Soilless culture in Dutch greenhouse tomato; History, economics and current issues

Workshop "Efficient water and fertilizer use in greenhouse tomato production"
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- Greenhouse Horticulture in The Netherlands
  - Structure
  - Economics
- EU and Dutch policy on emission of nutrients
- Closed cultivation system
- Water and nutrient use efficiency
- Constraints
- The way forward
Greenhouse horticulture in The Netherlands

Small country but big greenhouse horticulture
Greenhouse horticulture NL: structure

Area 2009 (ha): total: 10.325; vegetables: 4.825; cutflowers: 2.855; potplants: 1.940 and others (fruit/nursery/lowers): 705

Source: CBS, 2010
Greenhouse tomato NL: structure

- Area: half as much in 10 years
- Farm scale: almost 3x bigger in 10 years
- Number of farms: halving in 10 years

- Truss type: 70%
- Round type: 25%
- Cherry type: 5%

Source: CBS, 2010
Greenhouse tomato NL: production (in Europe)

- NL is small producer, but big exporter (incl. transit trade)
- Big growth of Dutch production because of increase in area and production methods
Greenhouse tomato NL: production (in Europe)

- High tomato production /ha in NL:
  - protected cultivation
  - mild climate: long season
  - new technologies, like:
    - more transparent greenhouses
    - CO$_2$ enrichment
    - artificial lighting
  - new varieties
Greenhouse tomato NL: import prices (in Europe)

- Import prices on trade level
- Higher prices for Dutch tomatoes
- Price difference between Dutch and Spanish tomatoes is decreasing

Footnote: Prices on trade level (unrespected quality, product type, season and market).
Source: Eurostat Comex, processed by LII.
Greenhouse tomato NL: Financial farm results

Remarks:
- Greenhouse size: ca. 4 ha
- Year round cultivation
- Yield: ca. 60 kg/m²
- Other output >
  - e.g. electricity to public grid
- Labour: 5-6 employees/ha
- Negative financial result > 2009!
  - low product prices (ca. 0,55 €/kg)
  - high cost levels
- Cost price in NL: ca. 0,65 €/kg

<table>
<thead>
<tr>
<th>Table</th>
<th>Financial results of Dutch greenhouse tomato farm (€/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
</tr>
<tr>
<td><strong>Benefits</strong></td>
<td></td>
</tr>
<tr>
<td>Turnover tomatoes</td>
<td>34.6</td>
</tr>
<tr>
<td>Other output</td>
<td>12.0</td>
</tr>
<tr>
<td>Total output (A)</td>
<td>46.6</td>
</tr>
<tr>
<td><strong>Costs</strong></td>
<td></td>
</tr>
<tr>
<td>Plantmaterial</td>
<td>3.2</td>
</tr>
<tr>
<td>Fertilizers, incl water</td>
<td>1.0</td>
</tr>
<tr>
<td>Crop protection</td>
<td>0.4</td>
</tr>
<tr>
<td>Other crops assets</td>
<td>2.0</td>
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<tr>
<td>Energy</td>
<td>16.2</td>
</tr>
<tr>
<td>Tangible assets</td>
<td>7.8</td>
</tr>
<tr>
<td>Labour</td>
<td>9.4</td>
</tr>
<tr>
<td>Contractors</td>
<td>1.9</td>
</tr>
<tr>
<td>Interest</td>
<td>3.1</td>
</tr>
<tr>
<td>General costs</td>
<td>2.2</td>
</tr>
<tr>
<td>Others</td>
<td>3.2</td>
</tr>
<tr>
<td>Total costs (B)</td>
<td>50.4</td>
</tr>
<tr>
<td><strong>Net financial result (=A-B)</strong></td>
<td>-3.9</td>
</tr>
<tr>
<td><strong>Profitability (=A/B*100)</strong></td>
<td>92%</td>
</tr>
</tbody>
</table>

Greenhouse tomato NL: Production costs

- Main costs: energy (32%), labour (19%) and depreciation (16%)
- Fertilizer and water use: 2% of total costs
Greenhouse horticulture NL: soilless culture

