Requirements for greenhouse coverings - latest developments and research

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Wageningen UR Greenhouse Horticulture







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Requirements

- Covering materials for horticultural applications:
  - High light transmission
  - Optimum light spectrum
  - Optimum heat input - low heat losses
  - Optimum condensation behaviour
  - High mechanical resistance
  - Low sensitivity to ageing (UV, temperatures, chemicals)
  - Fabrication sizes
  - Costs

General



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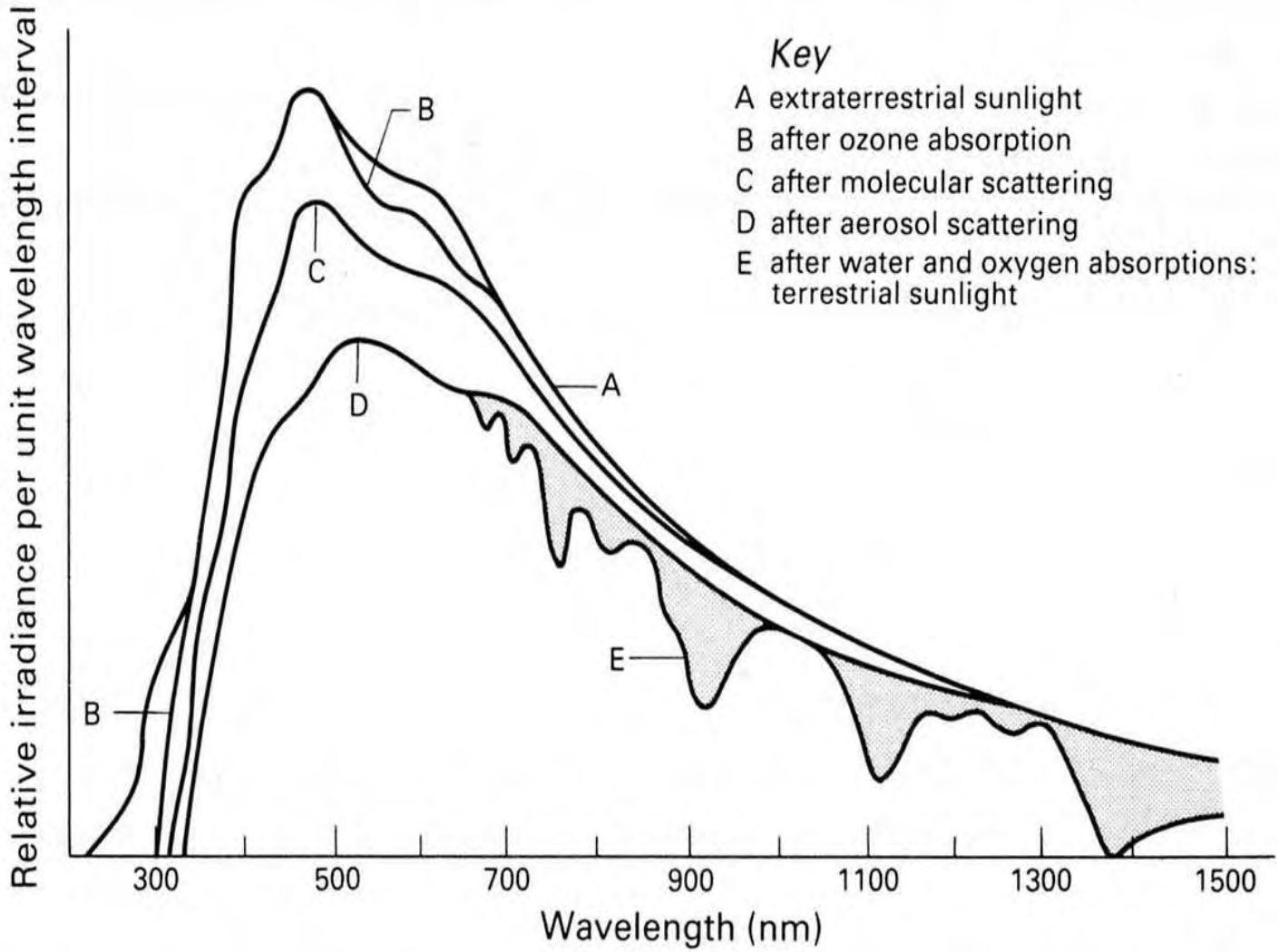
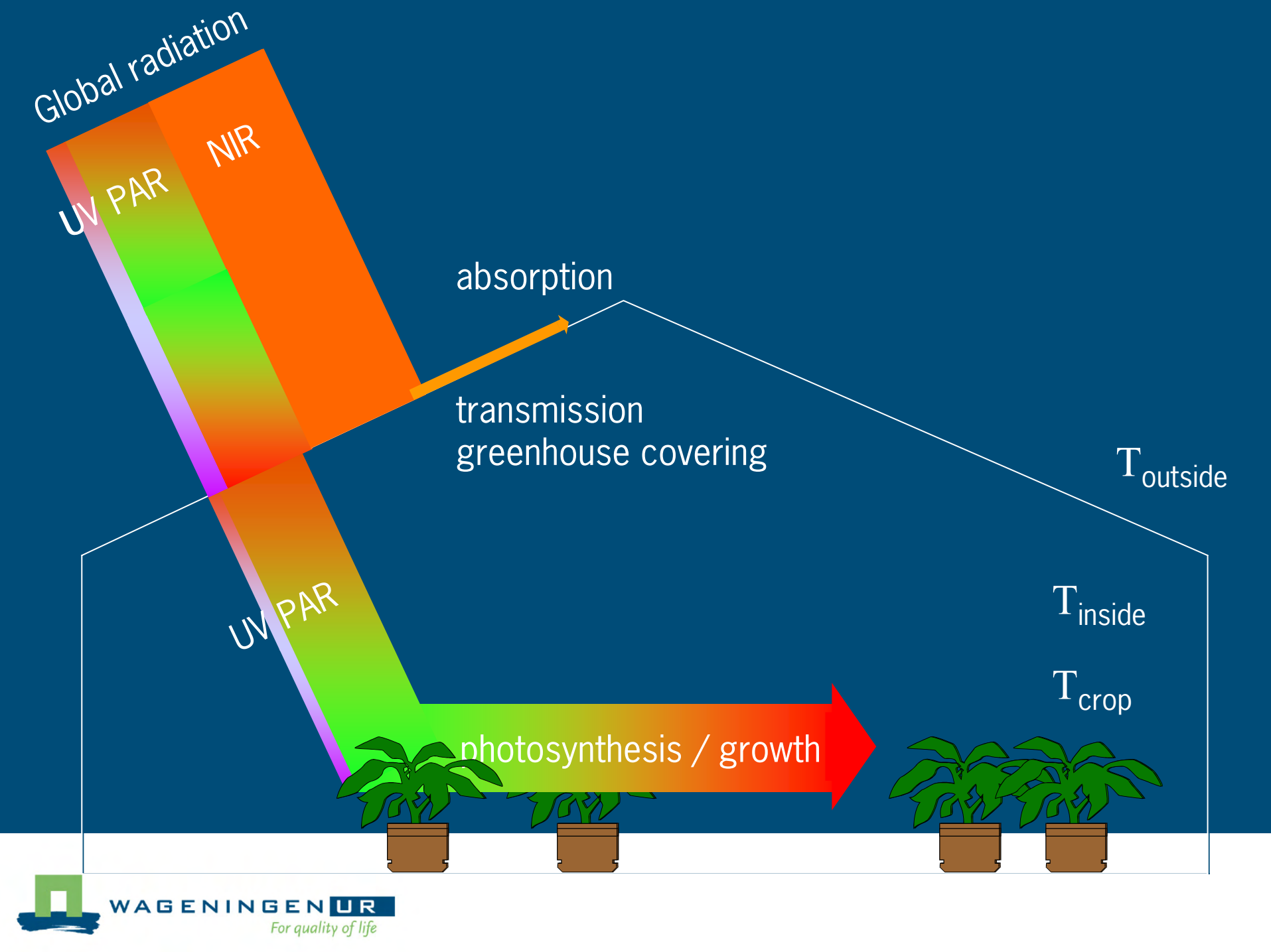
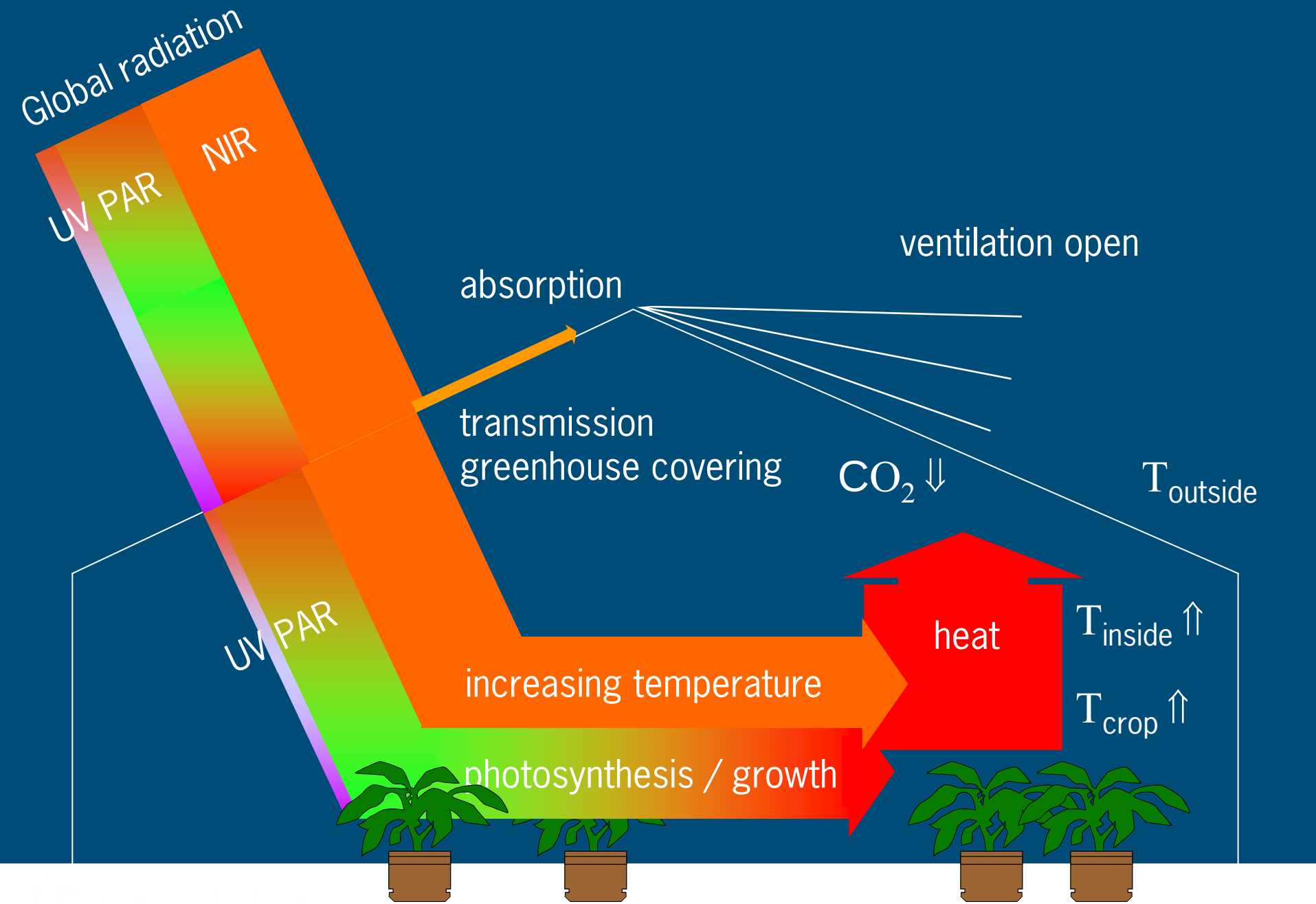


Figure 3.1 The spectrum of sunlight, progressively modified by various processes as it penetrates the atmosphere.


