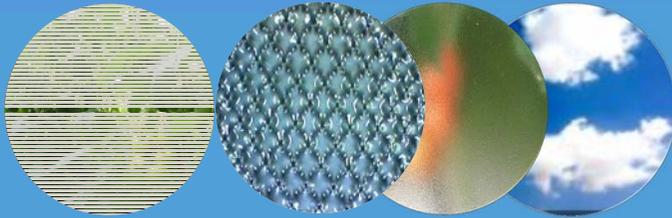


Diffuse glass: A light added value?

Masterclass 1 oktober 2015 InHolland Delft
BOGO project "Klimaat en energie: nieuwe low input teeltsystem in de tuinbouw"

Tom Dueck, Wageningen UR Greenhouse Horticulture



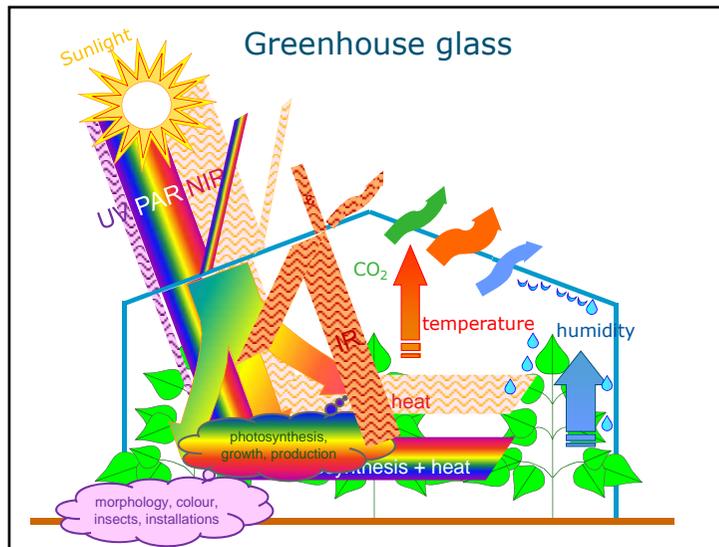
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For quality of life

Why diffuse light?

- Natural sunlight is free!
- Free light through greenhouse coverings for growth
- Free energy in the greenhouse
- Make the most of it !



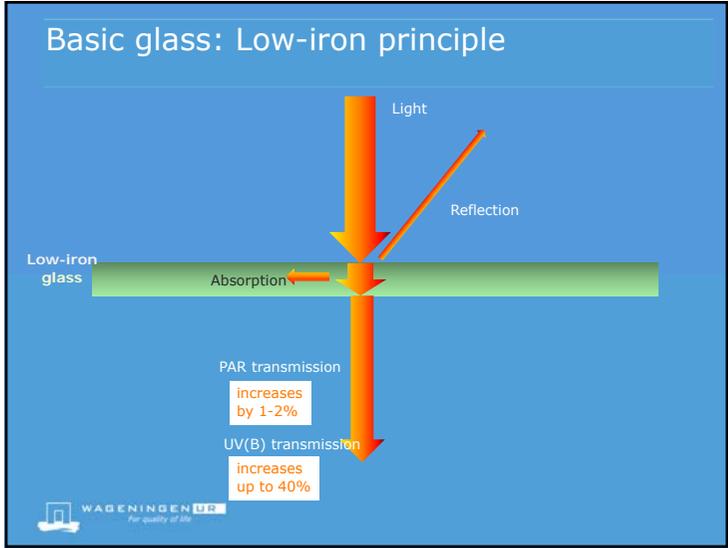
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What is diffuse light?

- Hemispherical transmission
 - Light transmitted over 180°
- Haze
 - Amount of light scattered > 2.5°

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Basic glass: transmission

		Hemispherische licht transmissie (PAR)
traditional glass	89+	τ_h 0.824
low-iron glass	91+	0.844 +2%

