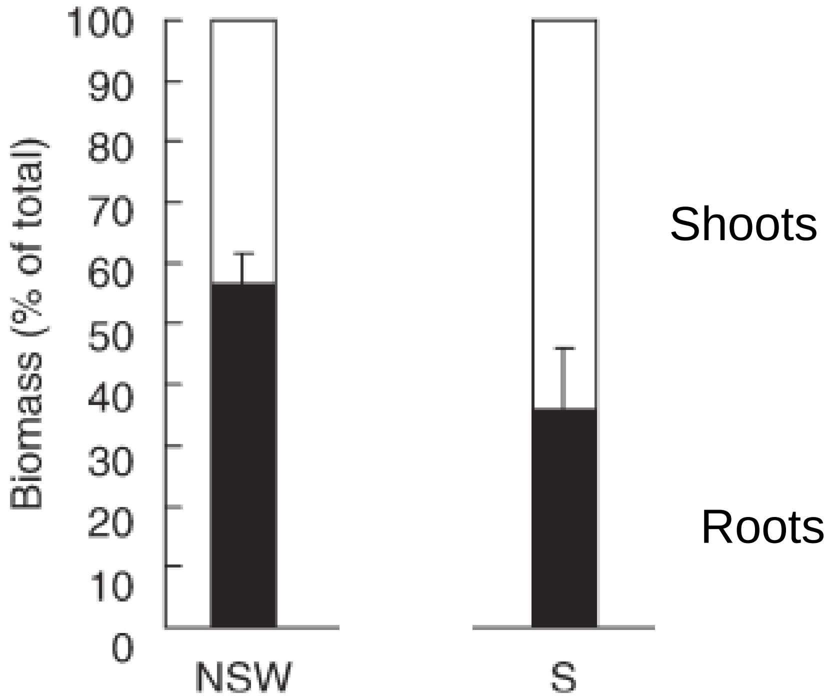
Fig. 4. Diurnal variations of CO_2 concentration inside different types of treeshelters. Data recorded on 4 September 1991 at mid-canopy height.

Key finding 4

When CO_2 is back,
more light is useful

Ventex Equilibre Treeshelter

Prunus avium (cv Monteil)



