ESCOLA DE CIÊNCIAS E TECNOLOGIA
DEPARTAMENTO DE ENGENHARIA RURAL
ISHS
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Climate Management in Unheated Greenhouses

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BioGreenhouse
COST EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY
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Contents

1. Climate control and energy use
2. Trends and solutions for energy efficient greenhouse climate control
3. Final considerations

Greenhouse production areas

Europe - 160 000 ha in 2009 (EC, 2013)

Spain – >50 000 ha

Holland - 10 000 ha

Portugal - 3 000 ha

Turkey - 66 000 ha (27 000 ha tunnels)

Why is the environmental control so important in greenhouse crop production? And in the Mediterranean regions?!

Computed maximum and minimum air temperatures if no climate control actions occur (without heating, ventilation, shadow or cooling). (Baptista et al., 2012)

Location	Maximum Temperature (ºC)	Minimum Temperature (ºC)
Azores	51,8	10,9
Faro	**53,1**	8,0
Madeira	51,4	12,6
Torres Vedras	52,0	7,6
Vila do Conde	51,6	6,6
Almeria	52,7	6,5
Castellon	**53,1**	**3,9**
Coruña	46,2	5,8
Huelva	**53,6**	6,8
Madrid	**53,9**	**0,5**
Navarra	47,9	**1,2**

Plastic covered
Natural ventilation (passive climate control)
Low to moderate investment

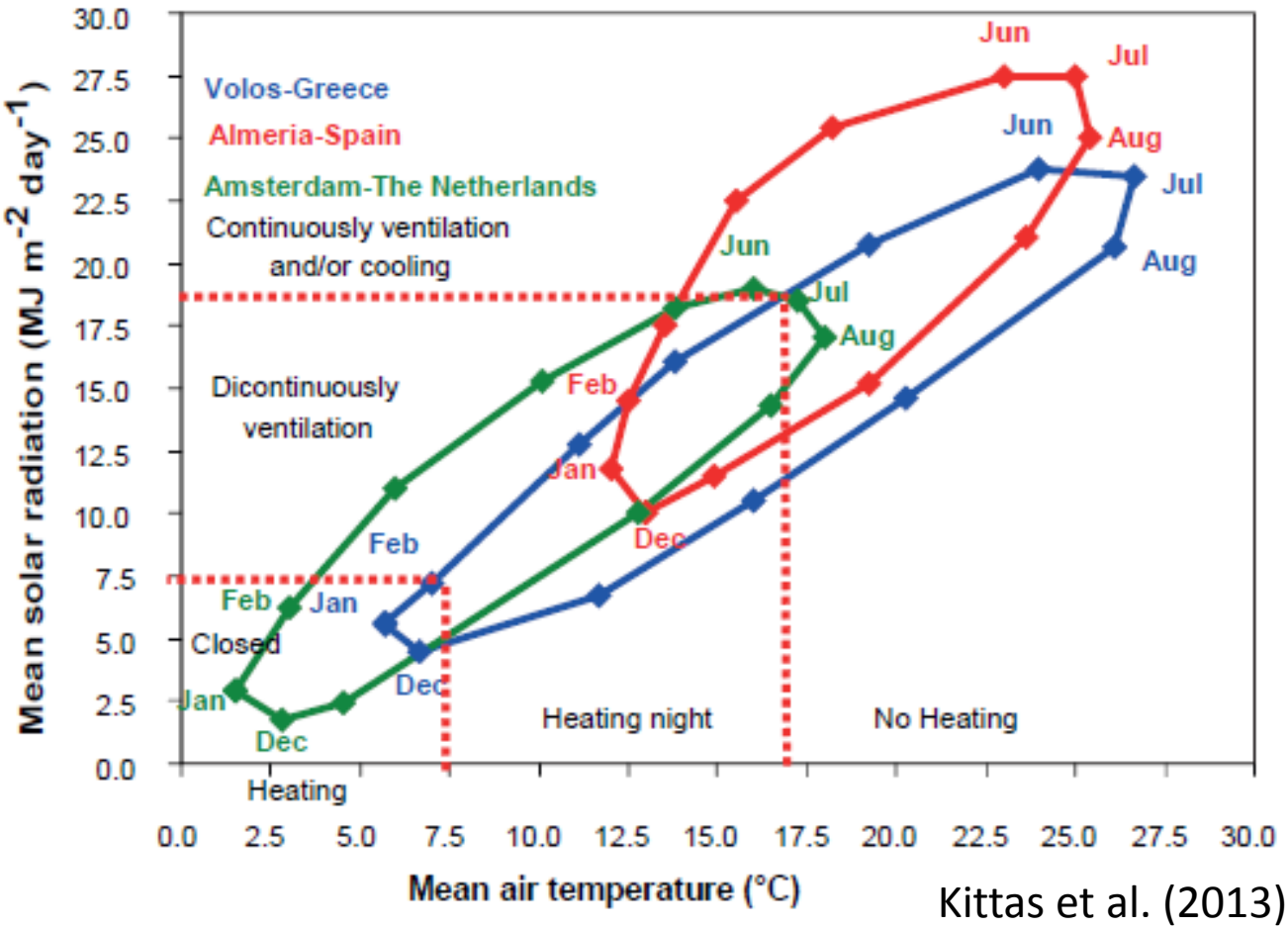
Limited yields (20 kg m^{-2})
Good quality in limited periods
Irregular production