Albarino Zero Crystal

Vetraclear

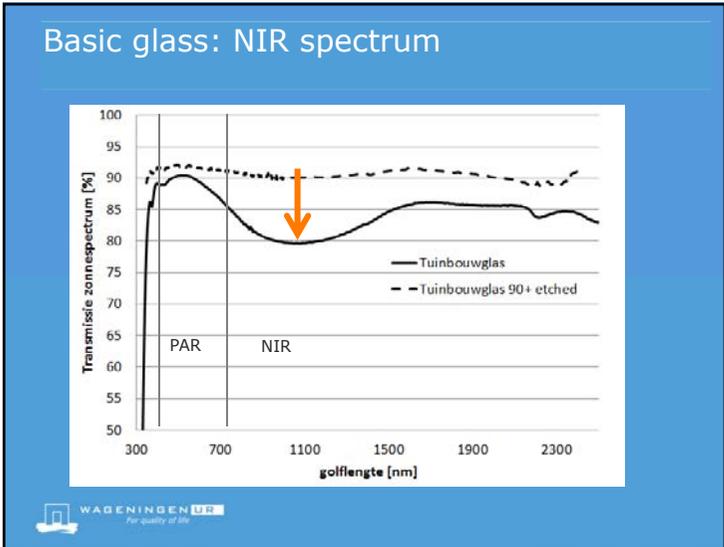
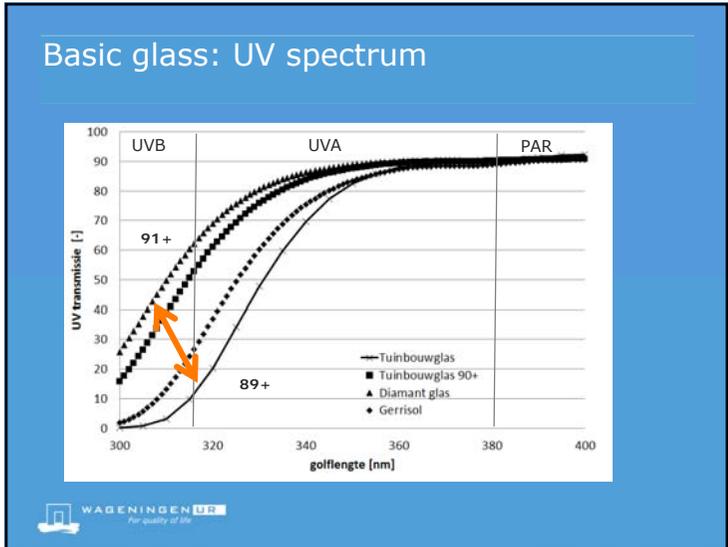
HGI 91+

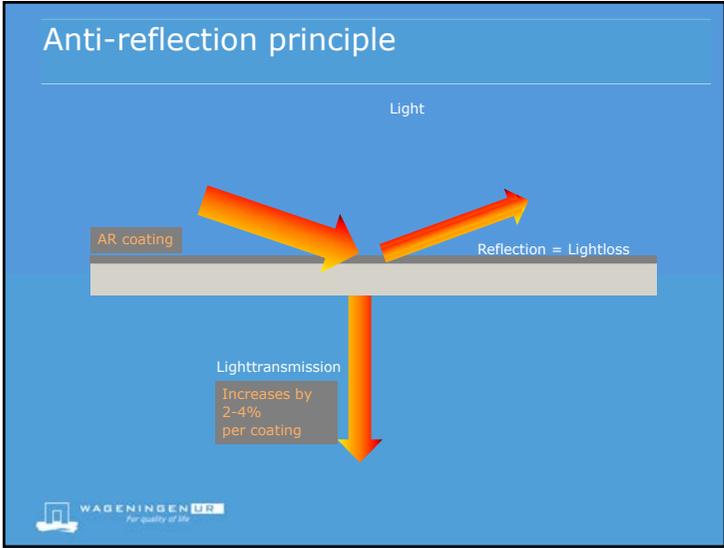
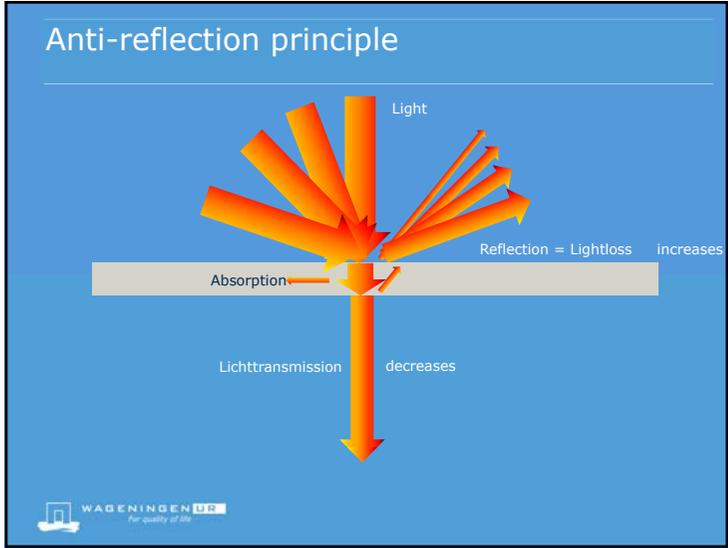
Diamantglas

Extra Clear, Ultra Clear

Etc. etc.