NSW : No Shelter and wind

S : Ventilated Shelter

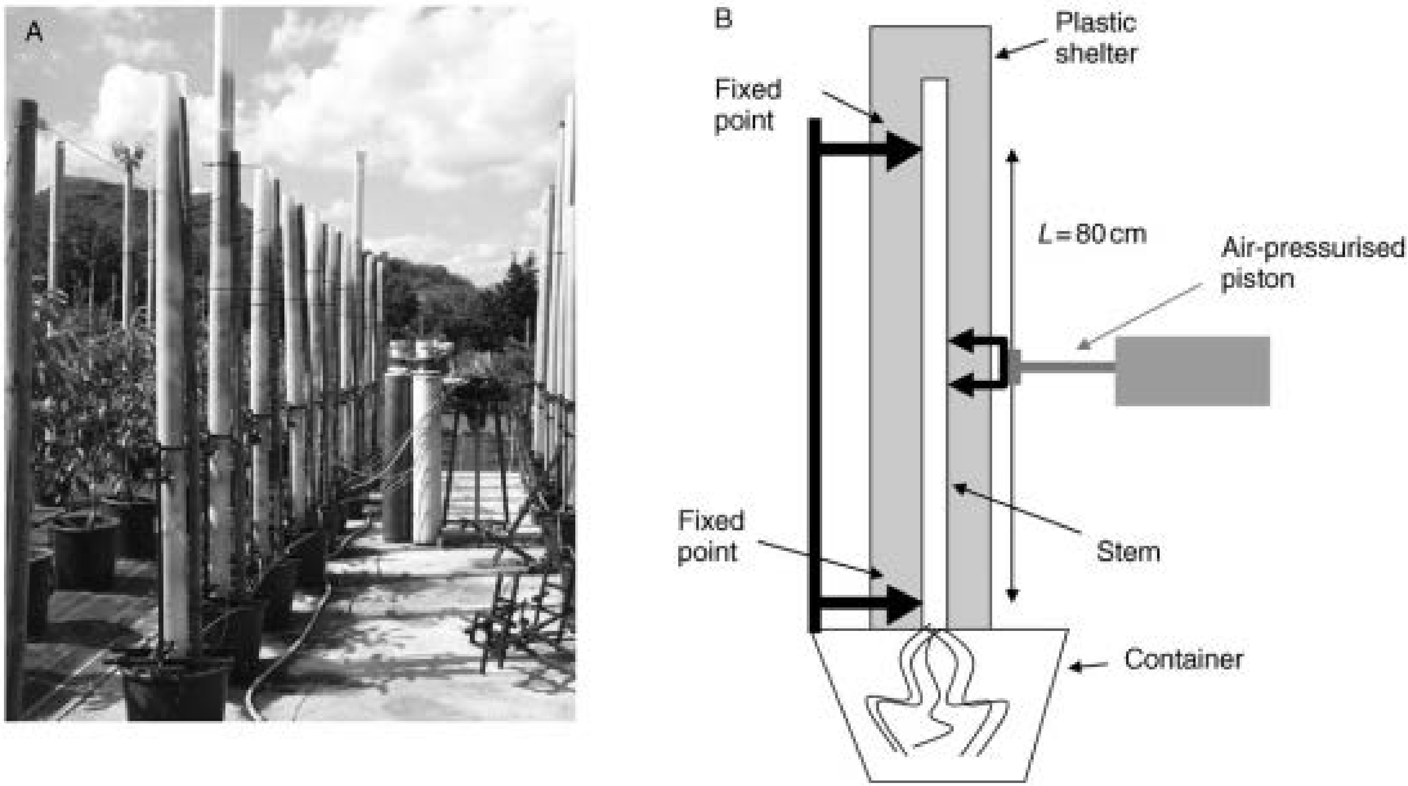
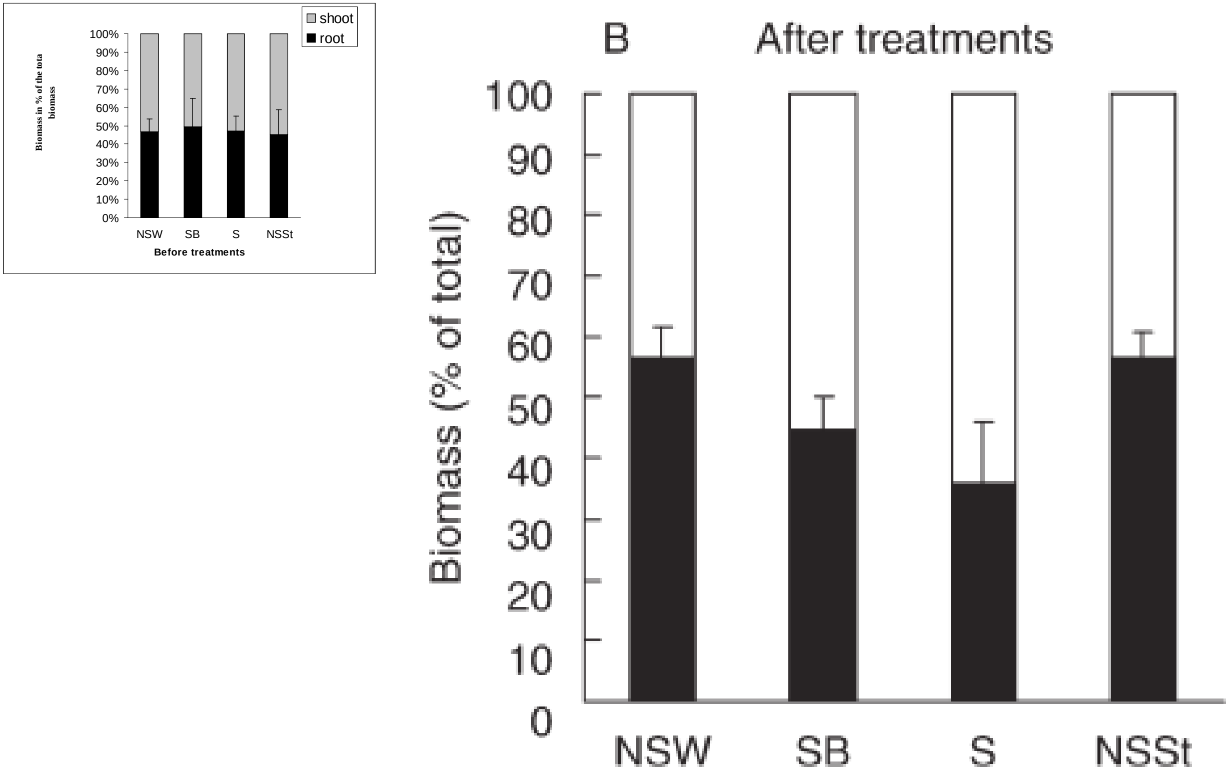


FIG. 1. The experimental device for bending sheltered trees. (A) View of the SB treatment. (B) The stem inside the shelter is attached to two fixed points and a moving arm piloted by an air-pressurised piston imposes a lateral displacement, which results in the bending of the stem.


FRAG
BAS

Prunus avium (cv Monteil)



NSW : No Shelter and wind

SB : Shelter + Bending

S : Shelter

NSSt : No Shelter + Stake

FIG. 6. Biomass partitioning between shoots and roots before and after treatments, expressed as a percentage of the total biomass of the tree.