Glass covered
Sophisticated active control systems
High investments

High yields (> 60 kg m^{-2})
Good quality almost year-round
Regular production

FIGURE 1

Mean solar radiation versus mean air temperature for several locations around Europe



Kittas et al. (2013)

Energy consumption in tomato greenhouse production

	Production (t ha^{-1})	Specific energy (GJ t^{-1})	
UK	213	137	Stanhill (1980)
Spain	120	1	Muñoz et al. (2008)
	200	7	Antón et al. (2009)
	165	4	Torrellas et al. (2012)

	Production (t ha^{-1})	Total energy (GJ ha^{-1})	Specific energy (GJ t^{-1})
Greece	160	195	1,22
The Netherlands	640	15289	23,89
Portugal	180	364	2,02

(Baptista et al., 2014)

Nowadays MEDITERRANEAN horticulture is not dependent on fossil fuels for acclimatisation…

HOW CAN ENERGY EFFICIENCY BE IMPROVED?

- **More efficient use of the energy coming from the sun (to produce more)**
- **More efficient use of water**
- **More efficient use of fertilisers**
- **More efficient use of pesticides**
- **…**

New trends and solutions for energy efficient greenhouse climate control

1 - light use

2 - screens

3 - natural ventilation

4 – cooling/heating

Mediterranean growers must increase yield and product quality

improving greenhouse structures

implementing technology for climate control

ADAPT TECHNOLOGY

NOT ADOPT (WITHOUT PREVIOUS TESTING)