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Anti-reflection and low-iron

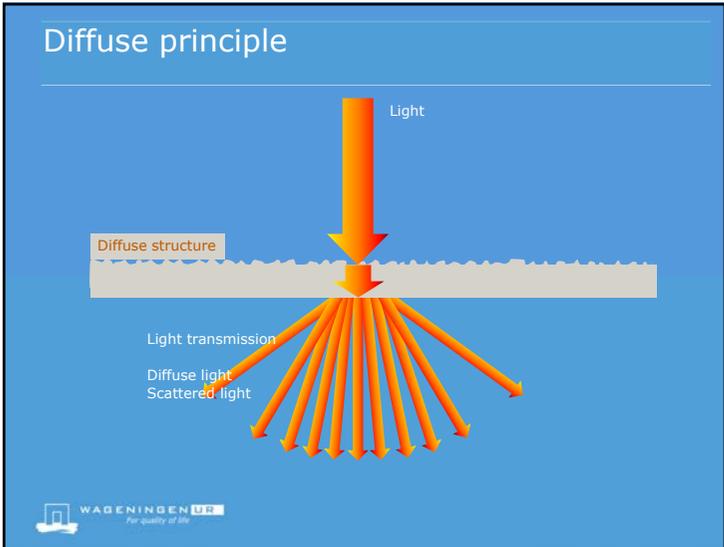
		Hemispherische licht transmissie (PAR)	
traditional glass	89+	0.824	+3.5% per kant
low-iron glass	91+	0.844	
AR glass	89+ AR	0.893	
low-iron AR glass	91+ AR	0.911	

HGI 91+ AR

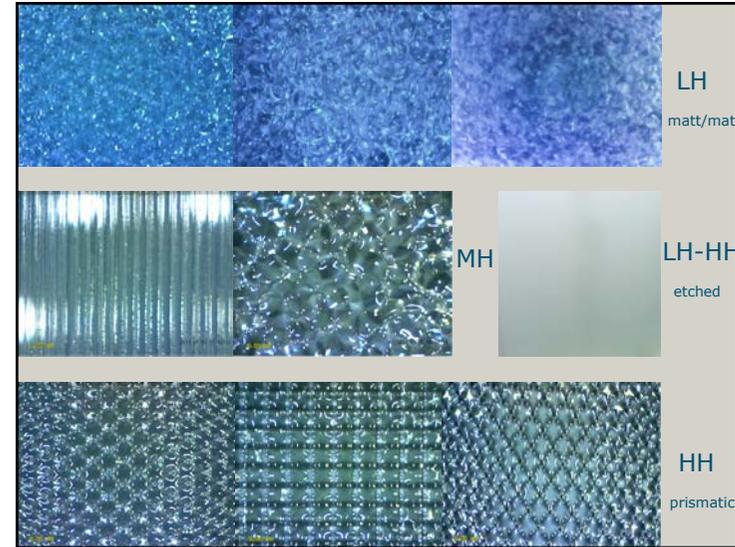
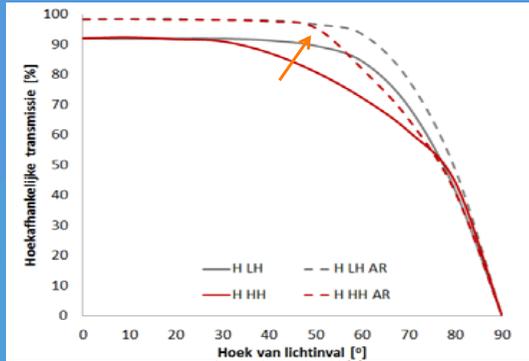
Albarino Zero Crystal+ AR DA Glas 101-103

Etc. etc.