Key finding 5

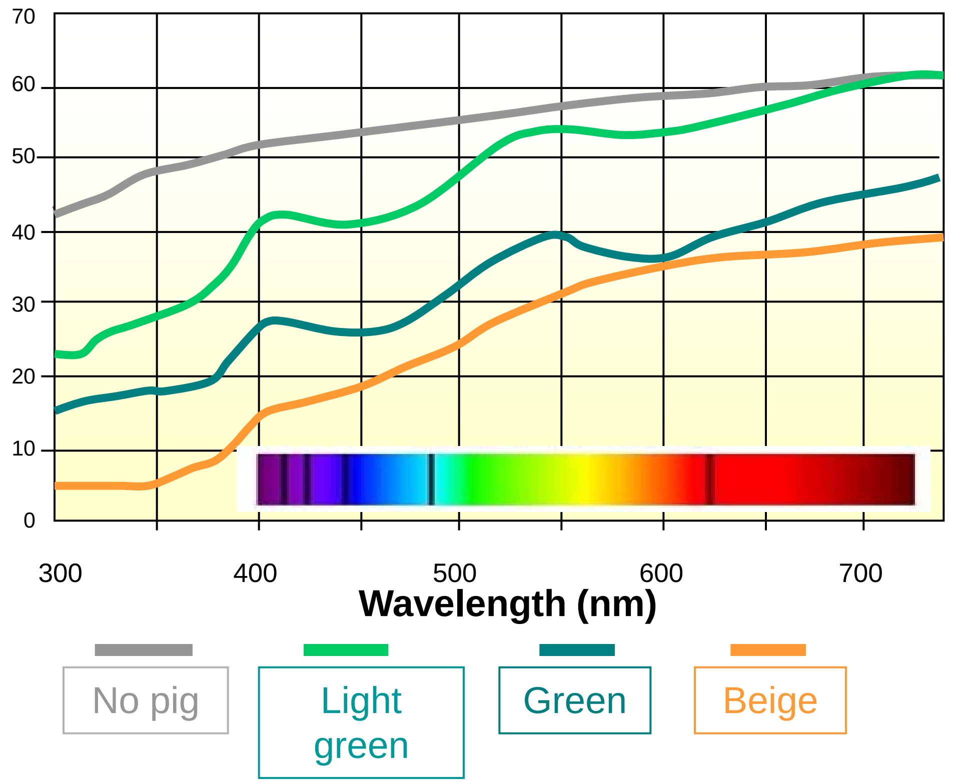
Stem swinging and bending by wind is important

The sooner the tree emerges from the shelter, the better. So height growth is important

Ventilation failures

- When water stress is too high
- When light availability is too reduced
- When the seedlings emerge from the shelter very early or from the start

Light transmission of visible light of 4 twin walled treeshelters



Light green colour provides:

- High light transmission close to non pigmented tube (Photosynthesis),
- Good mix of blue and red radiation for the Photo Active Radiation while keeping the tubes green for blending in the fields.
- Red/Far Red =0.94 (Photomorphogenesis).

Standard

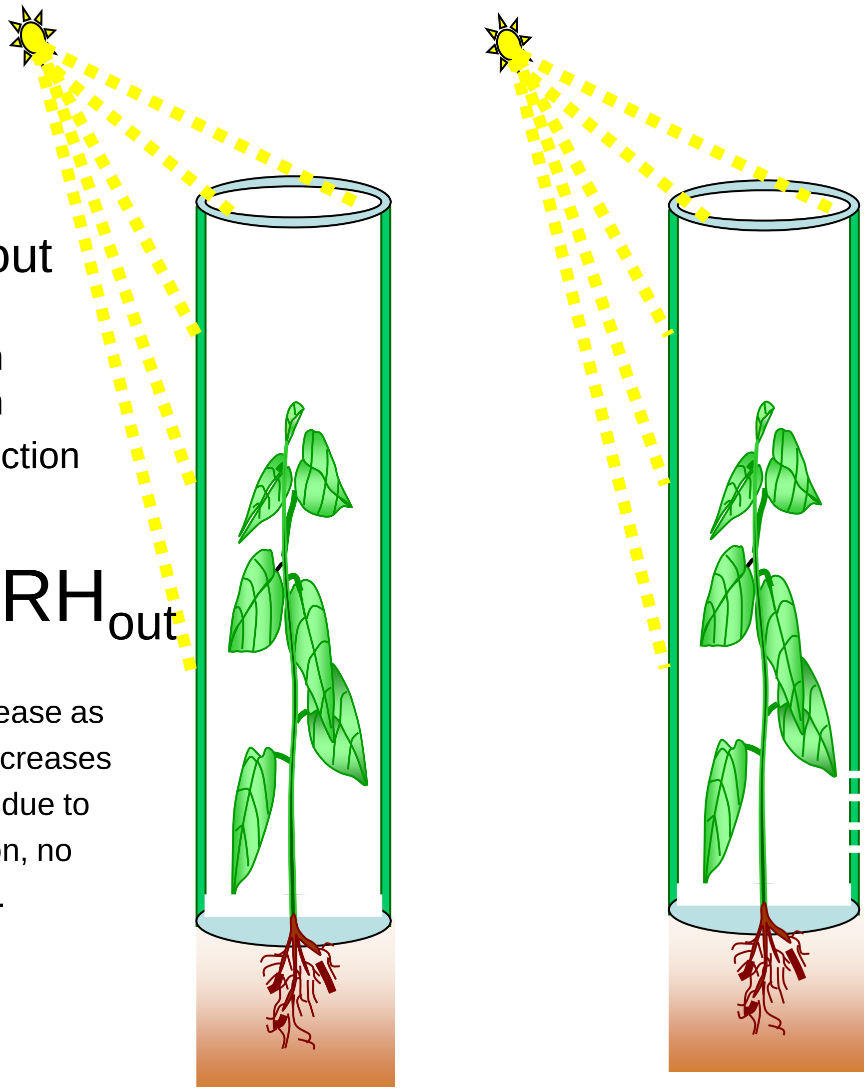
Ventilated

$T_{in} > T_{out}$

Insolation
Insulation
No convection

$RH_{in} > RH_{out}$

VPD* decrease as moisture increases in the tube due to transpiration, no convection.