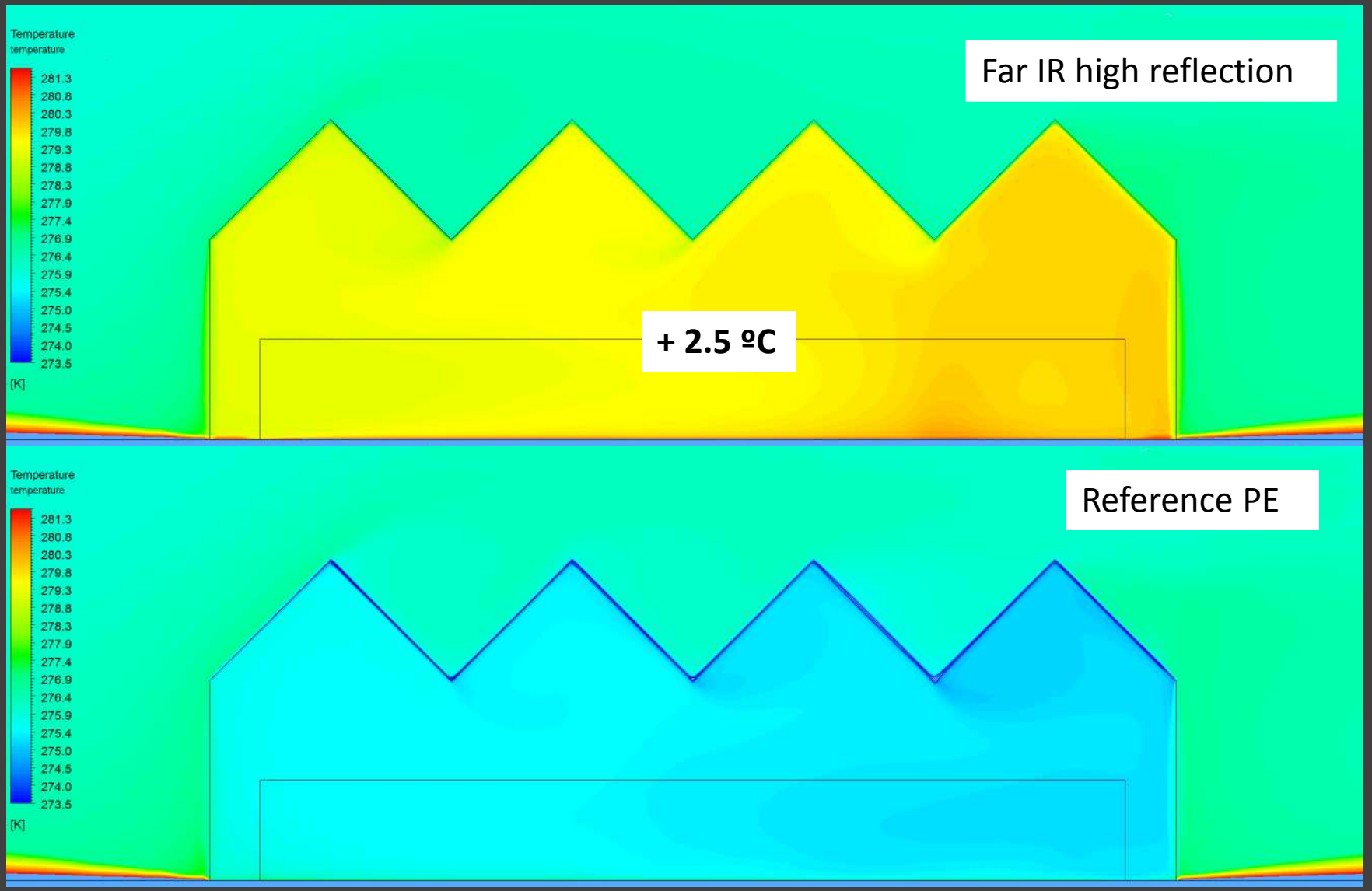
Greenhouse climate control: technological packages

- It is necessary to know, at local level, the crop response (technical and economical) to the climate control improvements and transfer the information to the grower
- According to the local technical and socio-economical conditions, achieving an economic compromise between:
  - Agronomic performances of each "greenhouse techn. Package"
  - Costs
  - Different solutions to obtain proper quality at competitive prices

(Castilla, N.)

1 - Maximize the light (and its quality) entering the greenhouse

- Greenhouse cover with maximum possible transmissivity to PAR radiation
- Materials with high reflection to thermal radiation
- Greenhouse cover with good diffusion and anti-dripping effect
- Use shading and thermal screens wisely
- Optimize greenhouse roof slope and orientation
- Change and clean the plastic in the right moment



Piscia et al. (2013)

2 - Screens


Kittas et al. (2013)

Thermal screens

- High air and crop nocturnal temperature
- Reduction of infiltration (humidity increase – diseases)
- Savings 35-40% energy (Kittas et al., 2013)
- Shading screens during day period

3 – Natural Ventilation

↳ main environmental control technique in Mediterranean regions (low cost and maintenance)

↳ temperature and humidity control

↳ prevent CO_2 depletion (370 ppm)

↳ if mean t_{out} < 27ºC ventilation is enough for temperature control (Kittas et al., 2013)

↳ Summer/winter; day/night

Natural Ventilation

- lateral openings
- roof openings
- Lateral and roof openings


Stanghellini, C.