Global radiation
NIR
UV PAR
absorption
transmission
greenhouse covering
T outside
UV PAR
T inside
T crop
photosynthesis / growth



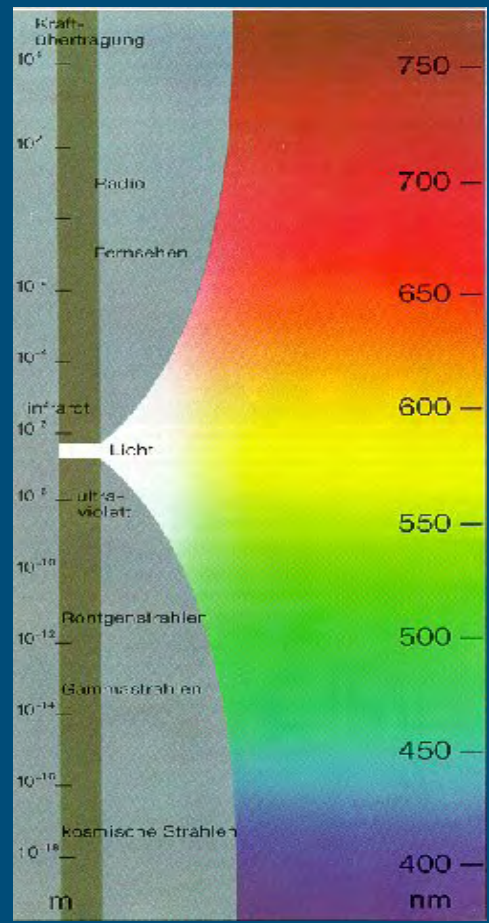
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General

Solar radiation (300-2500nm), energy input greenhouse

Relevant for horitcultural applications

UV	300-400 nm	morphogenesis
PAR	400-700 nm	photosynthesis, morphogensis
FR	700-800 nm	morphogenesis
NIR	800-2500 nm	*increasing greenhouse temperature*
FIR	2.5-100 µm	*heat radiation*



Philips

Heat radiation, energy loss greenhouse

Light quantity



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Light quantity

Light transmission <<50%



Tropics



Spain

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Light quantity

Light transmission >75%



The Netherlands

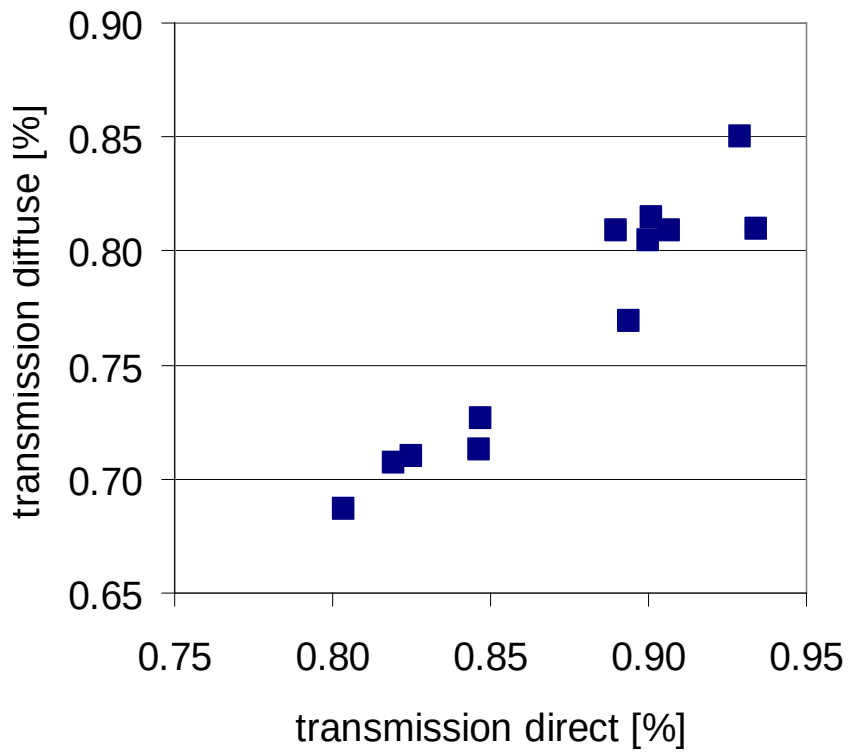


Spain

Light quantity

- PAR transmission different materials

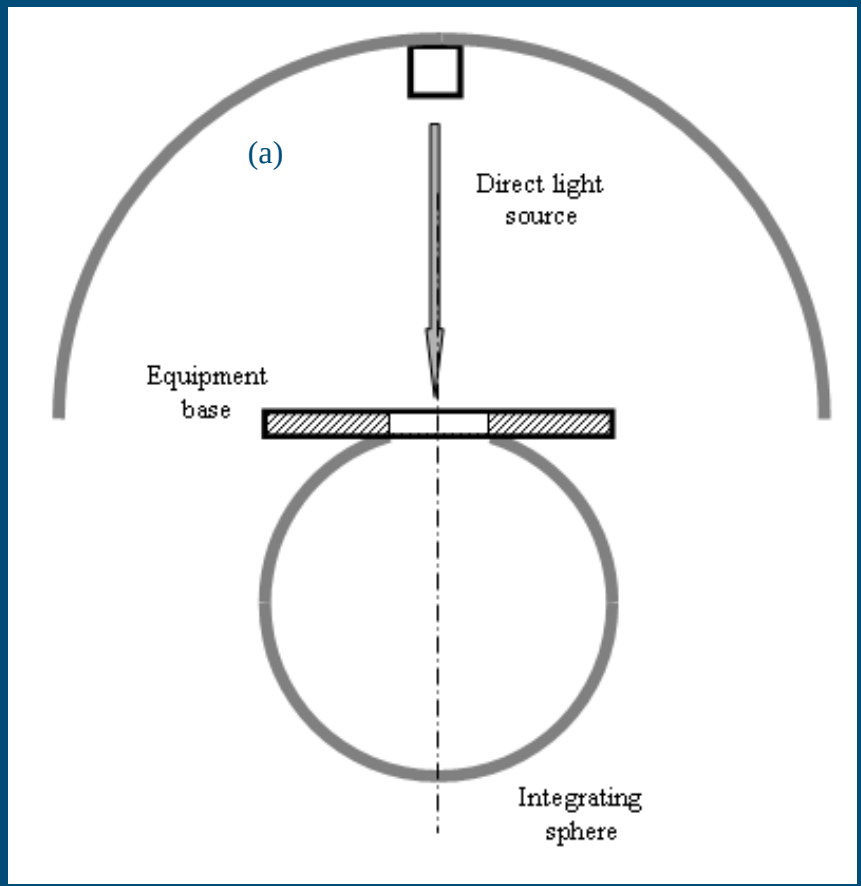
Material	*perpendicular*	*diffuse*
FVG PE-EVA-film Sun Eva 5 Plus	89.0%	80.9%
FVG PE-EVA film Sun Saver 5 Pro	89.4%	76.9%
FVG PE-film FVG Kupfer 5.10	82.0%	70.7%
Plastika Kritis PE-EVA-film TUV 3946	90.1%	81.5%
Plastika Kritis PE-EVA-film TUV 3945	84.7%	72.6%
Plastika Kritis PE-EVA-film TUV 3999	84.7%	71.3%
Plastika Kritis PE-EVA-film TUV 3973	80.3%	68.7%
Plastika Kritis PE-film UV 2794	90.0%	80.5%
Pati EVA-film Patilite E	82.5%	71.0%
Pati EVA-film Patilux LD	90.6%	80.9%
Asahi ETFE Film F-Clean Clear	92.9%	85.0%
Asahi ETFE Film F-Clean Diffuse	93.4%	81.0%

