Three European protected crops: LCA and alternatives to reduce environmental impact

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Goal and scope:

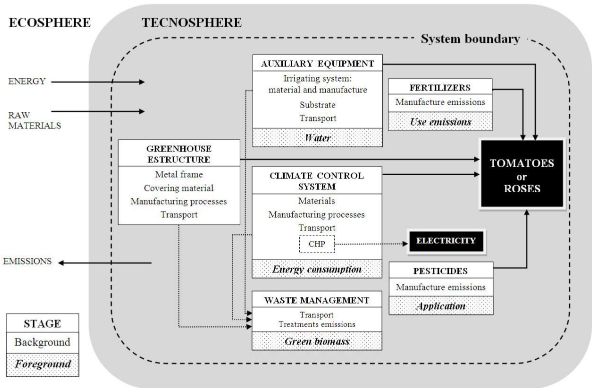
- **Analysis of protected agricultural crops in different climate conditions in Europe, and comparison with alternatives of cleaner production**

Fig1. Scenario 1:
Tomato crop , multi-tunnel greenhouse, Almeria, Spain

Fig 2. Scenario 2:
Tomato crop, Venlo greenhouse, the Netherlands

Fig 3. Scenario 3:
Rose crop ,Venlo greenhouse, the Netherlands

Fig 4. Flow diagram for production systems



Materials and methods:

- **Methodology:** Life Cycle Assessment (LCA)
- **Data:** Foreground data: - Estación Experimental Fundación Cajamar, Almeria, Spain, 2008.
  - Wageningen UR, Greenhouse Horticulture, the Netherlands, 2008.

  Background data: - Ecoinvent database v.2.2, 2010 and LCAFoods database, 2003

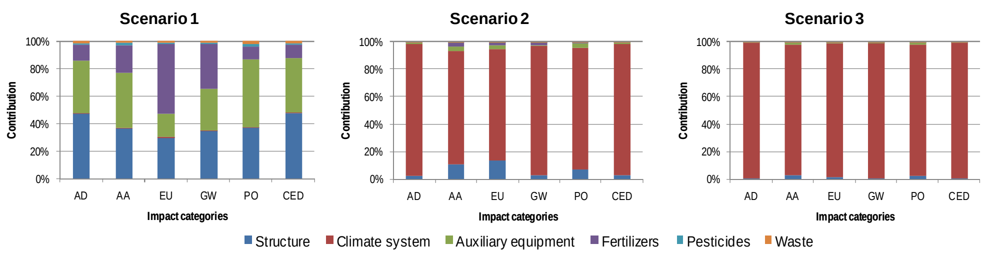
Table 1. Representative data for analysed scenarios

	Tomato, multi-tunnel, Spain	Tomato, Venlo, the Netherlands	Rose, Venlo, the Netherlands
FU	1 ton tomato	1 ton tomato	1000 stems
Yield	16.5 kg·m^{-2}·y^{-1}	56.5 kg·m^{-2}·y^{-1}	276 stems·m^{-2}·y^{-1}
Substrate	Perlite	Rockwool	Rockwool
Fertirrigation system	Open-loop	Closed-loop	Closed-loop
Water (l·m^{-2})	475	794	902
Water use	28.8 l·kg^{-1}	14.1 l·kg^{-1}	3.3 l·stem^{-1}
Climate system	Natural ventilation	Co-generation Natural gas	Co-generation Natural gas
Lighting	no	no	yes

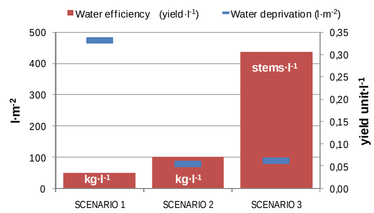
Results:

- **Reference situation:** Main contributors:
  - Scenario 1: Structure, auxiliary equipment, fertilizers
  - Scenario 2: Climate control system (heating)
  - Scenario 3: Climate control system (lighting electricity)
- **Impact categories selected:**
  - AD: Abiotic depletion (kg Sb eq)
  - AA: Air acidification (kg SO_2 eq)
  - EU: Eutrophication (kg PO_4^{-3} eq)
  - GW: Global warming (kg CO_2 eq)
  - PO: Photochemical oxidation (kg C_2H_4eq)
  - CED: Cumulative energy demand (MJ)
  - WSI: Water deprivation (Pfister et al., 2009)

Graphic 1. Contribution of the stages to the total production system for the three scenarios



Graphic 2. Water use environmental impact



- **Alternatives for cleaner production**

Tables show the percentage of environmental impact reduction versus the reference situation, for scenarios and their alternatives.

Scenario 1

	AD	AA	EU	GW	PO	CED
Fertilizers ↓30%	3.6	6.0	15.3	9.7	2.7	3.0
Closed irrigation system	5.2	9.9	48.2	12.3	5.1	4.9
New type of greenhouse with improved ventilation	42.6	38.8	36.0	39.3	41.8	42.7

Scenario 2

	AD	AA	EU	GW	PO	CED
Energy saving cultivation method	31.1	25.9	20.4	30.4	29.1	30.9
New type of glasshouse with double glazing	38.8	29.9	6.4	38.0	39.9	38.7

Scenario 3

	AD	AA	EU	GW	PO	CED
Diffuse glass covering	4.7	4.6	4.5	4.7	4.6	4.7
Substrate volume reduced by 30%	4.8	5.1	4.9	4.8	5.1	4.8

% Reduction: <5 | 5<10 | 10<20 | 20<30 | ≥30

Conclusions:

- A multi-tunnel greenhouse is an unheated passive system which requires little energy and inputs other than fertilizers and water.
- Greenhouse production in the Netherlands is an efficient process that requires intensive technology and energy.
- In scenario 1, new type of greenhouse decreased environmental impacts significantly as yield increased up to 31.4 kg·m^{-2}.
- In scenario 2, energy saving cultivation method was a very efficient solution because of the reduction of natural gas consumption.
- In scenario 3, the reduction of inputs could not compensate the high contribution of electricity consumption for lighting.
- Inclusion of water assessment in LCA is important to evaluate the amount of water used and the localization of water resources.

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