Valera et al. (2014)


Valera et al. (2014)

↳ dependant on outside climate conditions, geometry and location - complex study but with great advances in last years

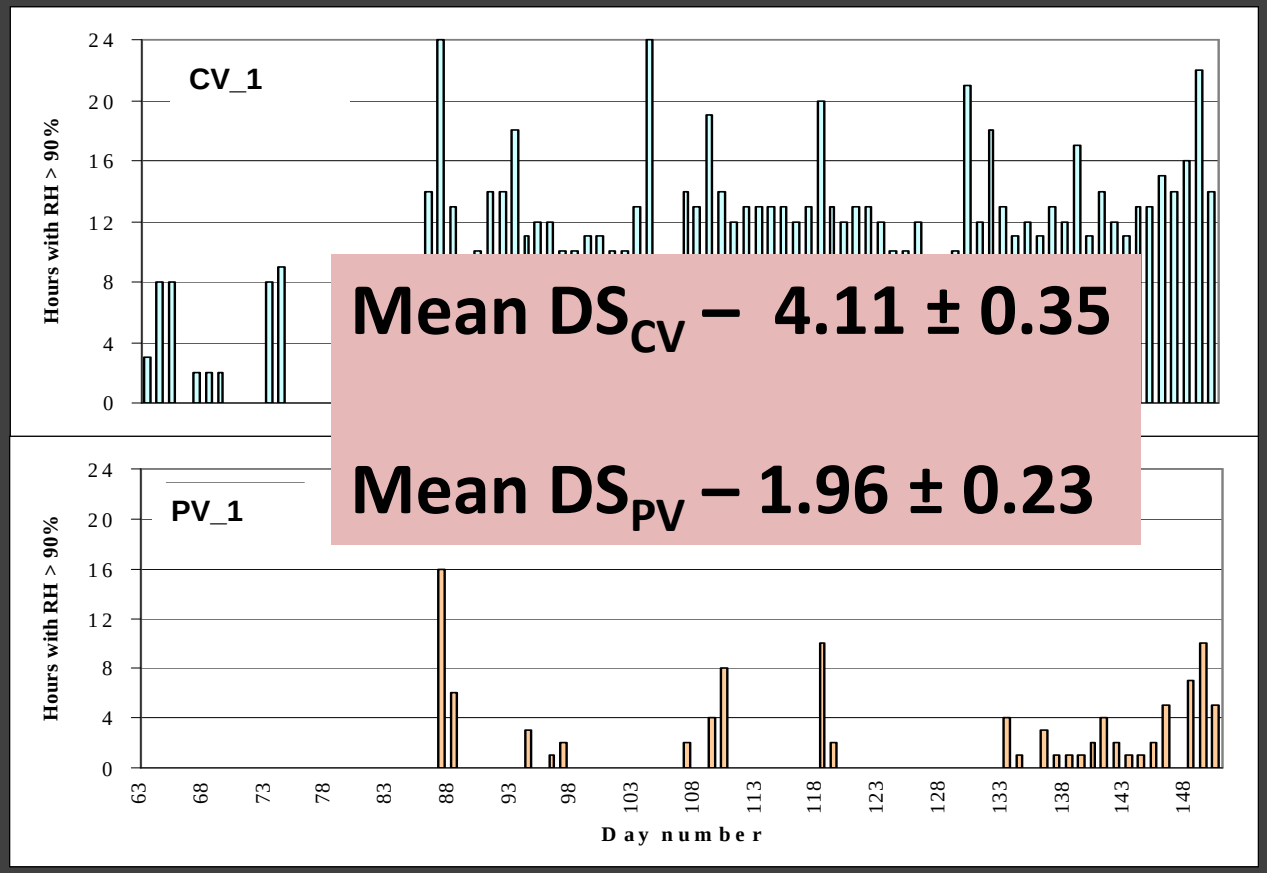
↳ recent research works, used CFD tools provided some of the key factors required for building a highly efficient natural ventilation design

- ↳ Maximum greenhouse volume
- ↳ Maximum ventilator area
- ↳ Increase the slope of the span

Nocturnal or permanent ventilation

Number of hours per day with relative humidity higher than 90%

(Baptista, 2007)



