# Modern technology for sustainable greenhouse production in Turkey

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## Trends world-wide

- Decrease of availability natural sources (water, gas/oil, fertilizers)
- Increase world population till 2050 from 6 to 9 billion heads
- Consumers more critical
- Strong economic development new countries
- Internationalisation of trade

source:

## Trends world-wide – greenhouse production

- New production areas are coming up
- From open field production to more protected systems
- Low tech and mid tech growing systems have biggest areas, but move to high tech
- Modern greenhouse industry in Western Europe and US develops more and more to year round production with high quality

source:

## Greenhouse production in Turkey

### Strong

- Great agricultural history
- Good strategic position (gate to East)
- Areas with good growing climate
- Geothermic sources
- Young population, fast increasing
- Cost level still reasonable
- Big home market

### Challenges

- Greenhouse industry traditional
- Small companies
- Big scope on seasonal low cost production
- Marketing and sales important
- Management en training important

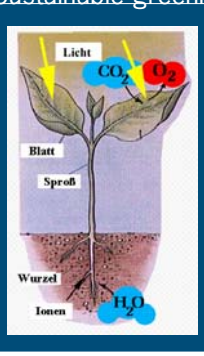
source:

## Sustainable greenhouse production in Turkey

- Design greenhouse systems which combine (economic) production efficiency with minimal input of energy, water and nutrients

- Low energy input, use of sustainble energy (geothermal)
- High production, product quality, predictability
- Low pesticide use, high food safety
- High water use efficiency, low nutrient losses
- High ratio benefit – costs of the production system

## Sustainable greenhouse crop production




- $CO_2$ + water + light → sugar + $O_2$
- Sugars and nutrients are used for growth
- Growth ➔ yield
- Reactions are temperature dependent

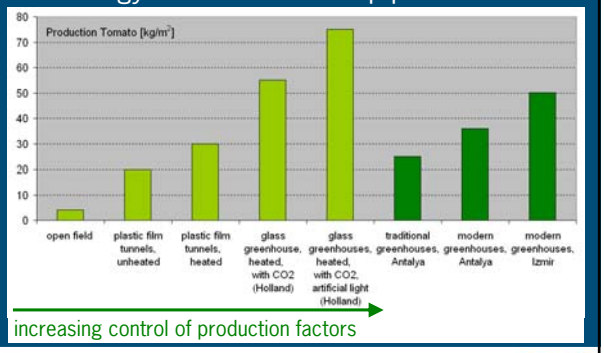
→ control all growth factors
→ technology needed

## Technology for sustainable crop production

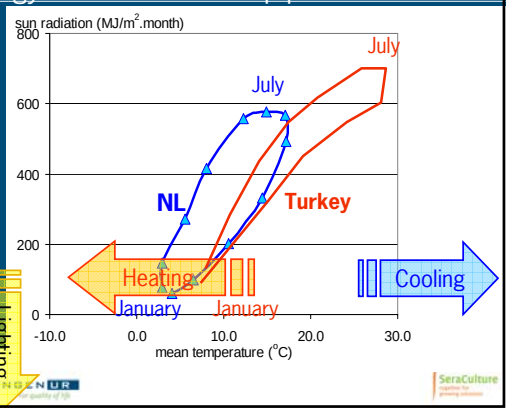
- Increasing degree of technology
  - Heating
  - $CO_2$
  - Cooling
  - Light control
  - Soil / Soilless culture
  - Open / closed water cycle
  - Computer control

→ greenhouse climate
→ crop response
→ economic result

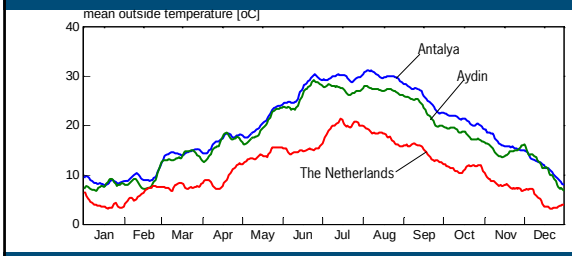
## Technology for sustainable crop production