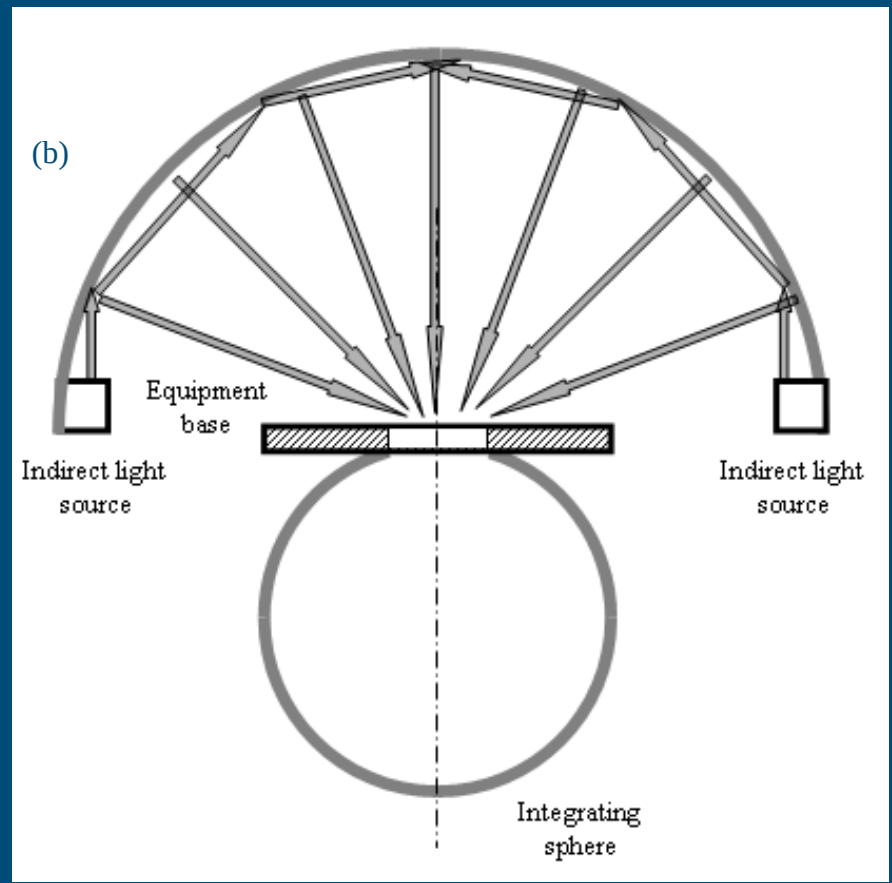


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Light measurement

Measure hemispherical light





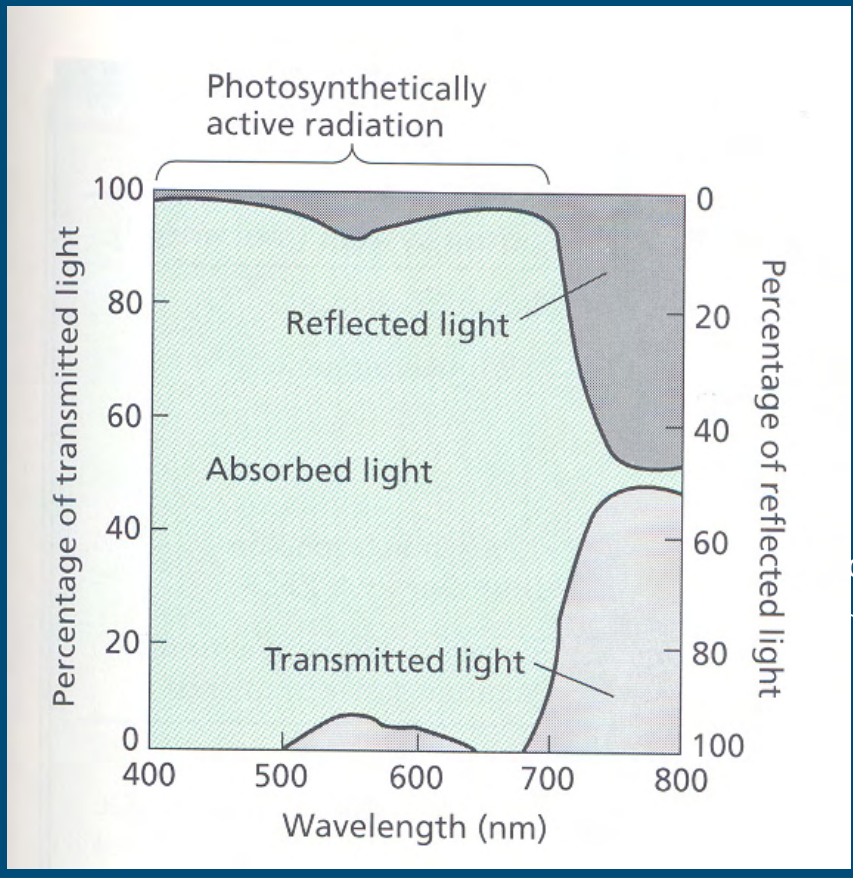
Light quality



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Light quality

- Absorption, reflection, transmission by a leave

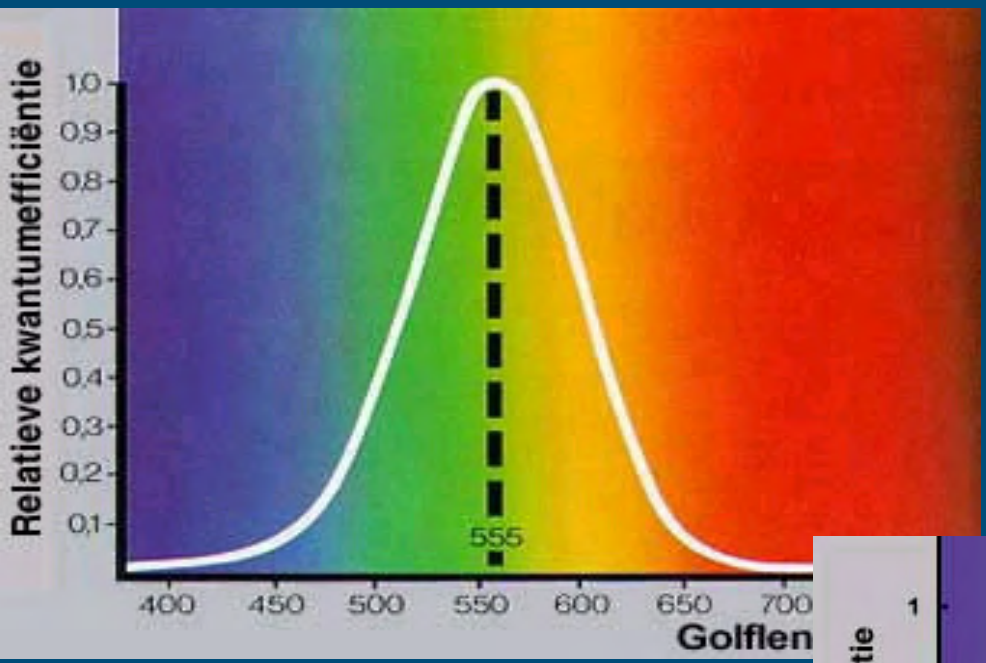


Taiz en Zeiger, 1998

Photosynthesis

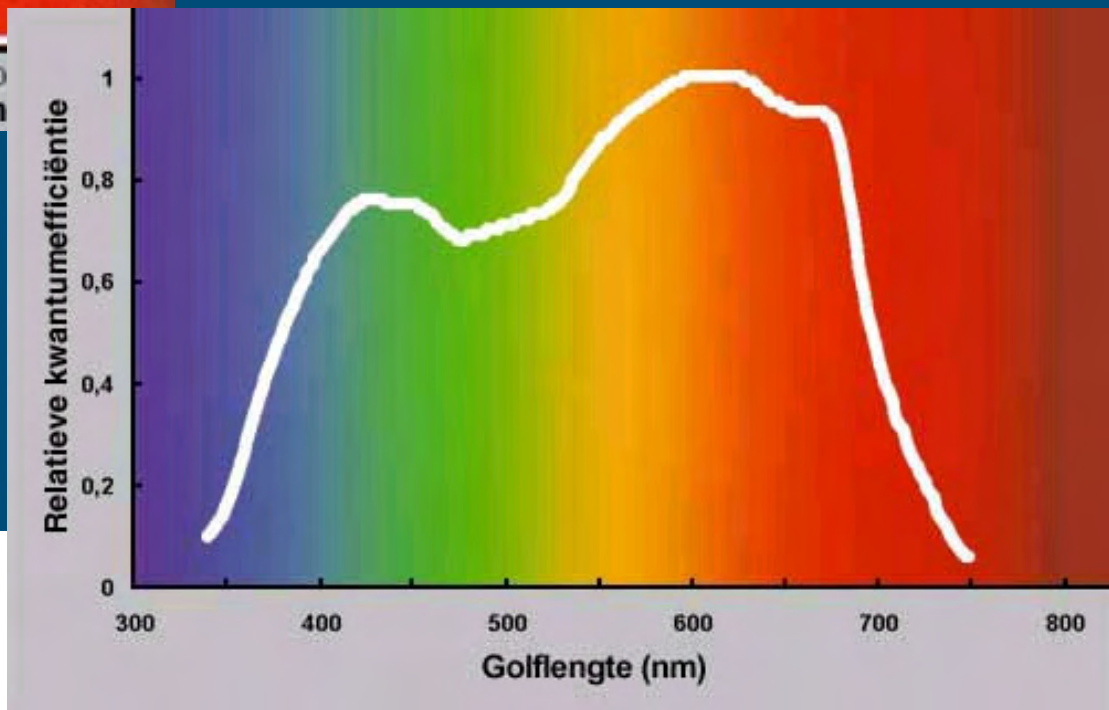
- 400-700nm photosynthetic active radiation
- Lightreceptors: chlorophyl, carotinoids
  - Plants use theoretically all colours for photosynthesis
  - Most plants use red light (≈650nm) and blue light (≈ 450nm) more efficiently
  - Plants adapt to colours during growth

Photosynthesis



Sensitivity of
human eye
= visible light 380-780nm

Sensitivity of
'all' plants
= PAR 400-700nm



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Morphogenesis

- 300-800nm
- Specific lightreceptors for UVB, UVA, Blue and Red:Far-red
  - Elongation
  - Side shoots
  - Leaf area and leaf thickness
  - Flowering
  - Colour of flowers and leaves
  - Germination