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For quality of life



Diffuse + anti-reflection: angles of incidence

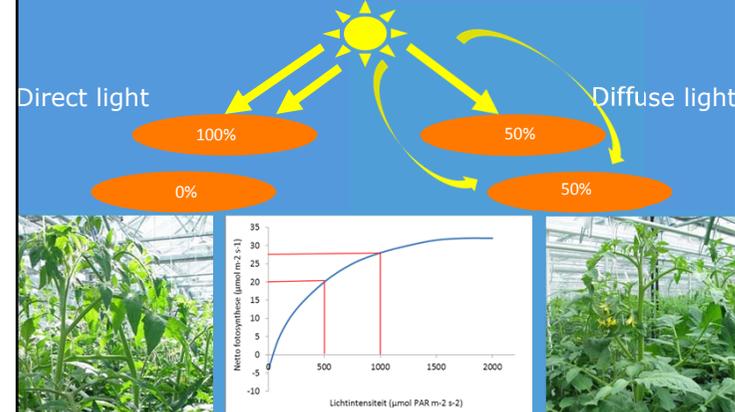


Demands on diffuse glass

- Light transmission (crop dependent)
- Light scattering (crop dependent)
- Light spectrum (UV, PAR, NIR)
- Condensation properties
- Dust pollution, cleaning
- Corrosion, ageing
- Uniformity glass, batch, product
- Guarantees for product properties
- Timely delivery (new greenhouses, calamities)
- Size
- Costs



Effect of diffuse light on a crop



More photosynthesis
+ changed microclimate
= more production

Dueck, 2011

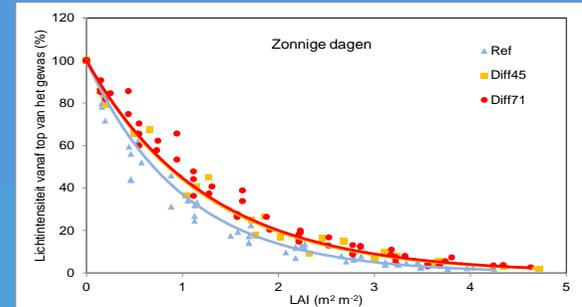
Diffuse light

Glass	% Haze	% Light transmission (hemispherical)
Control = reference	0	82
ReduFuse 1:8	50	78
Diff45 (etched)	45	82
Diff62 AR (structure)	62	85
Diff71 AR (structure)	71	82

Tomato 'Komeett'
Planting date: Dec 16th
Density: 2.55/m² to 3.4/m²



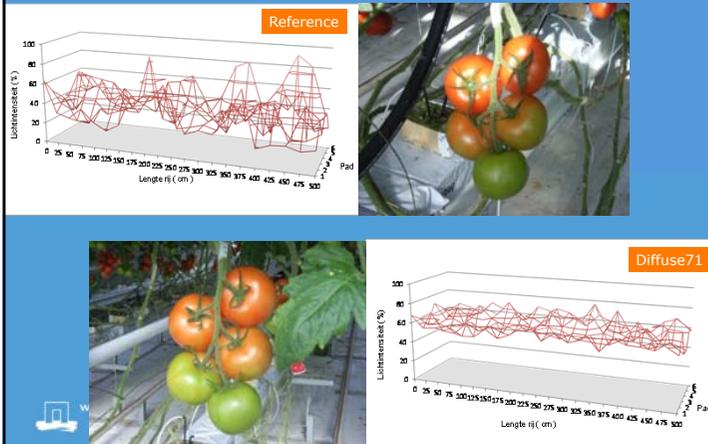
Light penetration in a crop



More light deeper in the crop on sunny days under diffuse glass, but not on cloudy days



Light distribution in the crop



Plant temperature

- Higher leaf temperature in top of the crop under clear glass
- Leaf temperature under diffuse glass -2 to +2°C i.r.t. air temperature
- Leaf temperature under clear glass -2 to +6°C i.r.t. air temperature