## Technology for sustainable crop production

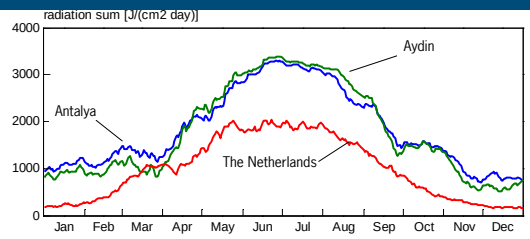



## Outside climate Turkey



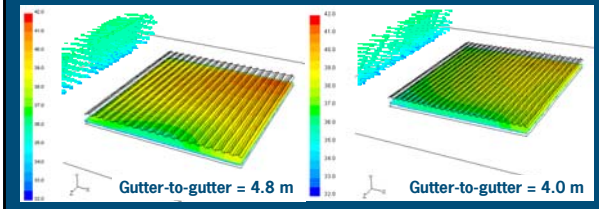

High irradiation, less wind
→ High ventilation necessary

## Outside climate Turkey




→ Make optimum use of natural light

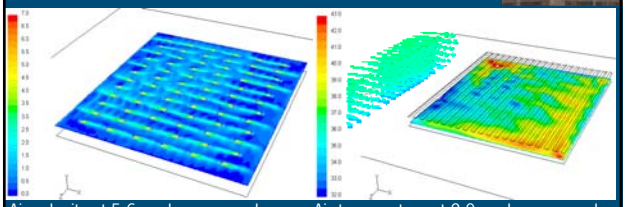
## Cooling: Effect of greenhouse geometry




Continuous roof ventilation
Ventilation rate 10% higher
Max air temperature 1°C lower
Good temperature distribution

Maximum temperatures too high

## Cooling: Effect of recirculation fans



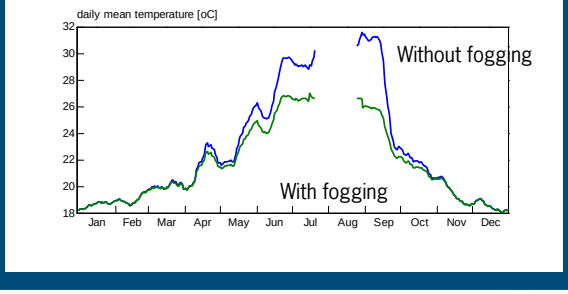
Air velocity at 5.6 m above ground

Air temperature at 2.0 m above ground

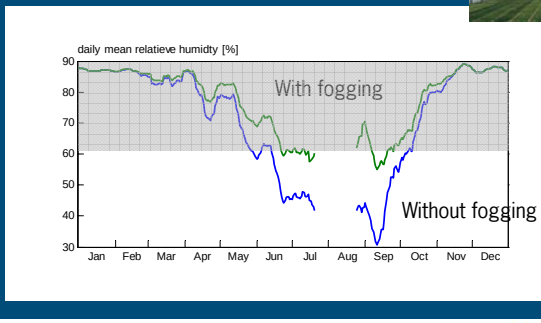
Average air temperature at crop level unchanged with/without fans
Temperature distribution getting worse

Fans are not useful

## Cooling: Effect of fogging




## Cooling: Effect of fogging




## Cooling: Effect of fogging

Aydin

| Fogging capacity | hours warmer than 30 °C | hours warmer than 35 °C | yearly sprayed water |
|---|---|---|---|
| No fogging | 773 | 249 | 0 |
| max 75 gr/(m² hr) | 683 | 169 | 121 |
| max 150 gr/(m² hr) | 620 | 105 | 209 |
| max 225 gr/(m² hr) | 563 | 50 | 279 |
| max 300 gr/(m² hr) | 496 | 15 | 335 |
| max 375 gr/(m² hr) | 448 | 6 | 381 |

Antalya

| Fogging capacity | hours warmer than 30 °C | hours warmer than 35 °C | yearly sprayed water |
|---|---|---|---|
| No fogging | 824 | 274 | 0 |
| max 75 gr/(m² hr) | 688 | 190 | 137 |
| max 150 gr/(m² hr) | 610 | 110 | 233 |
| max 225 gr/(m² hr) | 538 | 58 | 302 |
| max 300 gr/(m² hr) | 479 | 19 | 349 |
| max 375 gr/(m² hr) | 434 | 6 | 383 |

Investments of ca. €3-7 per m² needed
→ running costs very limited
→ production increase and quality improvement