Morphogenesis

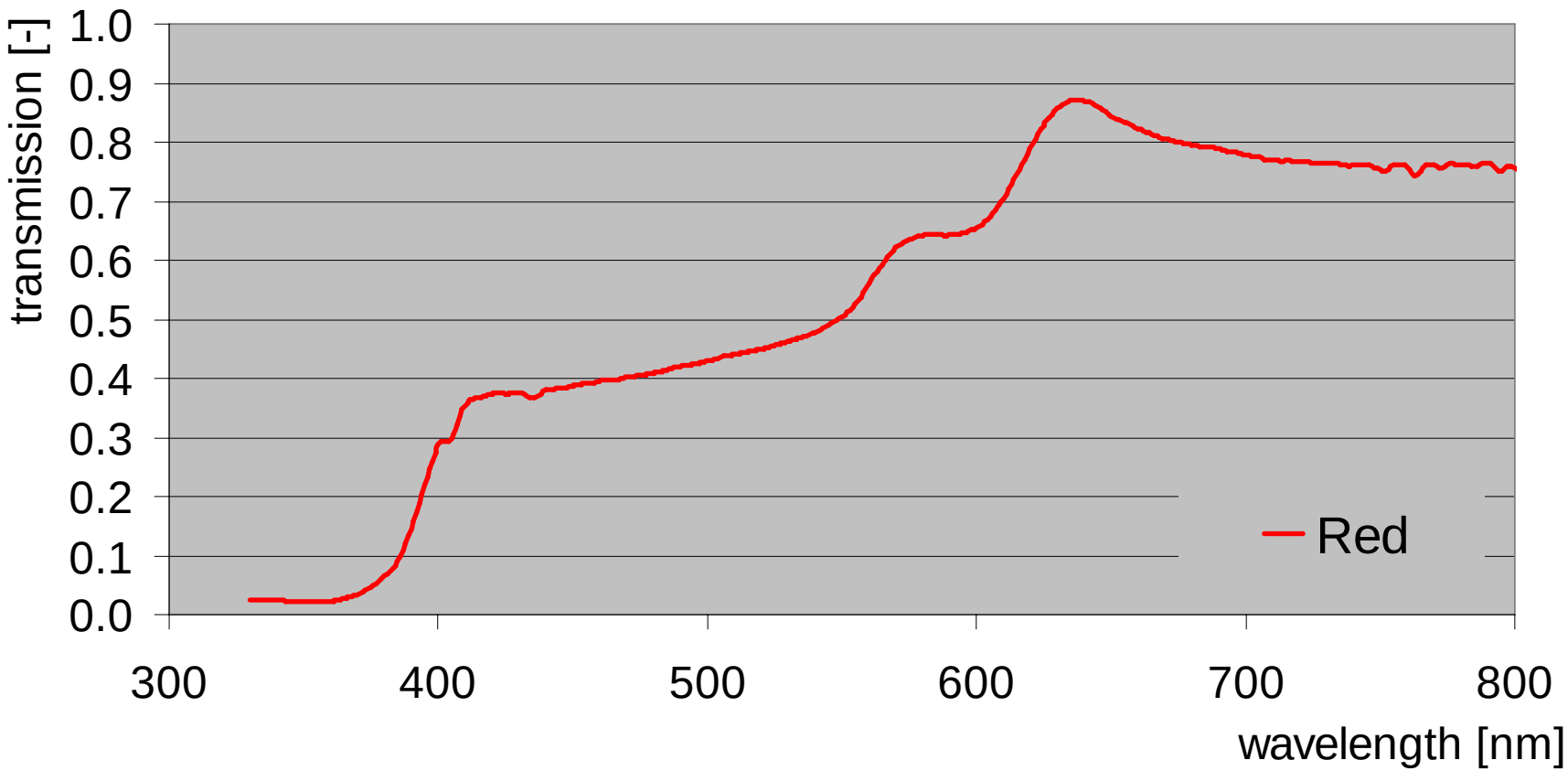
- More blue
  - shorter stems
  - smaller and thicker leaves
  - more side shoots
- Less blue
  - more leave area
  - higher light interception
  - faster growth / production
- More red / less far-red
  - shorter stems
  - more side-shoots
  - Without far-red reduced / no flowering







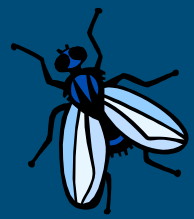
Materials – light spectrum



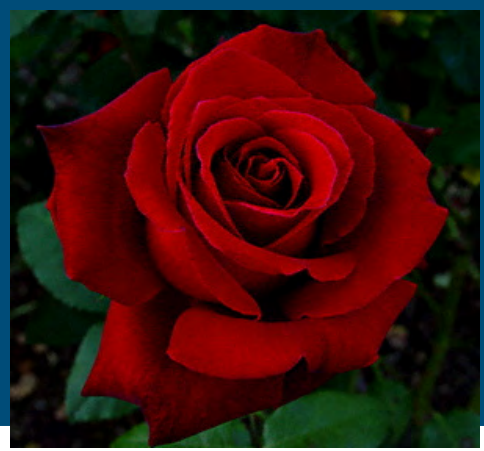
Spectrum changes are often combined with light reductions

Light quality

- Use UV-block films:
  - Dark red roses
  - Young plants
  - Leaf vegetable crops (salad etc.) – faster growth





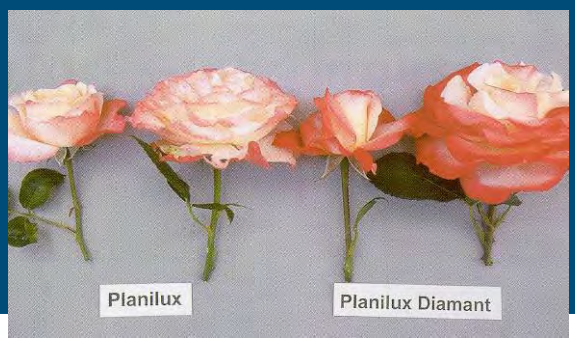




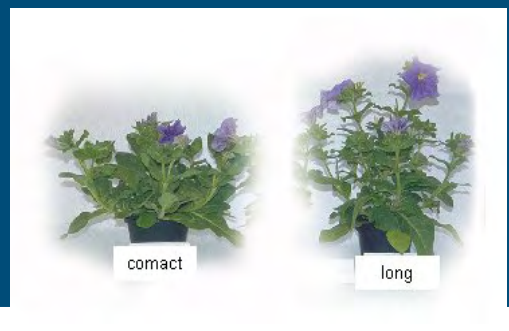
Light quality

- Use UV-transparent films for
  - plants which need hardening;
  - plants, which need UV for their colour (salad “lollo rosso”, aubergines, some flowers or flowering potplants);
  - plants, who need to grow compact (bedding plants, some potplants)
  - greenhouses where (bumble-) bees are needed!



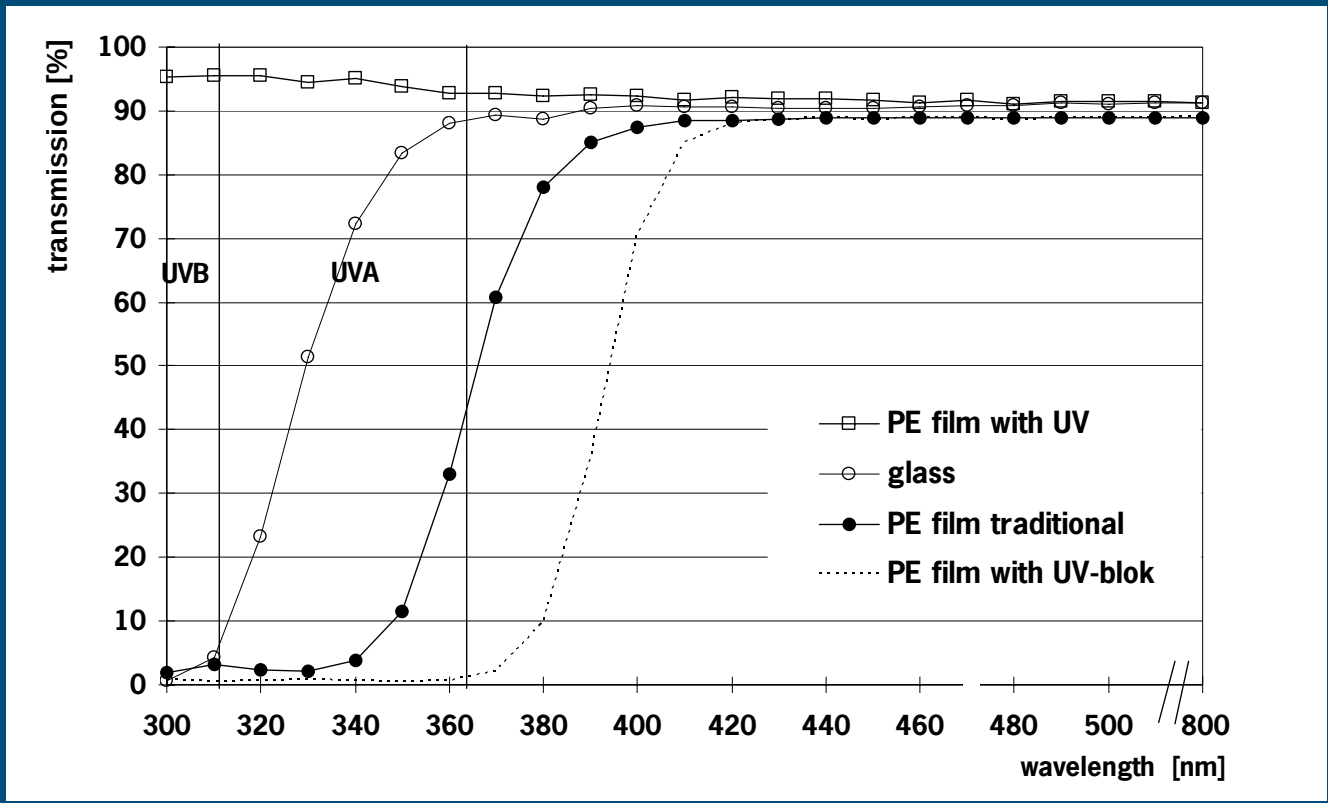






Light quality

- UV transmission of different materials



Light diffusion



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Light diffusion





- Vertical light distribution
  - Most light intercepted by upper leaves
  - Lower leaves contribute less to photosynthesis

Light diffusion

Greenhouse covering materials are able to scatter light rays, transforming direct light into diffuse light