Mean DS_{CV} – 4.11 ± 0.35

Mean DS_{PV} – 1.96 ± 0.23

CV_1 – 904 h

PV_1 – 104 h

CV_2 – 1052 h

PV_2 – 832 h

Mean temperature (ºC) for day, night and 24 h periods (Baptista, 2007)

		Day	Night	24 h
Year 1	CV	21.7±0.3	13.2±0.3	16.3±0.2
	PV	21.9±0.3	13.3±0.2	16.5±0.2
Year 2	CV	22.5±0.4	14.3±0.3	17.1±0.3
	PV	22.6±0.4	14.1±0.3	17.0±0.3

Significant differences $P < 0.05$, mean ± standard error

Recommendations to growers

RH > 90% for more than 9 h per day - HIGH RISK

prophylactic measures should be used (increase ventilation, cultural measures, crop protections meaan)

RH > 90% for periods between 4 and 9 h per day – MODERATE RISK

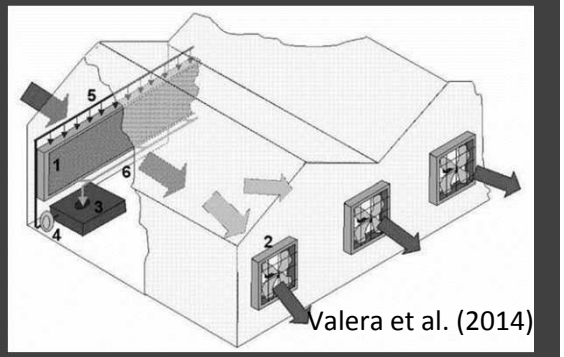
increasing ventilation should be enough to reduce relative humidity, depending on the outside conditions

RH > 90% for less than 4 h per day or RH < 90% - LOW RISK

no action needed

4 – Cooling and Heating

Cooling



Valera et al. (2014)

↳ if tout > 27-28 ºC usually cooling is required (Kittas et al., 2013)

↳ evaporative cooling

↳ pad and fan (low uniformity, temp. difference at 8ºC) (Valera et al., 2014)

↳ fog systems (more uniform conditions and does not need mechanical ventilation)


Kittas et al. (2013)

Demands high volume of quality water

Heating

- extend production period
- anticipate harvesting
- production out of season
- increase productivity and quality

- if t_{out} < 10ºC usually heating is required, mainly during the night (Kittas et al, 2013)

- select systems that works with different energy sources
- natural gas *versus* diesel
- renewable energies (biomass, biogas, …)

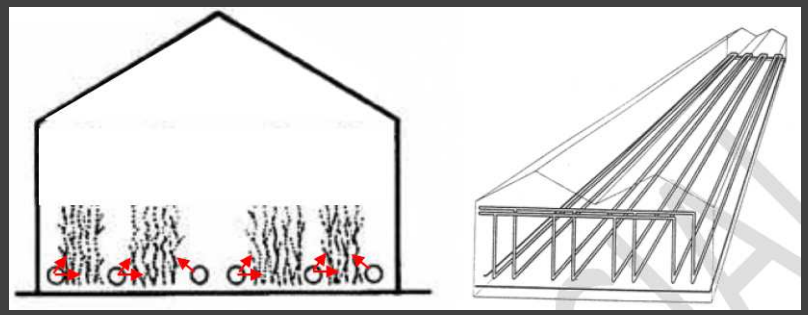
Evaluation of biomass heater with PE tubes for hot air distribution