Fogging is useful

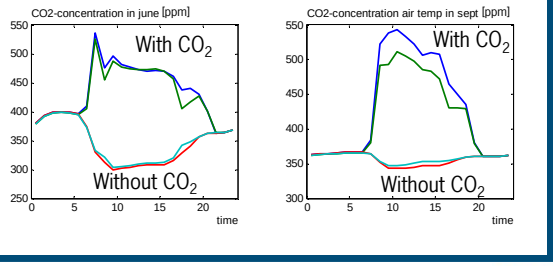
## Cooling: Effect of active cooling

## Cooling: Effect of active cooling

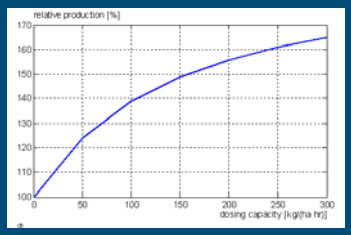
- In Dutch conditions: 1300 MJ/(m² yr)
- In Turkish conditions: 1800 MJ/(m² yr)
  → 250 kWh of electricity per m² per year
  + € 45 per m² additional investment (high)
- but: - saving water (1 to 2 m³/(m² year))
  - high production with limited $CO_2$-supply

Not likely to be economical beneficial

## Effect of $CO_2$ on production




## Effect of $CO_2$ on production




Investments of ca. €2 per $m^2$
→ running costs €ct 17.5 per kg
→ production increase of 30-60%

$CO_2$ is useful

## Effect of light transmission

Light transmission <<50%

Tropics

Spain

## Effect of light transmission

Light transmission 70-75%

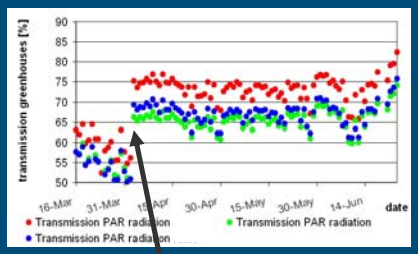
Investments plastic:
€1-1.5 every 2-4 years

Investment glass:
€4 once

The Netherlands

Spain

## Effect of light transmission – cleaning!




20% higher light transmission = 20% higher production

cleaning

## Effect of light control - screens

Light management

Interaction with ventilation

- What is the effect of screens on
  - energy saving?
  - greenhouse climate?
  - crop growth?

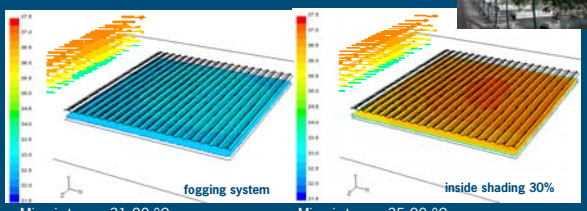
## Effect of light control - screens

| shading fraction | water consumption [m³/(m² yr)] | production |
|---|---|---|
| No shading | 1.217 | 100% |
| 30% shading | 1.090 | 94% |
| 40% shading | 1.067 | 93% |
| 50% shading | 1.034 | 90% |

Investment costs moving screens ca. €5-8 per m²
→ energy saving, better winter climate, better quality
→ +additional controlling summer light / - decrease production

Screens useful?