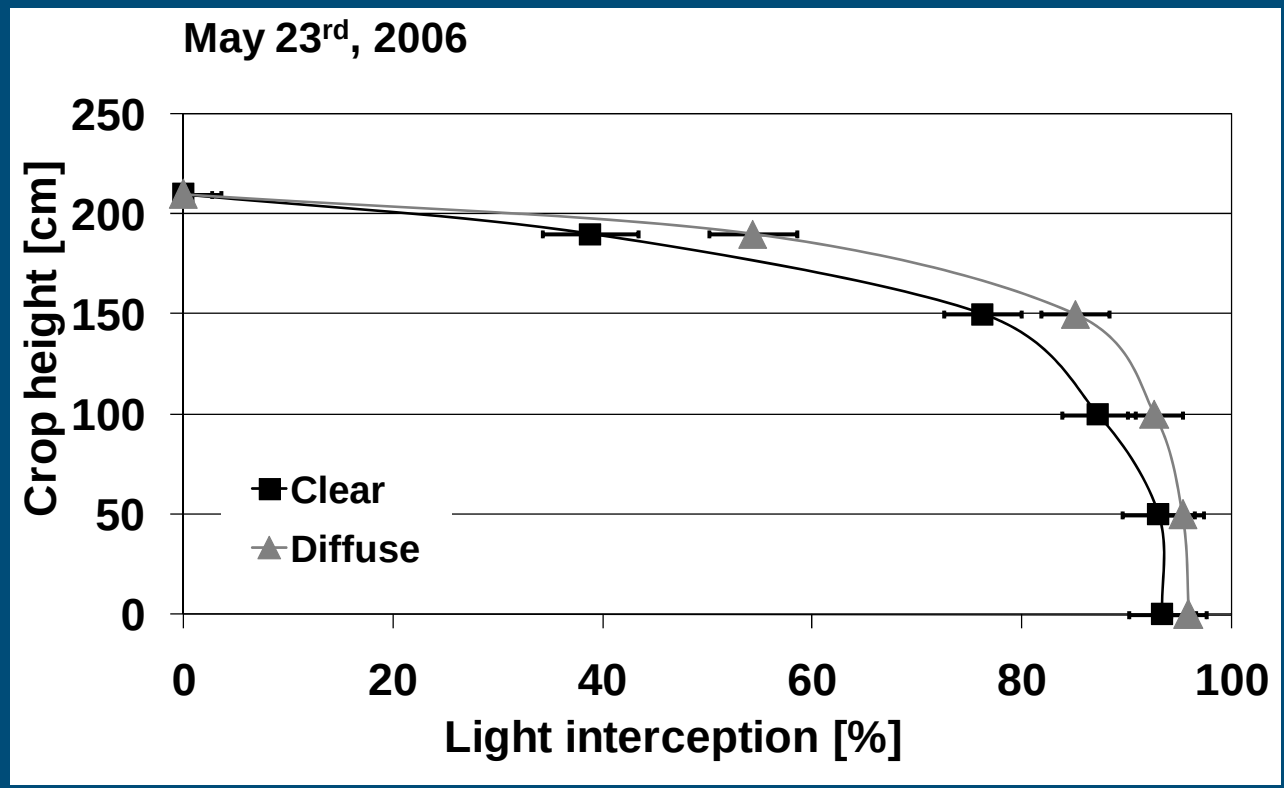


50% 0%

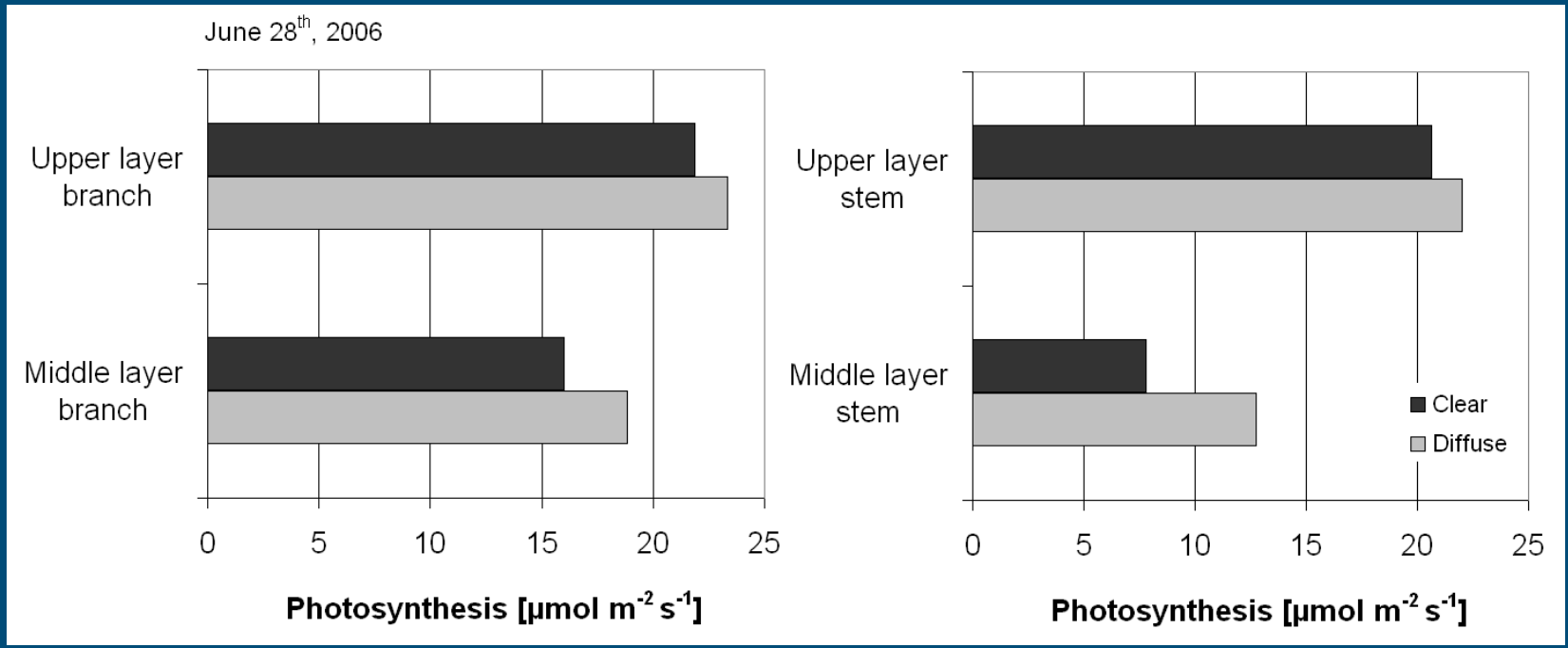
Haze

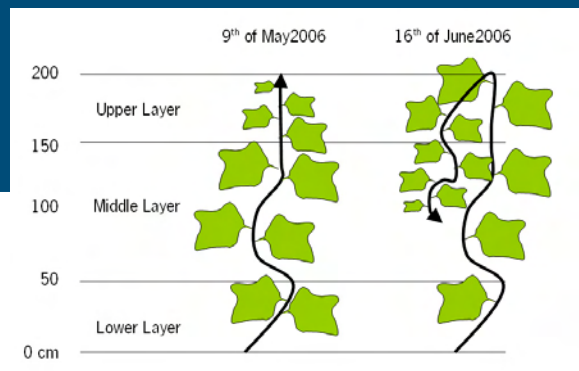
Light interception cucumber





Photosynthesis cucumber



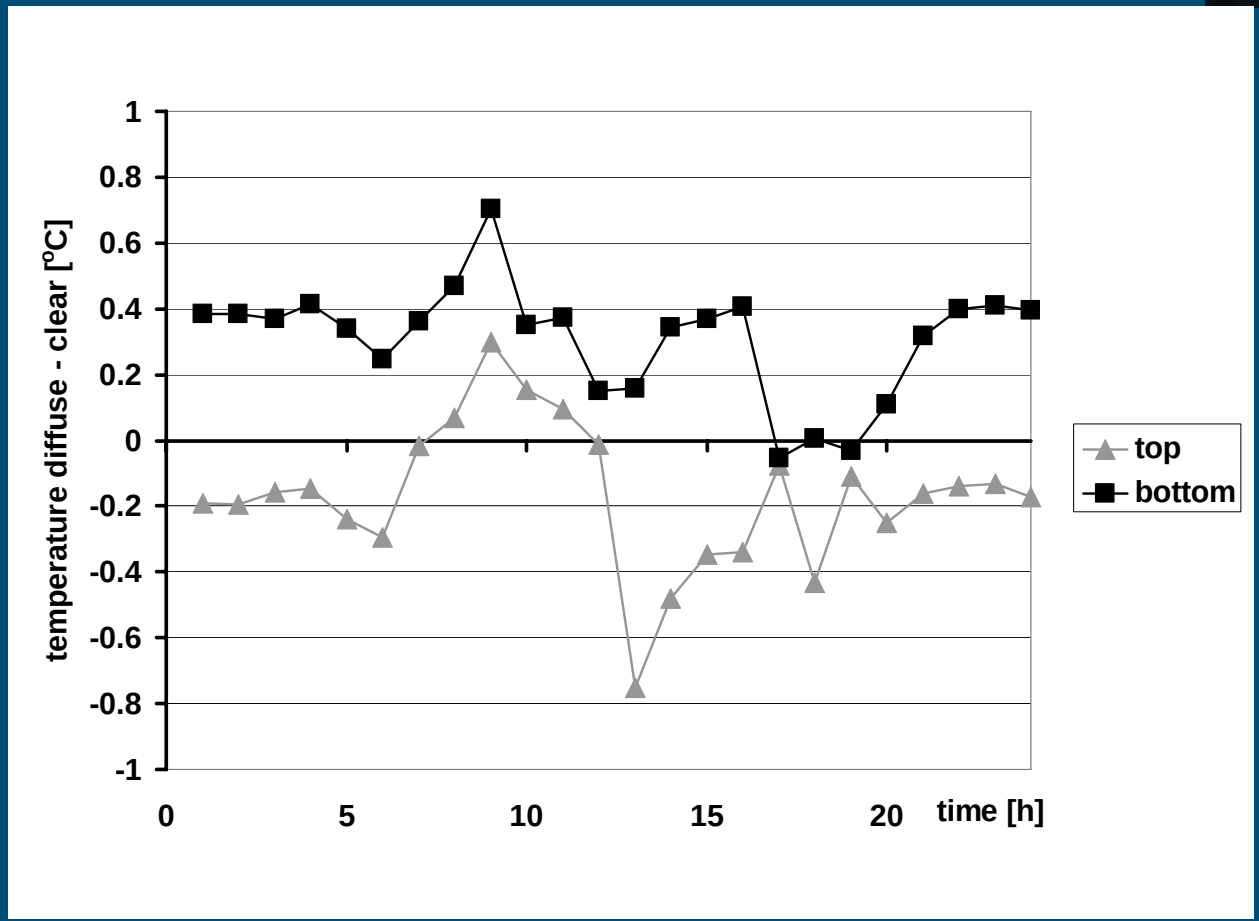