Share of soilless culture in 2009: vegetables: ca. 80%; tomato: ca. 90%; cutflowers: ca. 40% and pot plants: 100% (pots with peat mix)

Source: CBS, 2010
Greenhouse tomato NL: costs of soilless culture

- Investment: 10.9-12.3 €/m²
- Yearly cost: 2.15-2.45 €/m²
- Total cost of closed system, substrate and fertilizers:
  - 3.95-4.25 €/m²
  - 7.8-8.4% of total costs
- If fertilizer reduction = 10%-20%
  >> investment capacity = 0,45-0,90 €/m²
- Hardly an incentive for further actions to reduce fertilizer use and emission

<table>
<thead>
<tr>
<th>System component</th>
<th>Investment per farm</th>
<th>yearly costs per farm</th>
<th>yearly costs per m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>rainwater tank: 3000 m³/ha</td>
<td>41500</td>
<td>7263</td>
<td>0.18</td>
</tr>
<tr>
<td>dosage unit</td>
<td>56800</td>
<td>12780</td>
<td>0.32</td>
</tr>
<tr>
<td>drip irrigation</td>
<td>50000</td>
<td>11250</td>
<td>0.28</td>
</tr>
<tr>
<td>recirculating system</td>
<td>120000</td>
<td>27000</td>
<td>0.68</td>
</tr>
<tr>
<td>gutters, excl. substrate</td>
<td>168000</td>
<td>26880</td>
<td>0.67</td>
</tr>
<tr>
<td>Sub total</td>
<td>436300</td>
<td>85173</td>
<td>2.13</td>
</tr>
<tr>
<td>Sub total per m²</td>
<td>10.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Drainwater desinfestation:
- Heating: 10 m³/h
  - 50000              | 11250                 | 0.28                |
- High pressure UV: 10 m³/ha
  - 55000              | 12375                 | 0.31                |

Total, incl. heating
- 486300              | 96423                 | 2.41                |
Total, incl. heating /m²
- 12.2                |                       |                     |

Total, incl. high pressure UV
- 491300              | 97548                 | 2.44                |
Total, incl. high pressure UV/m²
- 12.3                |                       |                     |

a) Substrate: rookwool slabs: 0,80 €/m².
Soilless culture in Dutch greenhouses

- High water and fertilizer demand
- High growth rates
- High crop nutrient requirements
- Over irrigation necessary:
  - unequal water distribution.
  - prevent salinity

Initially low water - fertilizer use efficiency
Heavy environmental pollution
EU Policy

- Ground water protection
- Surface water protection
- Soil protection

European Water Framework Directive
Nitrate Directive (groundwater)
(1998) > Objective: Soilless growing

- Recirculation /reuse of drainage water obligatory
- Discharge drainage water only if:
  - Na > exceeds legal limits *(crop specific)*
  - Disease outbreak *(permission required)*
- Rainwater collection obligatory (500 m³/ha)
State of the art (2005)

Common growers practice:
- Frequent discharge quite common
- Significant N, P emissions + Plant Protection Chemic.
- Causes, motives
  - Disease risks
  - Na, Cl accumulation
  - Nutrient irregularities
  - Growth reduction
  - ........
Regarding European Waterframework Directive
Agreement growers - government: from 1-1-2010
- **Emission targets** to be reached
- In 2027 (almost) zero emission in greenhouse horticulture
‘Target’ instead of ‘means’ regulation

N emission
? Kg/ha/yr

2010 2019 2027
Reuse of drainage / Closed systems

- Hydroponics
- Substrate systems
- Potted plants on tablet ebb - flow system
Hydroponics

- Watercultures
  - NFT / DFT
Substrate systems

- Substrate systems
  - substrate in throughs / gutters
  - substrate in growth containers,

  drainage collection in gutters
Collection of leachate (drainage water)
After Stanghellini 2003, Acta Hort 609
High nutrient use efficiency possible

Furthermore...