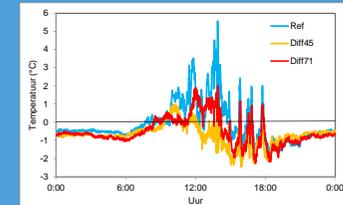
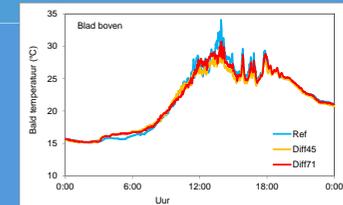
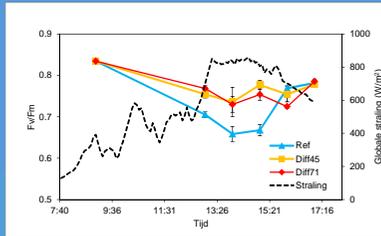
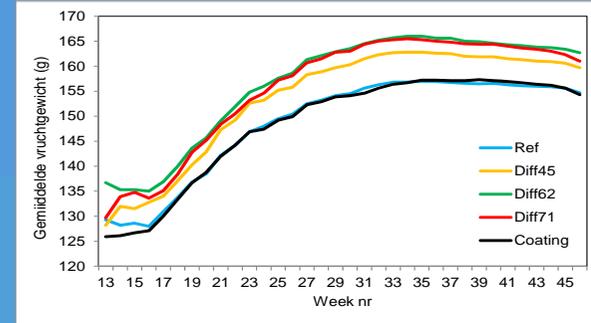


Photo-inhibition in tomato

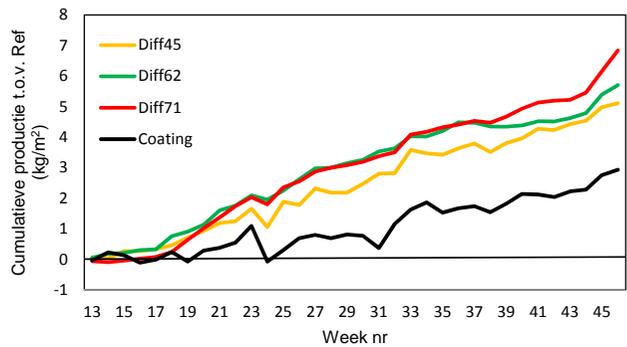
- Photo-inhibition occurs by radiation >500 W/m²
- Influence temperature, VPD?



Cumulative mean fruit weight



Fruits 5 to 8 g heavier on average under diffuse glass



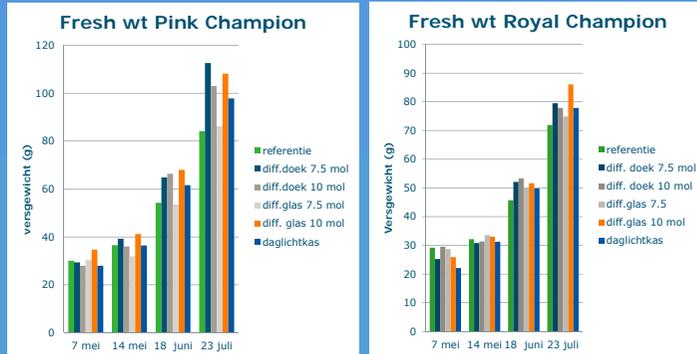
Production higher under diffuse glass from the start

More (diffuse) light for ornamentals

- Reference
 - clear glass, LS16 screen, 7.5 mol/m²/d
- Diffuse screen (XLS55 harmony)
 - 7.5 and 10 mol/m²/d
- Diffuse glass
 - 7.5 and 10 mol/m²/d
- Daylight greenhouse
- Anthurium, Bromelia, Phalaenopsis

Van Noort et al., 2014

Fresh weight Anthurium



End of crop cycle



Conclusions

- Good quality, no leaf burn or yellowing by 'too much light' up to 10 mol/m²/d
- Heavier plants (up to 25%)
- Shorter crop cycle (up to 25%), 16 weeks instead of 22 weeks

Conclusions: diffuse light ~ crop physiology

- Production
 - Increases production by 7-12% in vegetable crops
 - Shortens crop cycle in some ornamentals
- Plant temperature
 - Diffuse light flattens peaks in leaf temperature, resulting in more constant growth conditions
 - Relation to haze?
 - Larger use of leaf area – tends towards higher crop transpiration
- Crop status
 - Generative vs vegetative?
 - Appears to influence development rate (#trusses) less than assimilate flow to fruits

Conclusions: diffuse coverings ~ quality

- Quality and coatings
 - Good combination of diffuse and AR is necessary; depends on crop and location
 - Corrosion/porosity of AR coatings largely unknown
 - Guarantees from suppliers are possible
- Condensation
 - Depends on surface structure
- Pollution/cleaning
 - Diffuse structure inside/outside?
 - No fluorides

Wageningen UR Greenhouse Horticulture

With thanks to my colleagues:

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 Gert-Jan Swinkels