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Crop temperature

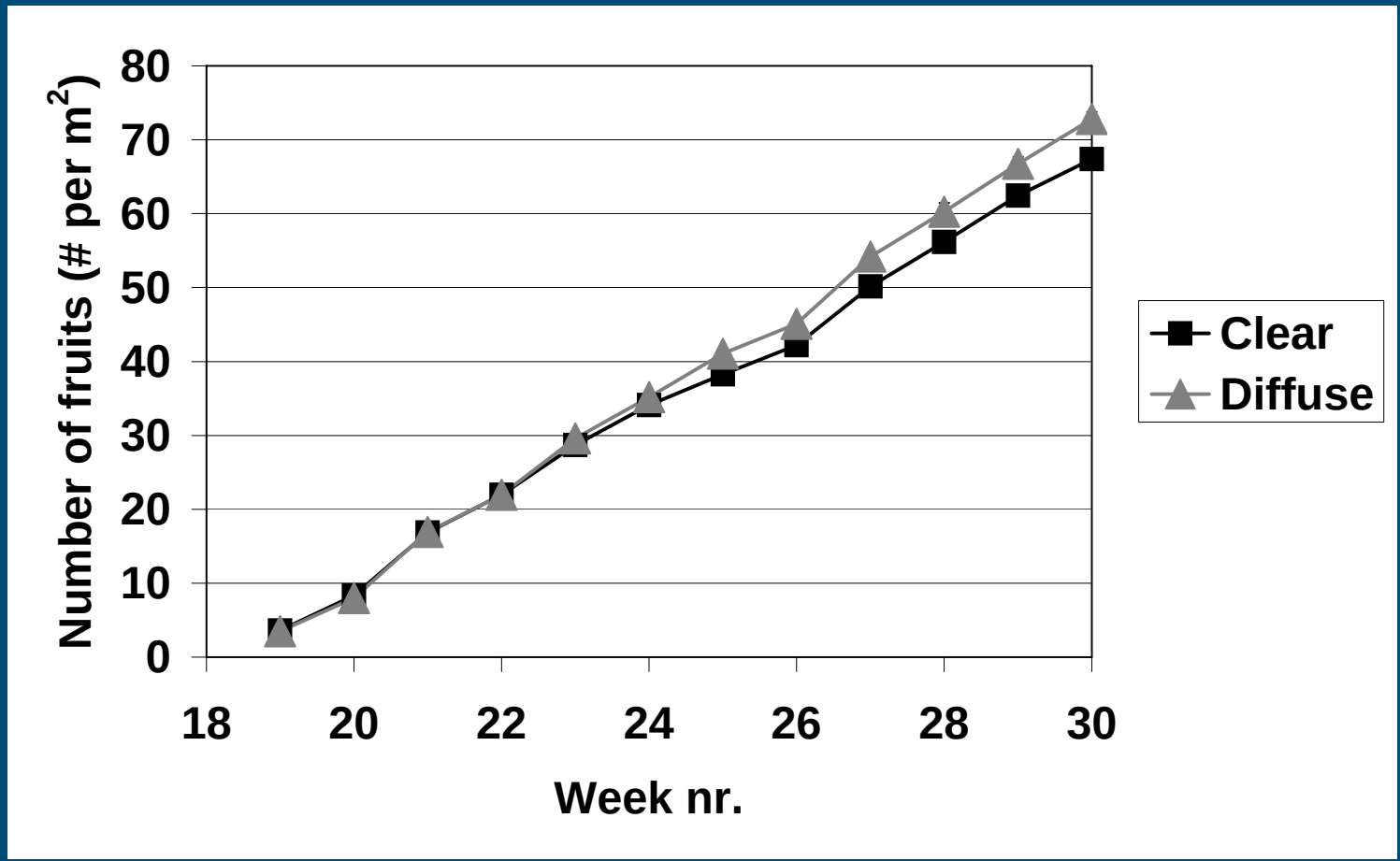




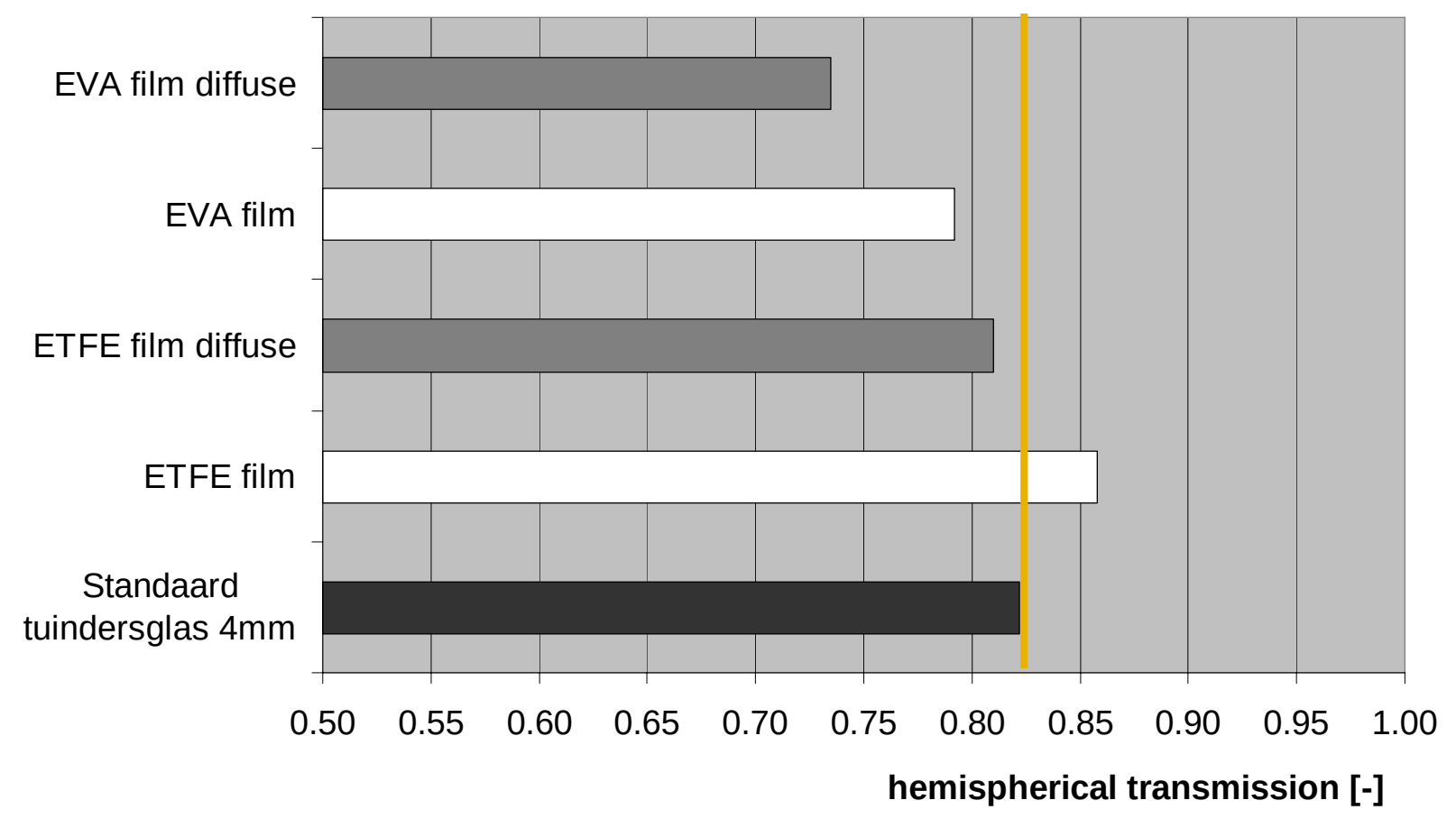
Yield cucumber

7.8% more fruits

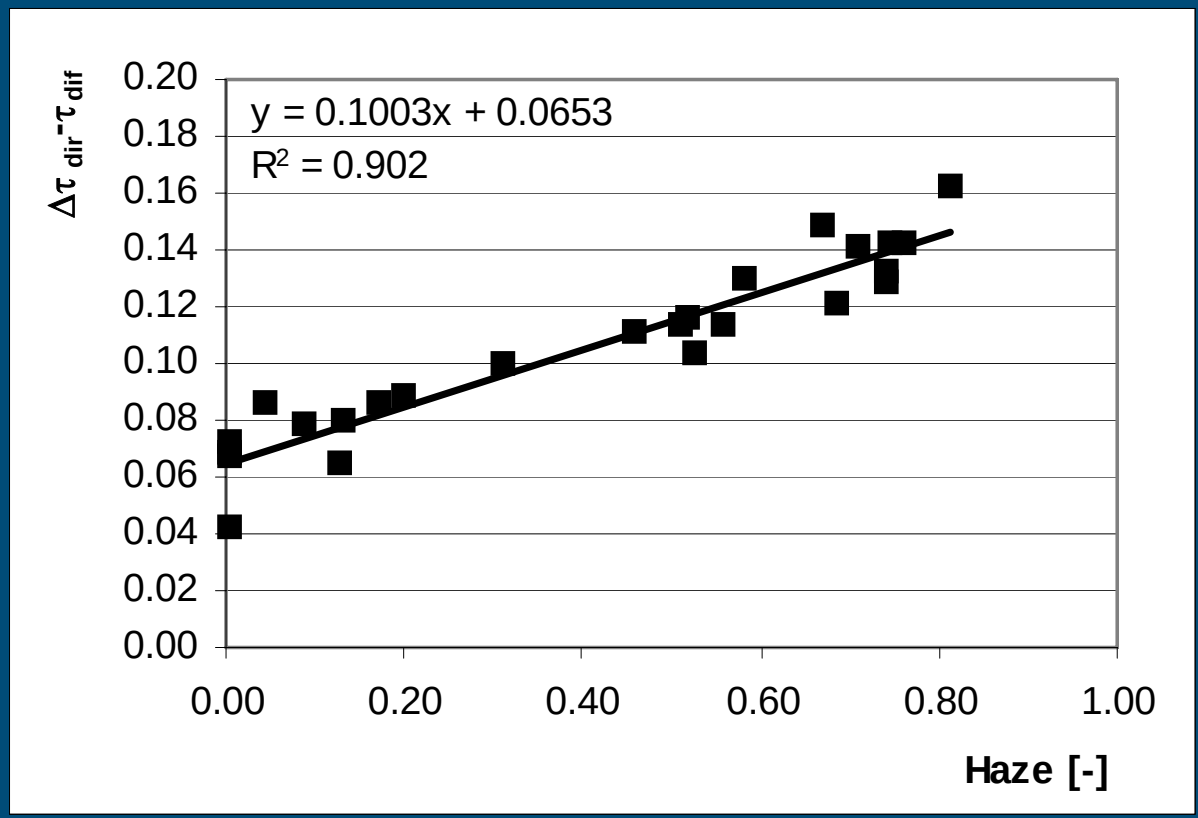
4.3% more fruit weight



Materials – haze and light transmission