- Closed or semi-closed greenhouse
Developments in water and nutrient use

- Completely closed greenhouse
  no ventilation, mechanical cooling
- Semi - closed greenhouse
  minimized ventilation + mechanical cooling
- ‘The new growing concept’
  (low ventilation, dehumidification, mechanical cooling,...)
kg fresh product per m$^3$ water

- tomato
- sweet pepper

Growing system:
- Israel & Spain, field
- Spain, unheated plastic "parral"
- Israel, unheated glass
- Spain, unheated "parral", regulated ventilation
- Holland, climate-controlled glass, CO$_2$ enrichment
- Holland, as at left, with re-use of drain water
- Dutch "closed" greenhouse

Increasing control of production factors
Constraints for closed systems

- 1 water quality
- 2 diseases
- 3 growth inhibitors
- 4 nutrient irregularities
- 5 water quantity
## 1) Water quality

- **Na and Cl**
- **Residual salts**
  - Ca, Mg, SO4, HCO₃
- **Micro elements**
  - Zn, Cu, Mn, B
- **Contaminants**
  - Al, F, Pb, Cd
Key to solution

- Prevention, choice of water source
- Discharge recirculating nutrient solution partially if Na above threshold levels
- ......developments in water technology
2) Root diseases

- Favorable conditions
  - Rapid development
  - Rapid spreading and infection
- No biological equilibrium
Key to solution

- Hygiene
- Crop resistance (conditions)
- Substrate type (O$_2$ supply)
- Adequate water treatment/dischination
  - Heating
  - UV
- (Future) suppressiveness of the substrate system
3) Growth inhibition

‘The Recirculation disease’

- Growth reduction, unknown phenomenon
  - Root exudates?
  - Contaminants?
  - Decomposition?

Organic micro pollutants

Bioassay
Key to solutions

- Desinfection, combined with advanced oxidation
- UV treatment + peroxide + active carbon
4) Nutrient irregularities

- Imbalanced nutrient ratios
- Rapid depletion / accumulation
- pH or EC deviation
- Decomposition (Fe-chelate)
Key to solution: proper Nutrient management

Nutrient solution
- Basic composition
- Fine tuning

Feed back

Analysis from root env.

Water

Control unit

Mixing tank

Disinfestation

EC control
pH control

• Basic composition
• Fine tuning

Feedback
5) Water quantity

3000 m³/ha

Average year

Dry year
And....

- Still discharge problem of residual waste water
Emission routes

Nutrients (N en P) en Plant protection chemicals via waterflows

- Residual drain off
- Backflush (sand-)filters
- Processwater
- Drainage (soil crops)
- Ditch
- Sewage system

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For quality of life
Closed water chain

From: Witteveen+Bos, 2002
To conclude

- Greenhouse crops extreme high WUE and NUE possible
  - Hydroponics + closed growing systems
  - ‘The new growing concept’ > Closed or semi closed greenhouse

- Important constraints: waterquality, diseases, organic micro pollutants, nutrient imbalances.
  - Adequate filtration and disinfection required
  - Sophisticated management and control
For those who want to know more....

Greenhouse cultivation is noted for its high uptake of minerals, consistent climatic conditions, exclusion of natural precipitation and control of soil accumulation. Acknowledging that plant nutrition in greenhouse cultivation differs in many essentials from field production, this volume details specific information about testing methods for soils and substrates in a greenhouse environment. It does so while offering a universally applicable analysis. This is based on the composition of the soil and substrate solutions, methods for the interpretation of these tests, and crop responses on fertility and water supply in relation to fertilizer application. Fertilizer additions, related to analytical data of soil and substrate samples, are presented for a wide range of horticultural and ornamental crops. The analysis is especially appropriate as sustainable greenhouse culture offers possibilities for the optimal use of water and nutrients, as well as the potential for sustainable production methods for greenhouse crops.
Thank for your attention

Are there any questions?

For more information:
- [www.glastuinbouw.wur.nl](http://www.glastuinbouw.wur.nl)
- [www.lei.wur.nl](http://www.lei.wur.nl)