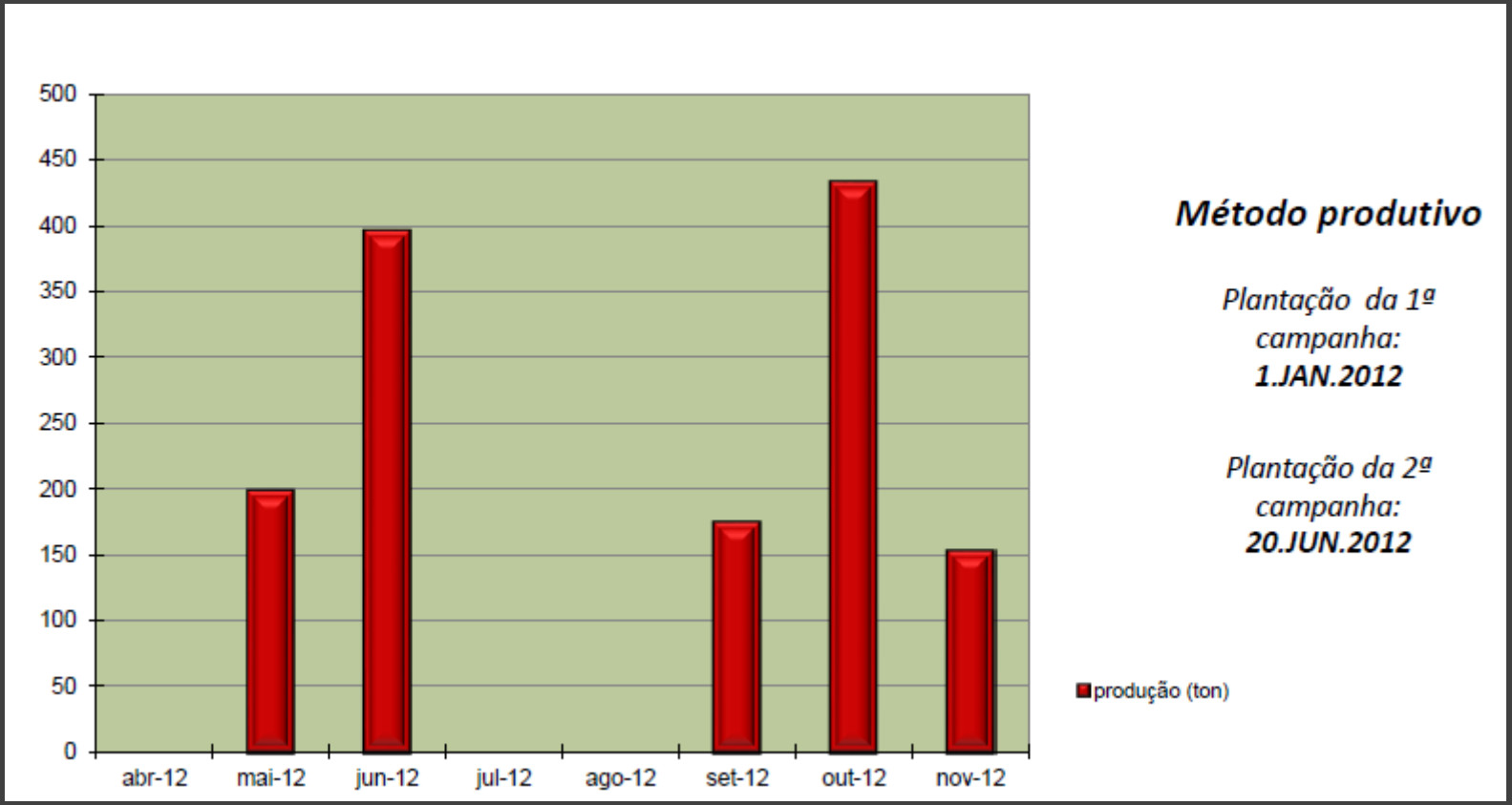
Paulo Maria, Ricardo Vicente, Sofia Rodrigues, Fátima Baptista,