Materials

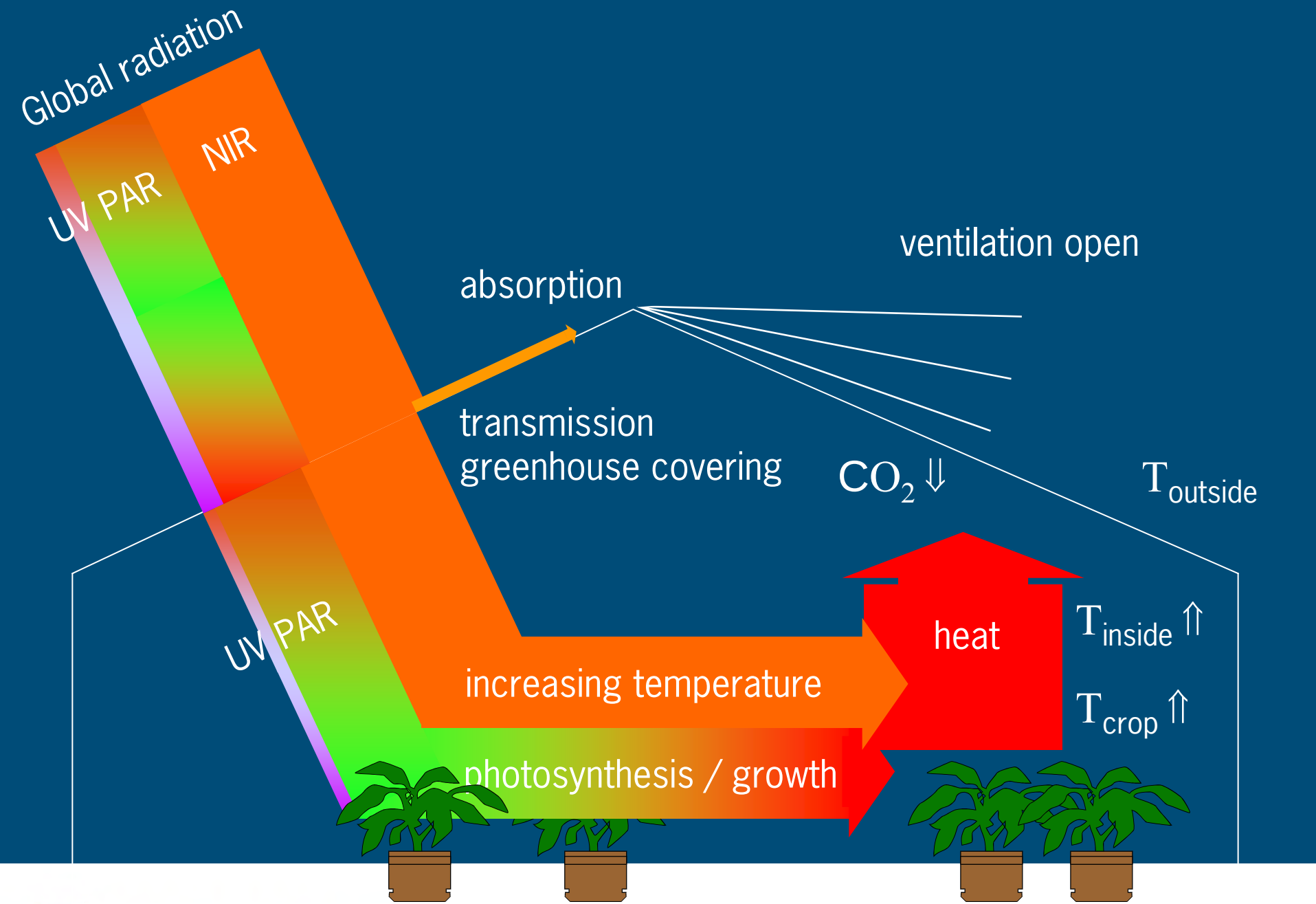


Be careful with light losses at high haze factors

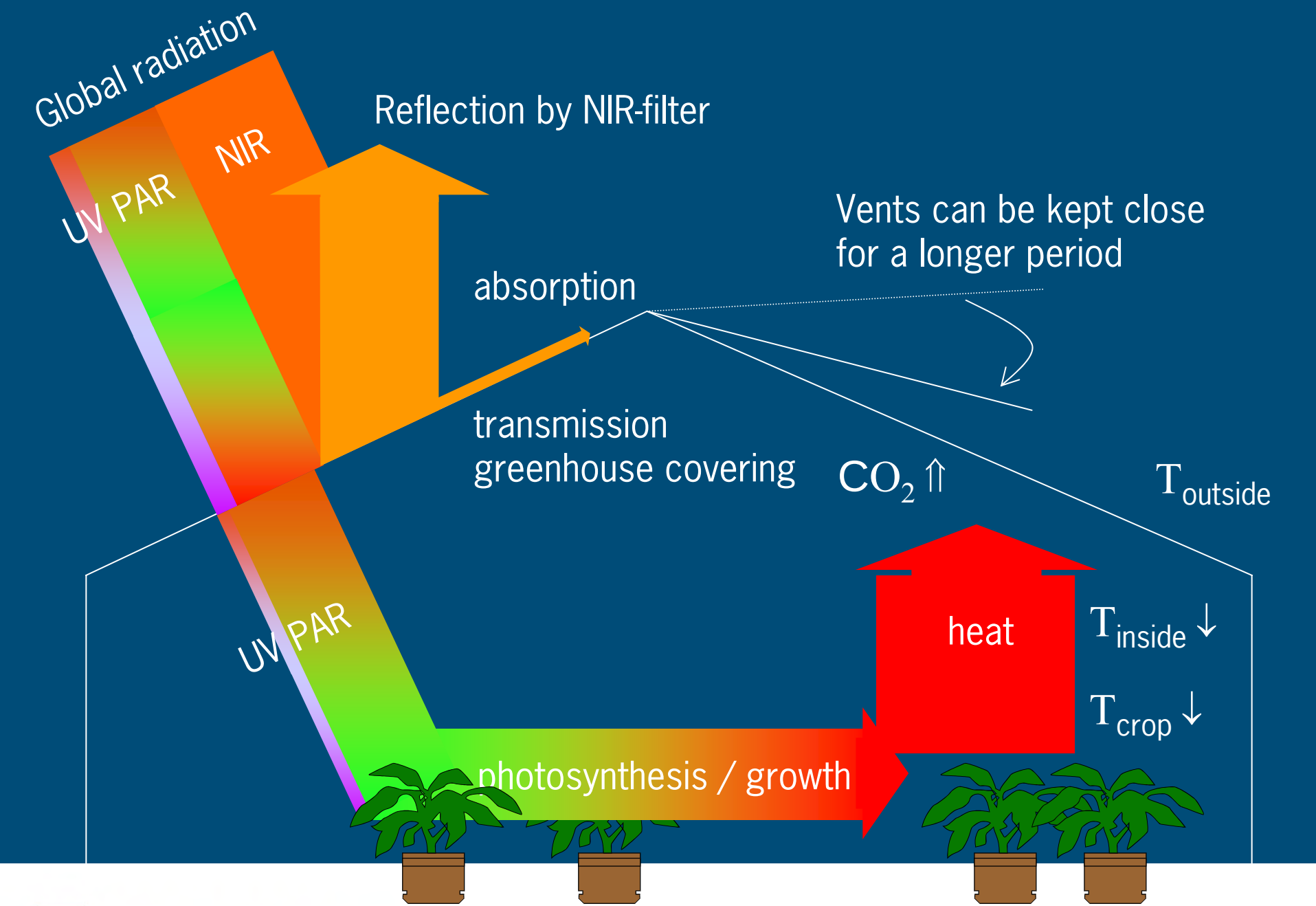
Heat input



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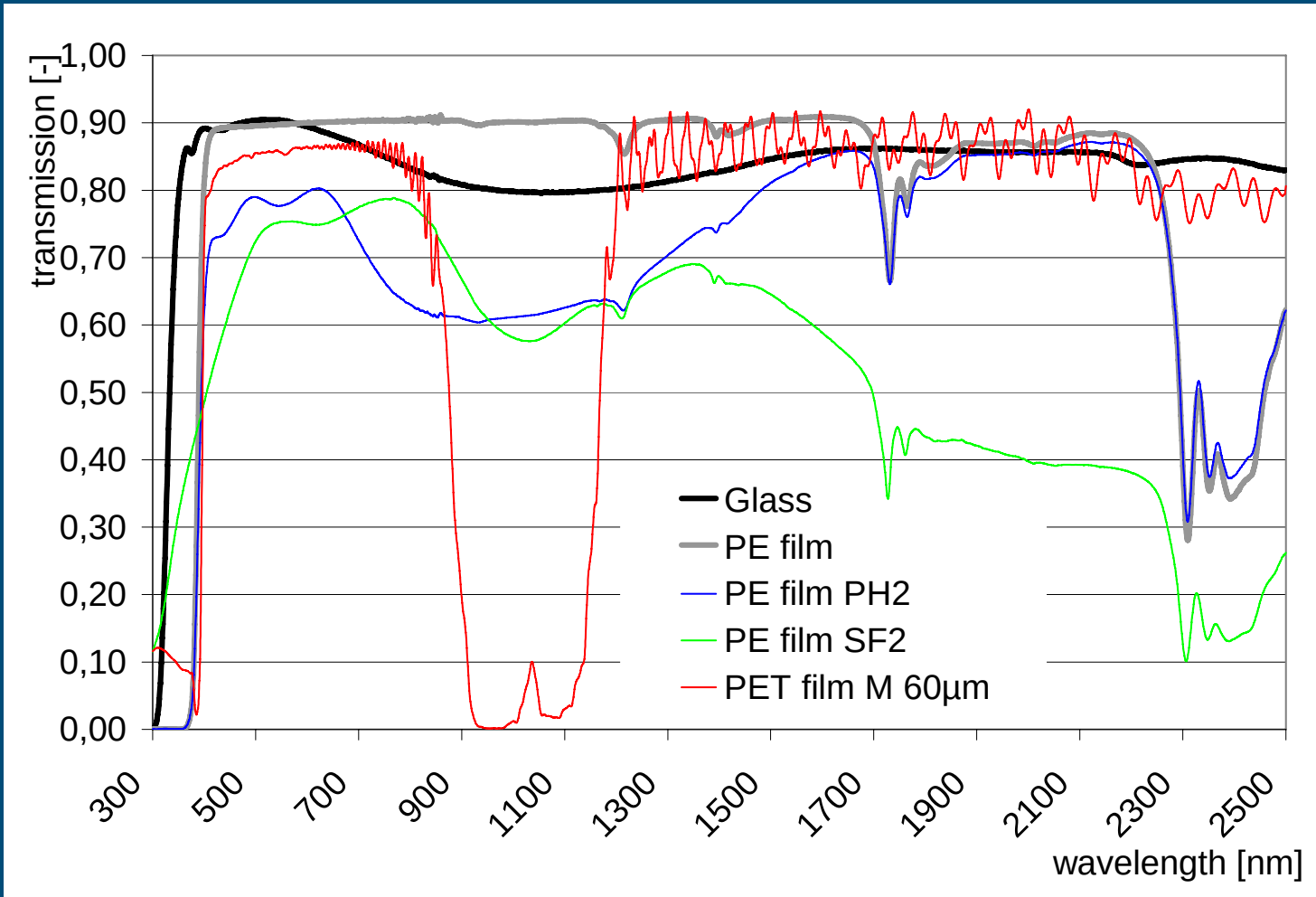