$T_{in} = T_{out}$

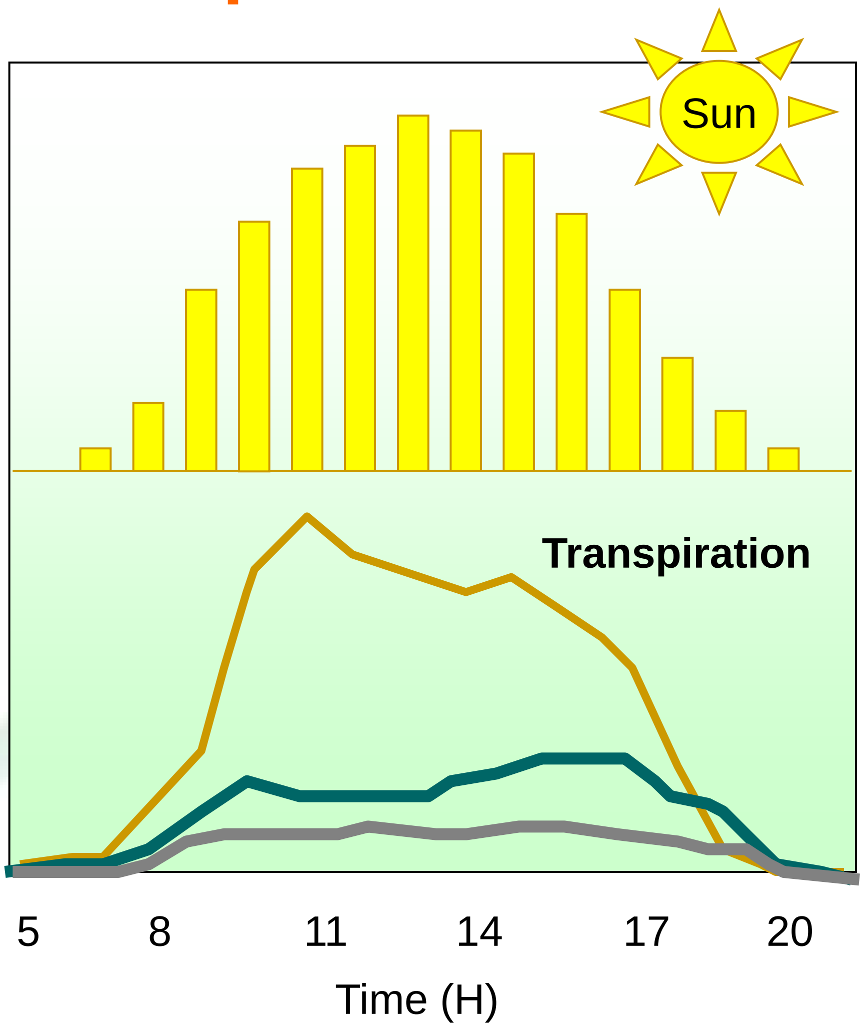
Convection

$RH_{in} = RH_{out}$

Moisture equilibrium

Summer Day time

Transpiration of a tree



Ventex →

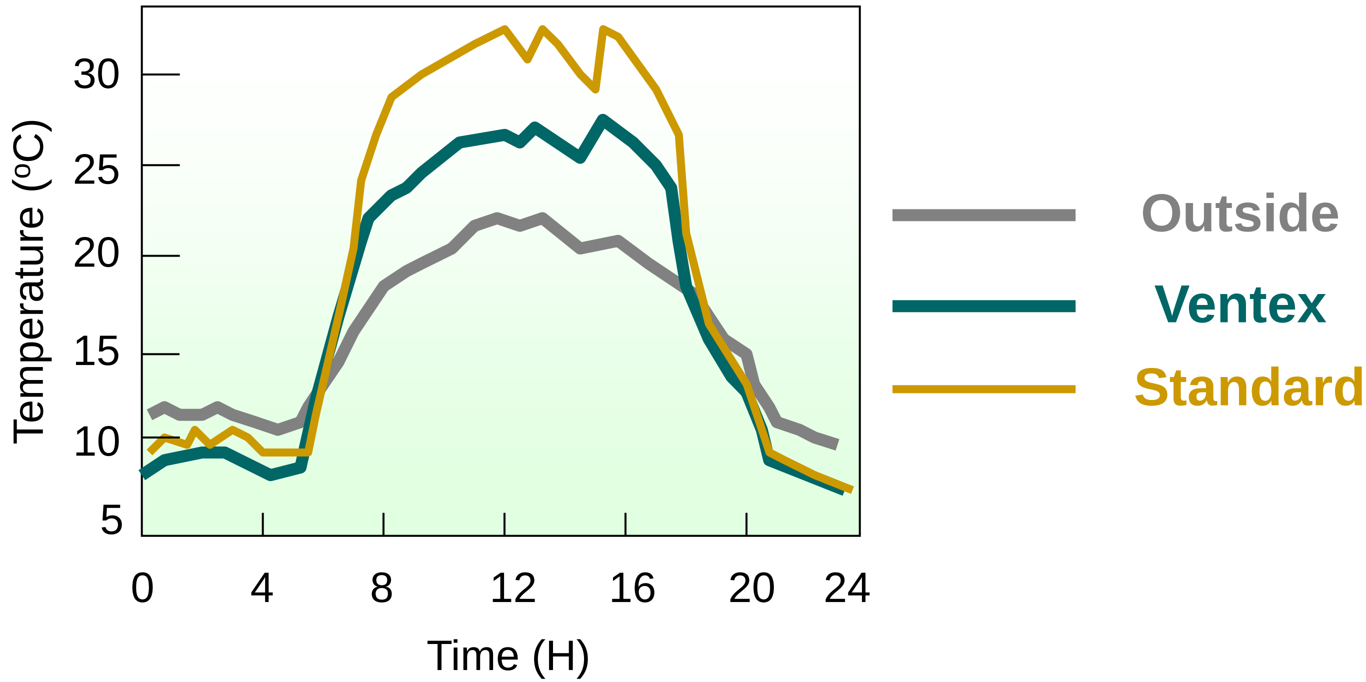
Controlled flow

CO_2 > 300 ppm

Temperature due to air flow

Air flow increases with sunlight.

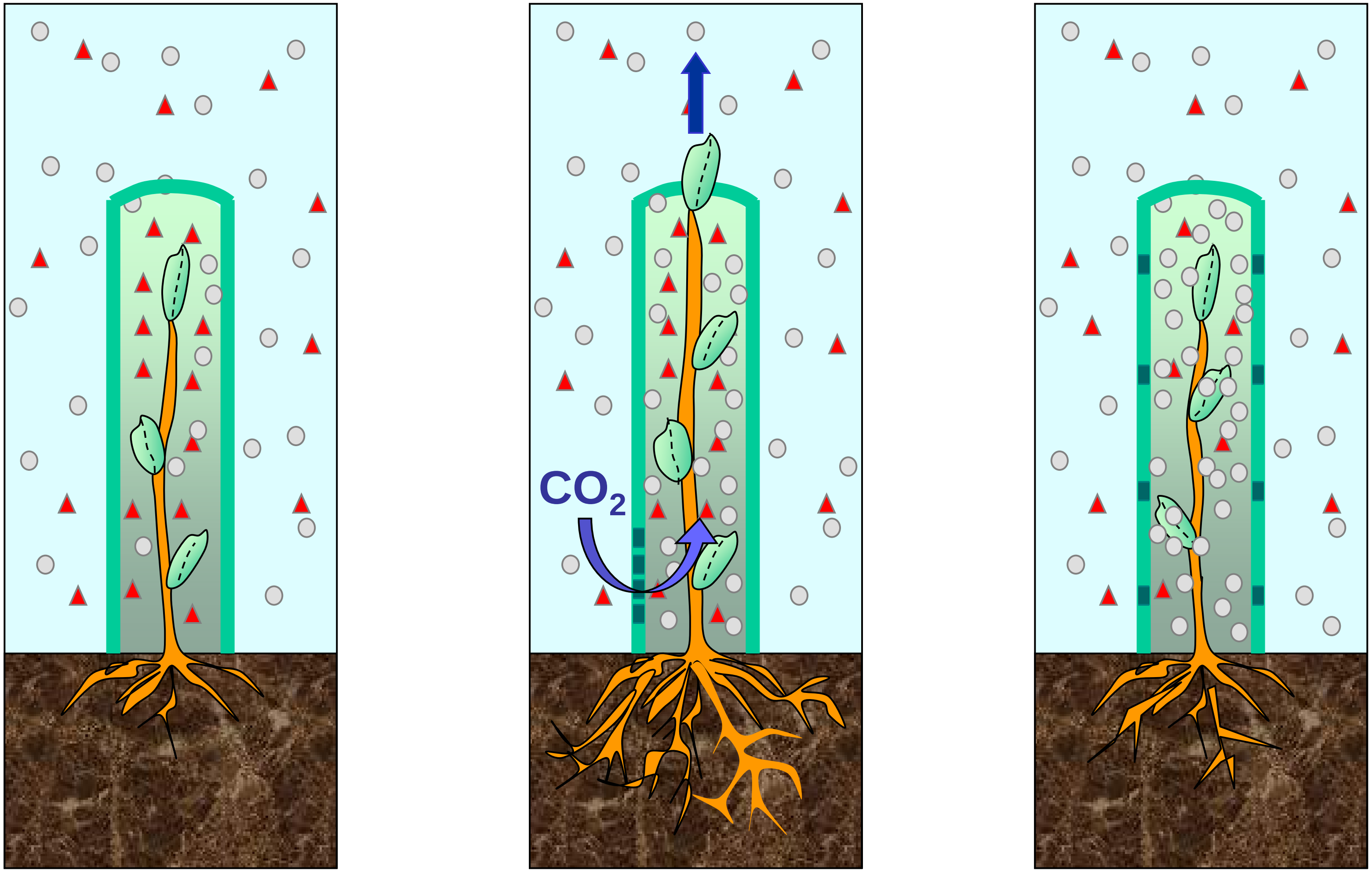
Tree is in good harmony with Heat / moisture / CO_2



Dupraz C., Bergez J.E., Amelioration de protections individuelles d'arbres a effet de serre. Patent 9204295.1, February 1992

See also USA study: B. R. Swistock, K.A. Mecum, W.L. Sharpe, Summer temperatures insode ventilated and unventilated brown plasic treeshelters in Pennsylvania, NJAF, 1999, 16(1), 7-10.