Domingos Almeida, Joaquim Cantandeiro, Rui Vicente

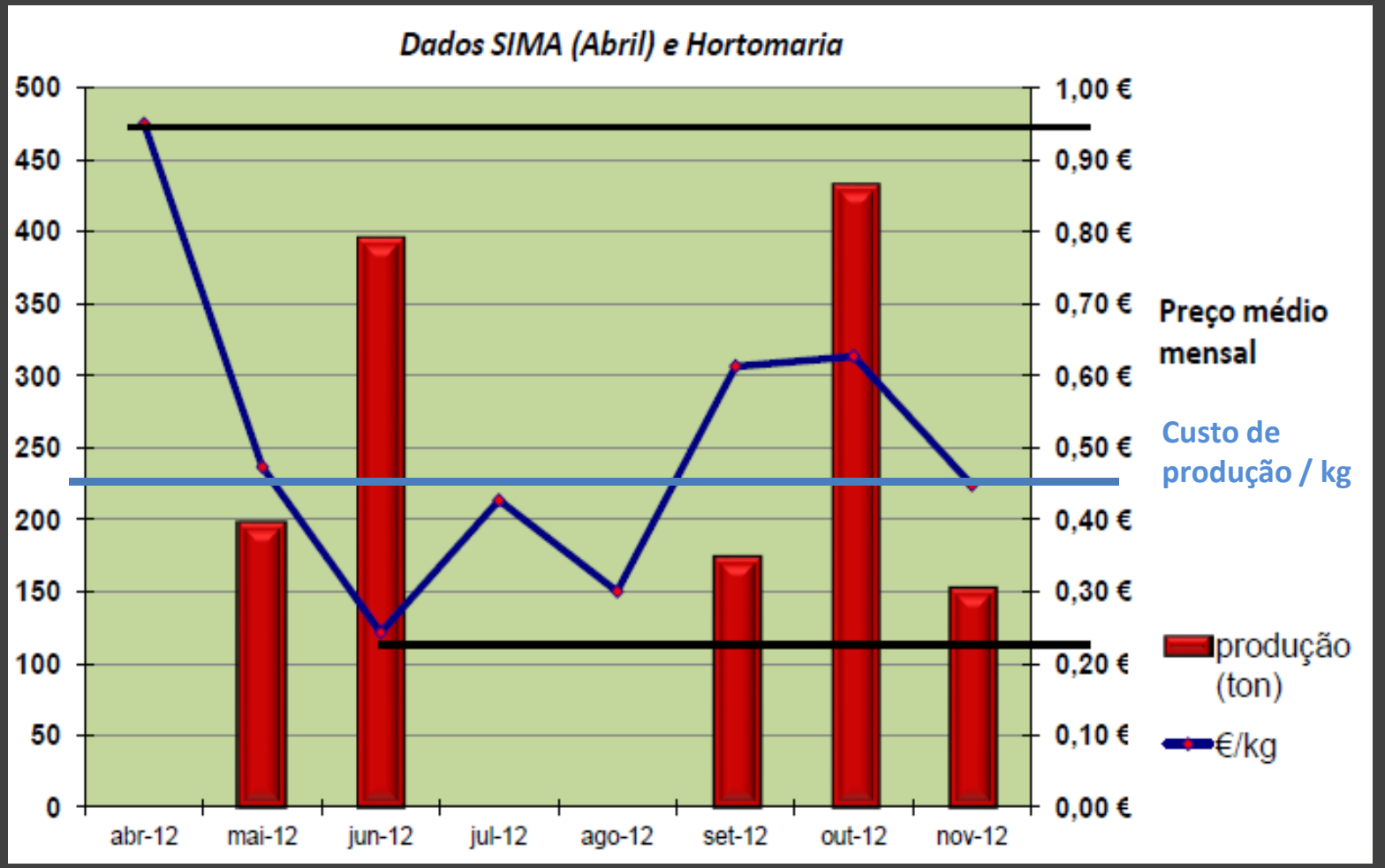
Main objectives:

- anticipate harvesting
- selling in periods with higher market prices





Paulo Maria (2015)