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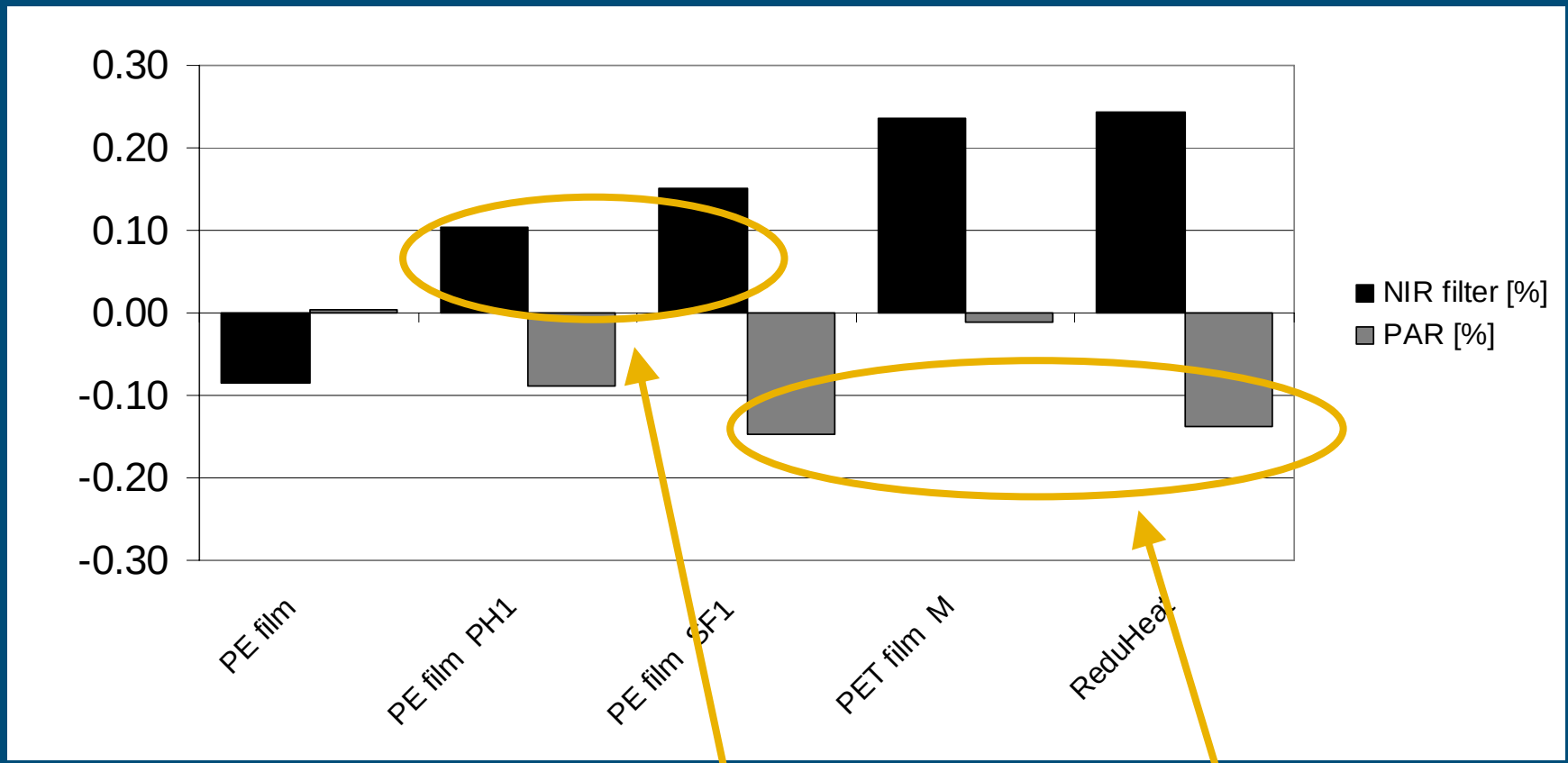


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NIR-filtering materials

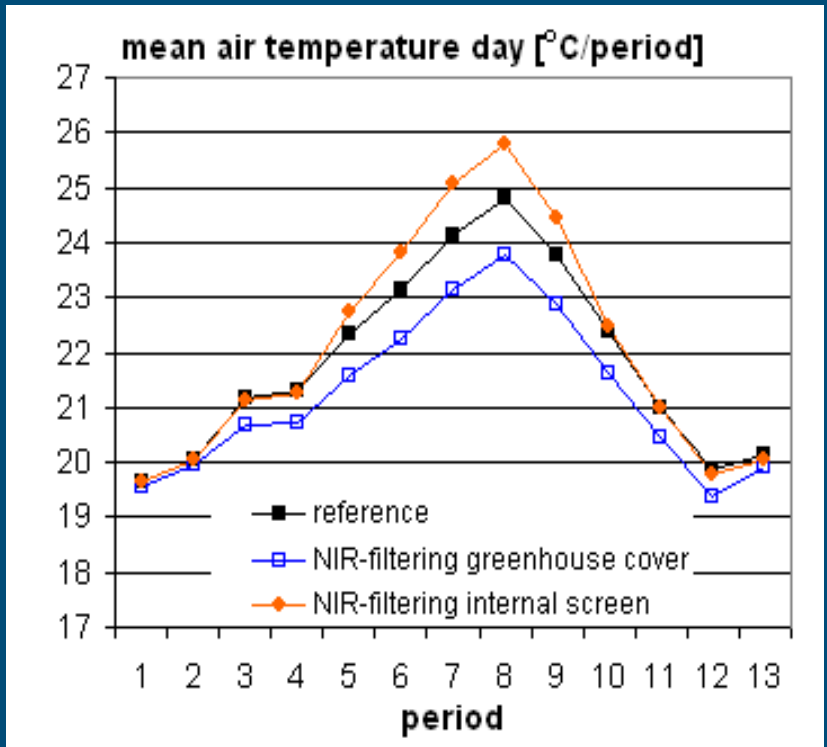


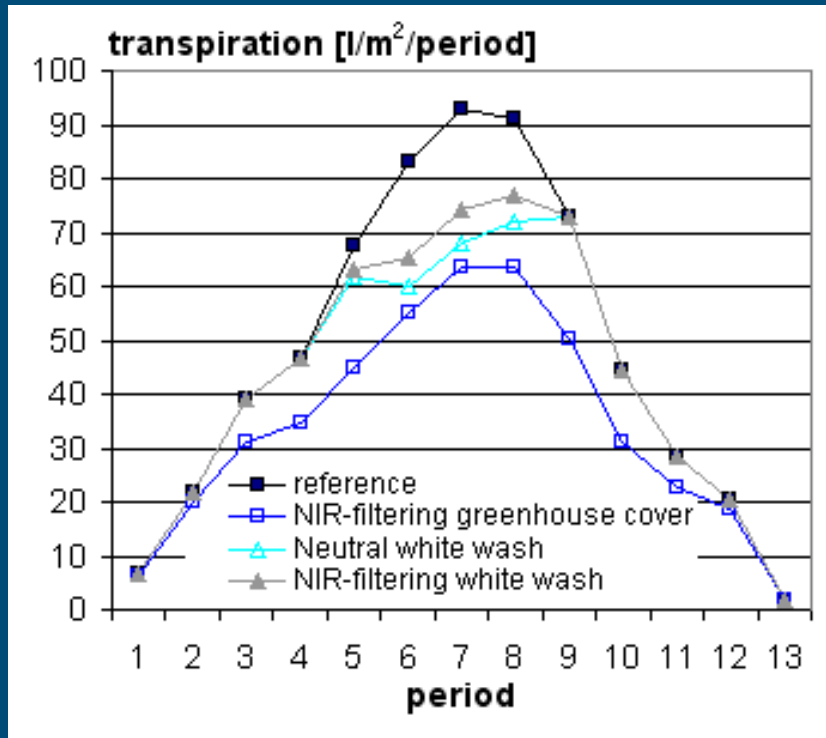
NIR-filtering materials



Crop reaction

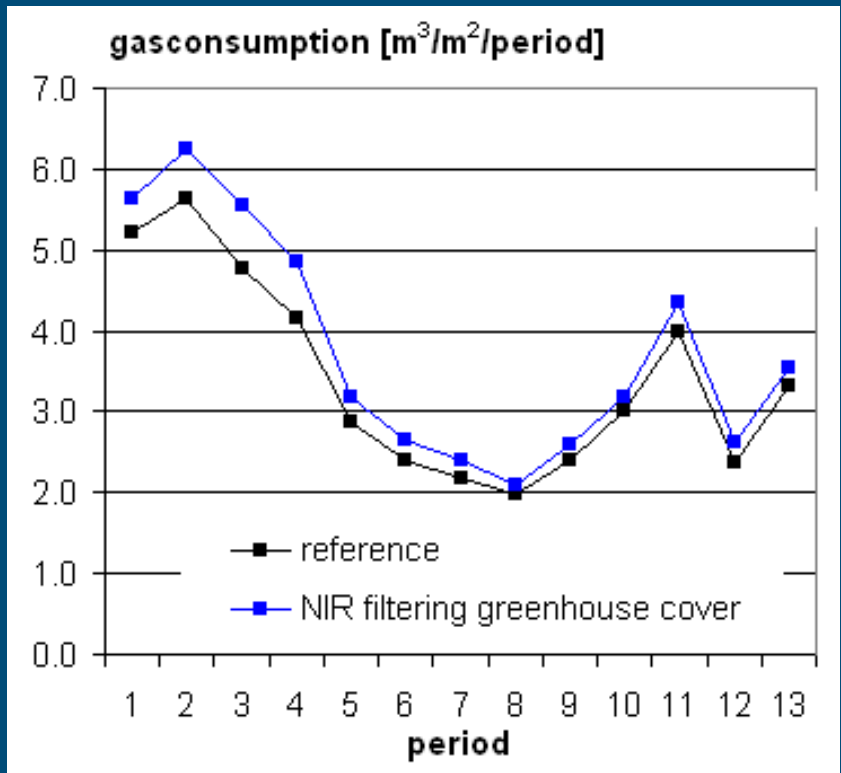
Air temperature is less affected, crop temperature drops…





Energy consumption

Higher energy consumption with NIR-cover, growth reduction in unheated greenhouses…



NIR-filtering

- Northern Europe:
- Adaptable NIR-filtering screen outside (!) with high light transmission
- In “closed greenhouse” NIR-filtering reduces cooling capacity up to 30%



NIR-filtering

- Mediterranean Countries:

In (unheated) greenhouses use of an (adaptable) NIR-filtering outside screen only in hot periods

- Tropical regions:

NIR-filtering coverings reduce air and crop temperatures permanently



Questions?



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