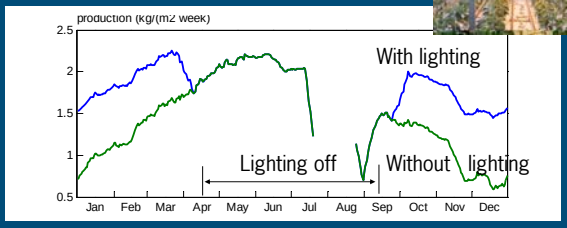
## Effect of shading vs. fogging




Min air temp: 31.20 °C
Max air temp: 32.98 °C

Min air temp: 35.90 °C
Max air temp: 37.05 °C

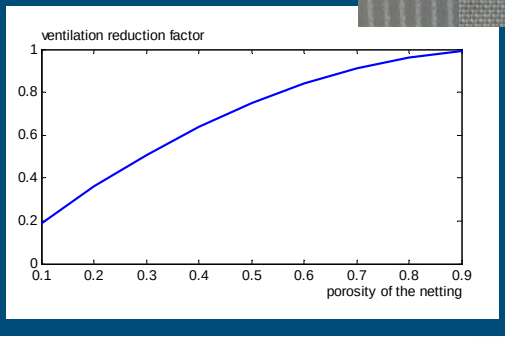
## Effect of artificial lighting



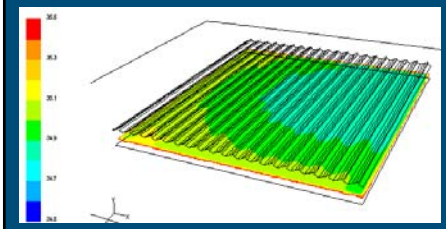

Investments of ca. €40 per m² needed
→ production increase of 20-30%
→ running costs ca. €25 per m² electricity, more $CO_2$

Not likely to be economical beneficial

## Effect of insect nets




## Effect of insect nets and fogging under extreme conditions

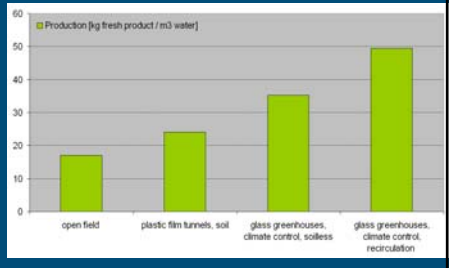


Outside temp. 38°C
rad. 1100 Wm$^{-2}$,
fogging 500 g m$^{-2}$ h$^{-1}$,
with insect nets,
ventilation windows
closed

Min air temp: 34.2 °C
Max air temp: 35.1 °C

## Hydroponics

- → Independent from soil quality
- → less nematodes
- → High water use efficiency
- → Saving nutrients, saving costs
- → Local and/or organic material?



## Integrated pest control

- Control of pest and diseases
  - Integrated pest and disease control
  - Biological pest control – beneficials
  - Hygiene
  - Insect netting

## Sustainability factors

| | Glass standard | Glass with $CO_2$ | Glass with fogging | Glass with $CO_2$ & fogging | Glass with $CO_2$ & fogging & closed water system | Glass $CO_2$ & fogging & closed water system & lighting | Glass with $CO_2$ & fogging & closed water system & insect nets & screens |
|---|---|---|---|---|---|---|---|
| **Use of resources:** | | | | | | | |
| Water consumption [kg produce/m²] | 28.3 | 41.8 | 27.1 | 38.4 | 49.4 | 62.3 | 51.9 |
| Energy (heat) consumption [MJ/kg] | 14.7 | 9.9 | 14.5 | 9.7 | 9.7 | 4.5 | 9.2 |
| **Produce less environmental loads:** | | | | | | | |
| CO2 application per unit produce | zero | high | zero | medium | medium | high | medium |
| Nutrient emissions | high | high | high | high | low | low | low |
| Pesticides applied per unit produce | high | high | high | medium | medium | medium | low |
| **Efficiency of production process:** | | | | | | | |
| Yield per area [kg/m²] | 36.0 | 53.3 | 36.4 | 54.7 | 54.7 | 68.9 | 57.5 |
| Profit per area and year [€/m²/year] | €6.90 | €14.87 | €6.74 | €15.56 | €15.62 | €2.40 | €16.58 |
| Payback period [years] | 4.3 | 3.0 | 4.4 | 3.0 | 3.1 | 7.9 | 3.0 |

## What is the optimum greenhouse design for Western part of Turkey?

- Highest yields and shortest return of investment by only heating and $CO_2$
- However,…
  - More technology (fogging, shading, insect nets) increase certainty of production, return of investment comparable
  - Economic results are strongly dependent on product prices and interest rates for capital costs

## Modern technology for sustainable greenhouse production in Turkey

- Heating needed, geothermal energy sustainable
- Natural cooling by continuous roof ventilation
- Fogging for additional adiabatic cooling
- No recirculation fans, No active cooling
- Application of $CO_2$ for higher production
- High light transmission of greenhouses!
- No artificial lighting
- Application of insect nets to save pesticides, better temperature distribution, higher $CO_2$
- Soilless culture for higher production, less diseases
- Water recycling, save water and nutrients

heating & cooling

$CO_2$

light

hydroponics

## Wageningen UR Glastuinbouw
## Innovations for the greenhouse sector

## Questions?