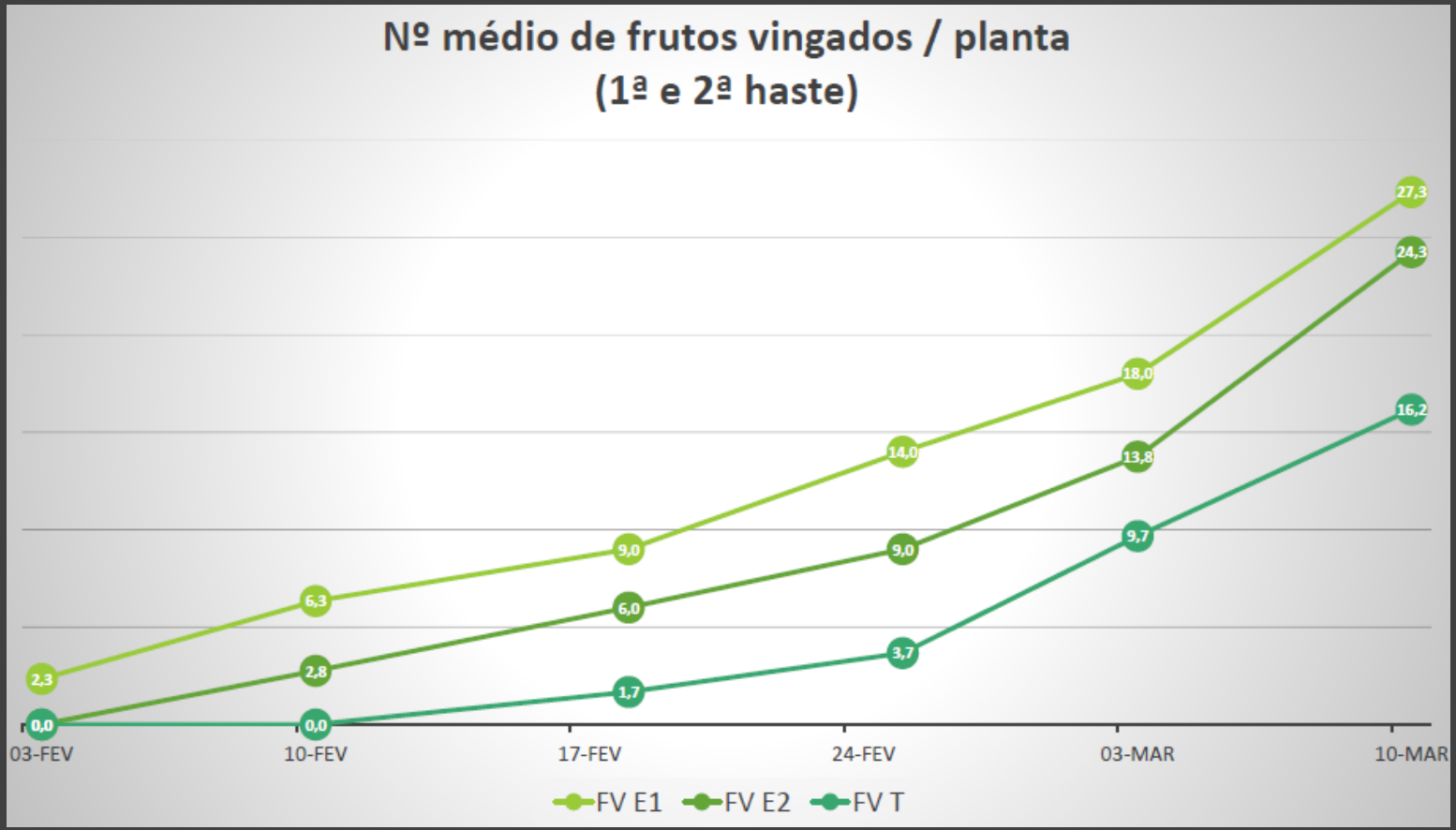


Paulo Maria (2015)

Heating versus no heating

27 January

10 March



Vicente (2915)

↳ Important questions:

1. Which is the ideal plantation date in order to optimise the heating system?
2. Which are the most adapted varieties?
3. What is the best relation plant density, line number, plants height?
4. Which are the necessary adjustments to optimise fertigation system?
5. What is the total production? How many does the production increased?
6. Does quality improved (colour, aroma, flavour, size…)? Which? How much?
7. Does high price compensate cost increase?

….

Final Considerations

- ✓ **Mediterranean greenhouse horticulture shows low dependency on fossil energy;**
- ✓ **Mediterranean growers, in order to stay competitive, must improve their productivity and quality and must be more stable in longer growing cycles;**
- ✓ **Research efforts must be undertaken on designing more efficient greenhouse structures with innovative covering materials, more efficient natural ventilation systems, better management and control.**

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