Standard | **Ventilated** | **Over ventilated**



Minimum CO_2

Excess H_2O

Optimum CO_2

Good H_2O

Maximum CO_2

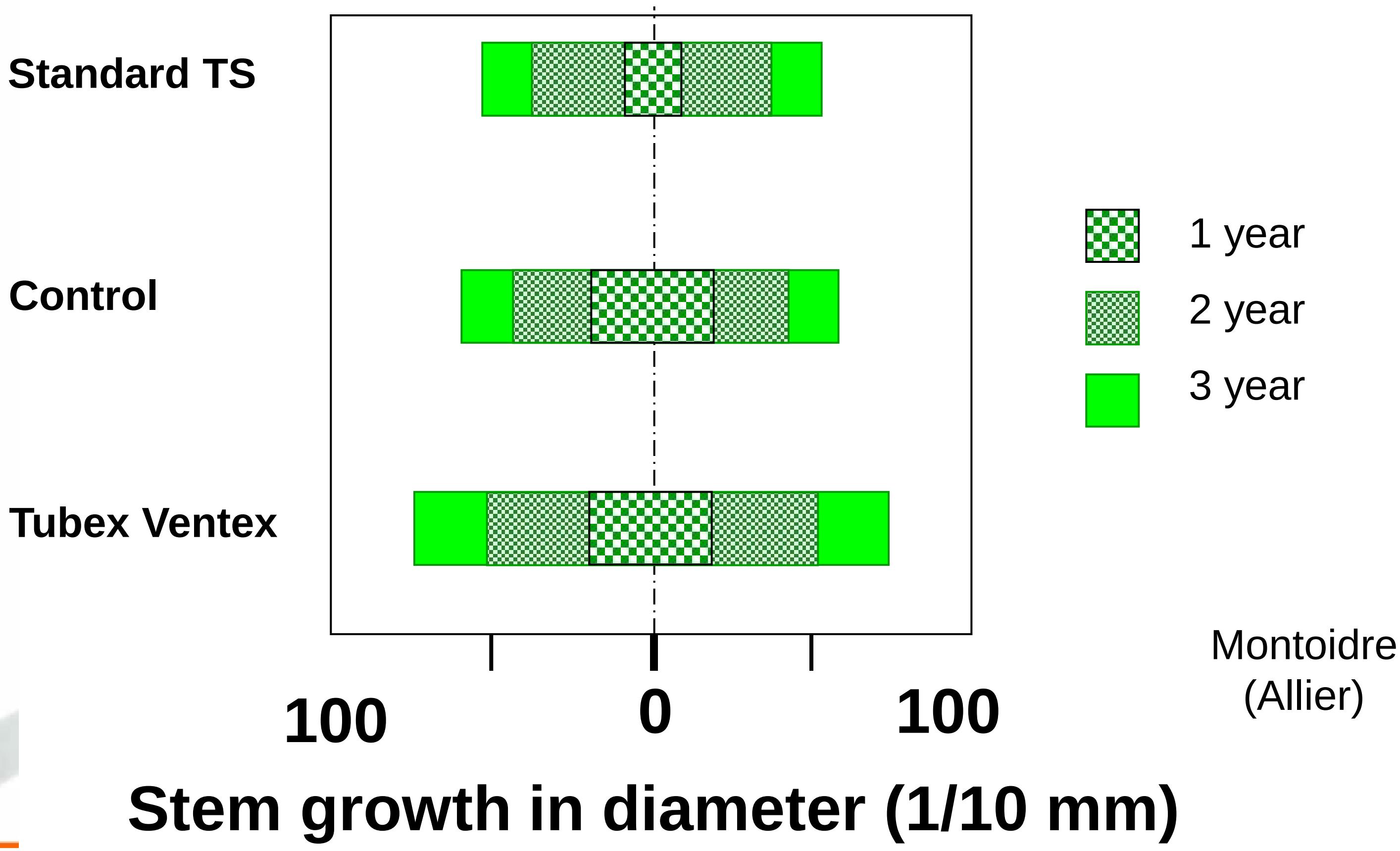
Low H_2O

▲ H_2O

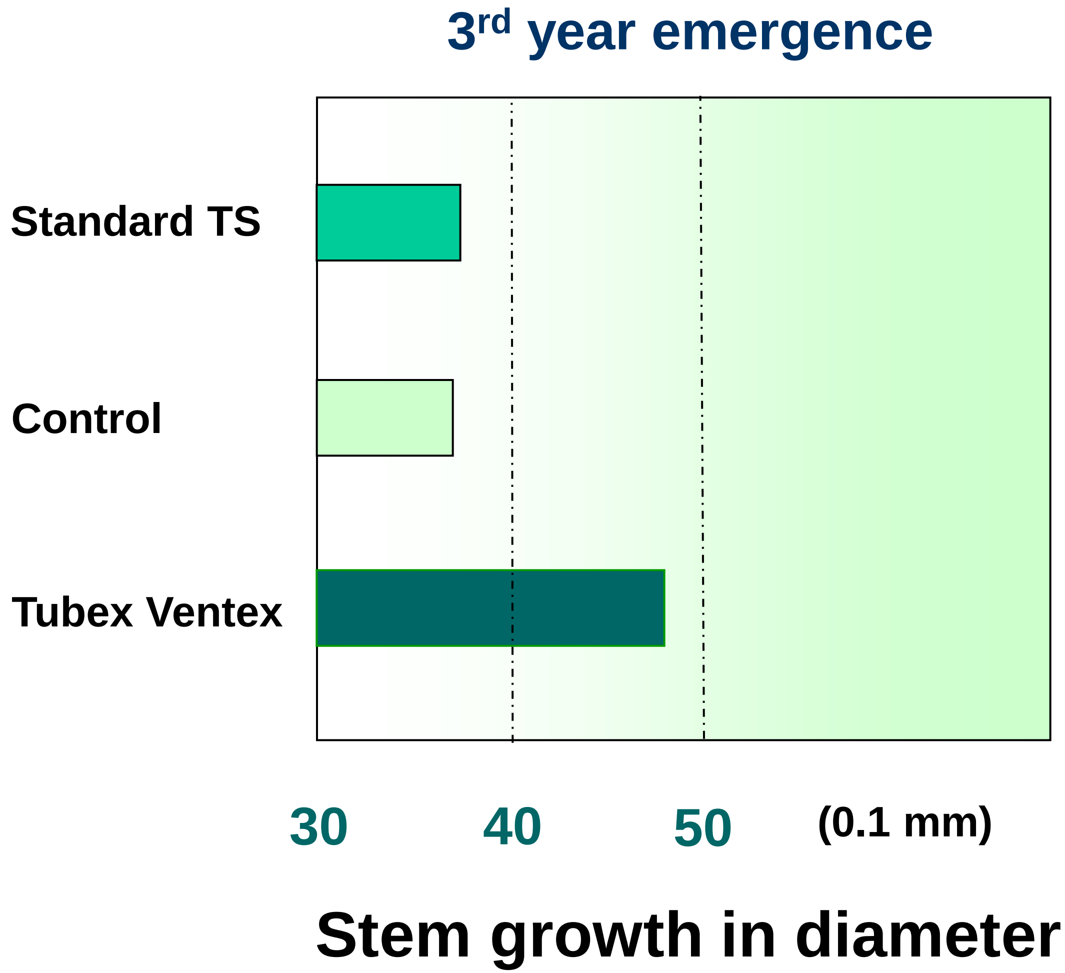
● CO_2

Ventex and walnut tree

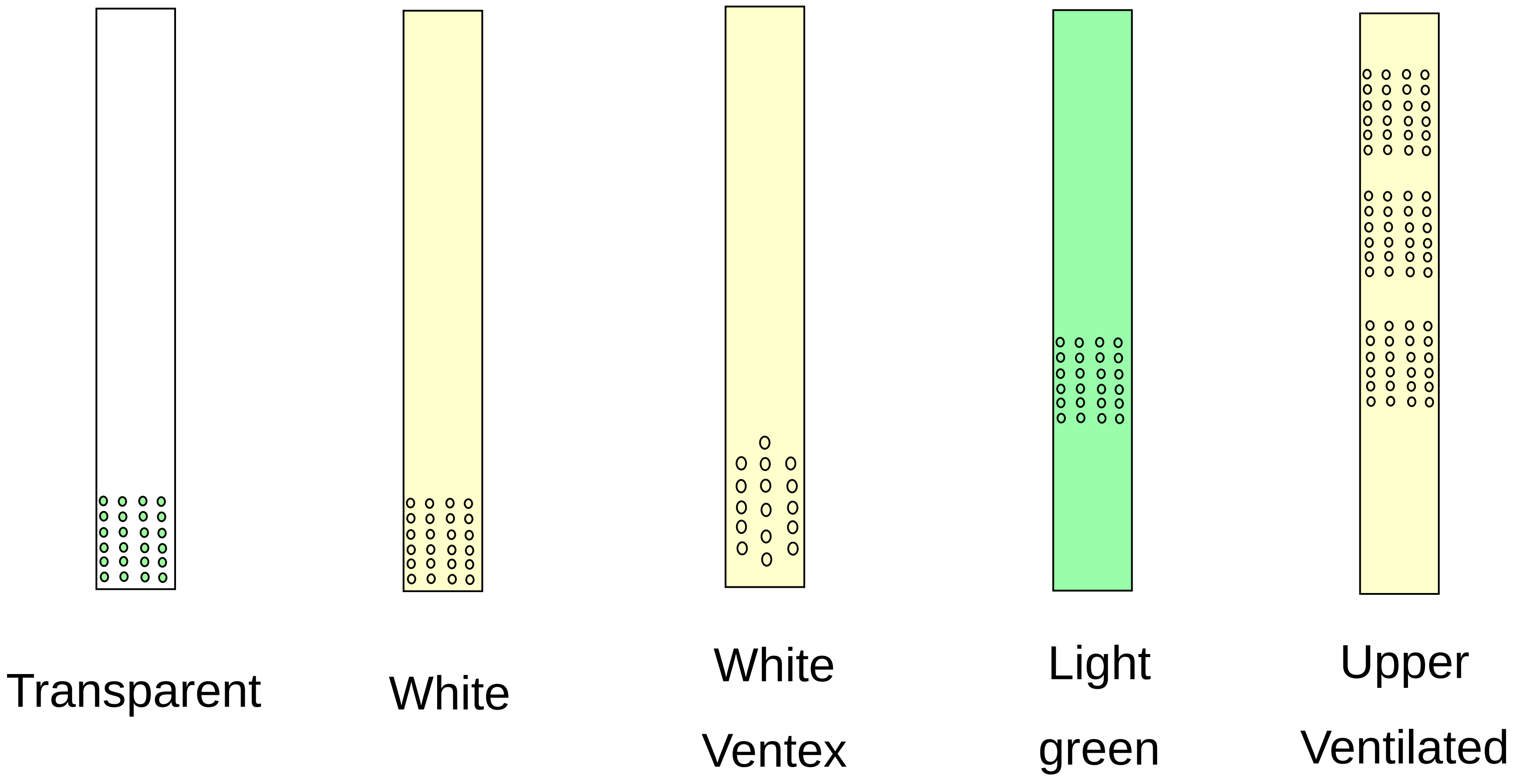
Ventex

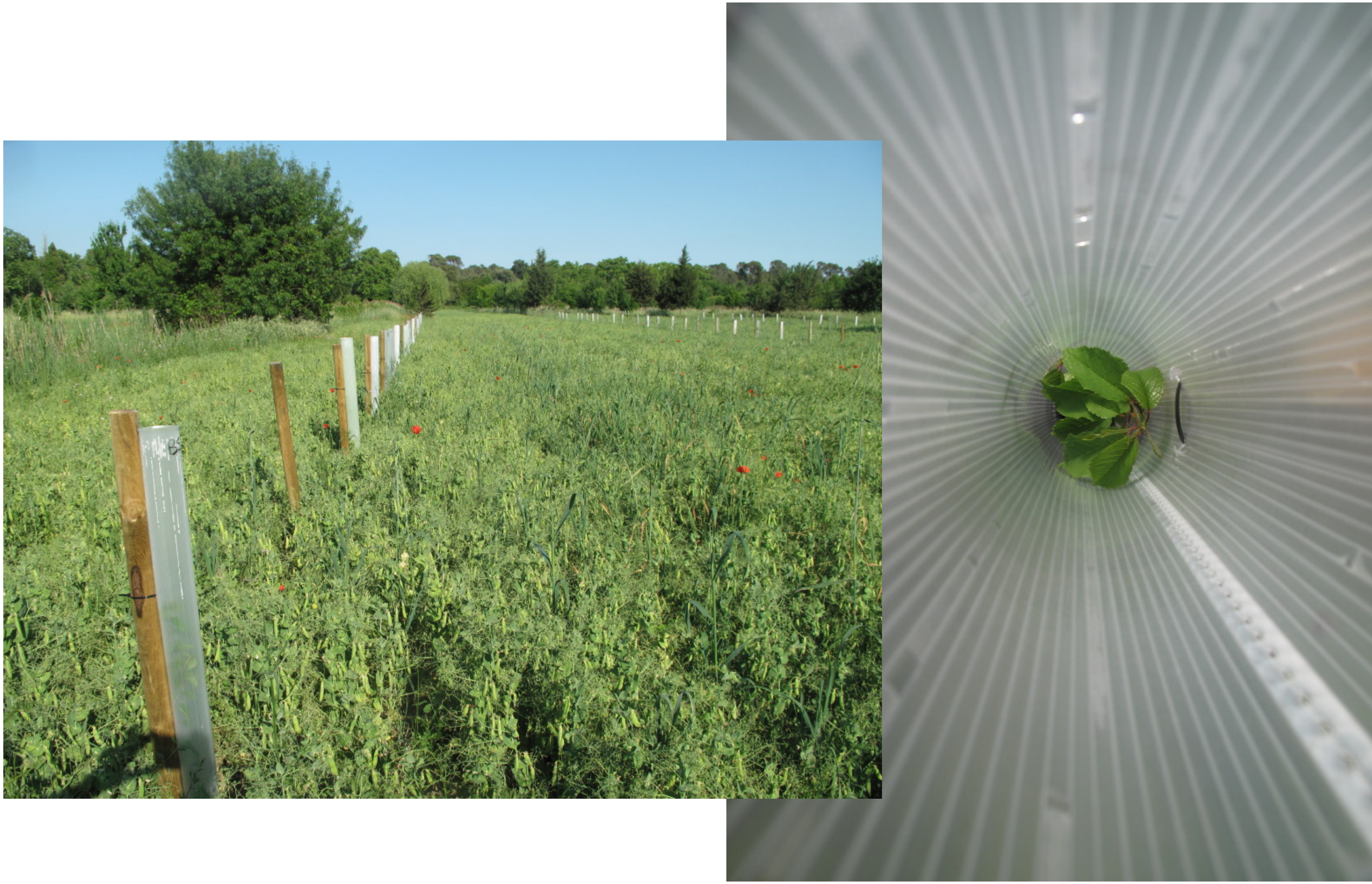


Ventex and red oak



New Beech Shelters





Take home messages

- Early Diameter growth is more important than early height growth
- CO_2 is more important than humidity
- Light is required when CO_2 is available
- Stem movement is the ultimate challenge

Take home message

- Never use unventilated shelters if the tree canopy spends more than 2 growing seasons fully inside the shelter

- With unventilated shelters,
    - the short term positive impact on height growth is deceptive.
    - the long term impact on DBH growth is negative.

Vielen Dank für Ihre Aufmerksamkeit

4th World Congress on Agroforestry

20-25 May 2019

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Montpellier, France

https://agroforestry2019.cirad.fr/

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