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Fertigation management in greenhouse hydroponics

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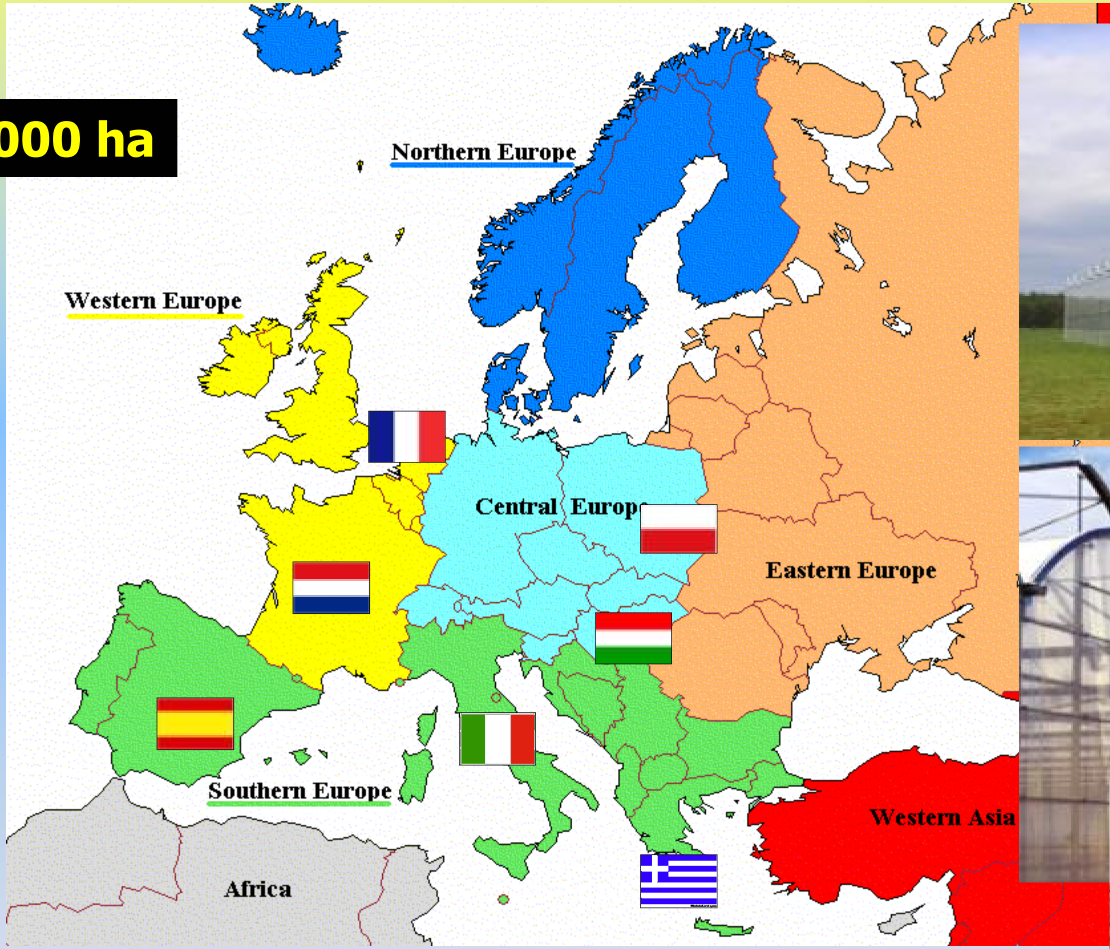
Contents:

- **Introduction:**
  - Greenhouse industry and hydroponics in Europe and Italy
  - Open- vs closed (loop) hydroponics
- **Project results**
  - Water quality for closed hydroponics
    - Boron toxicity in soilless tomato
  - Fertigation strategy
  - Quick tests
  - Simulation tool (water and mineral relations)

Greenhouse industry in Europe

~ 200.000 ha



(1000 ha)
Netherlands: 10.2
Poland: 6.3
Hungary: 2.0

France: 9.2
Spain: 66.0
Italy: 34.6
Greece: 5.3

Source: EUROSTAT 2008-09

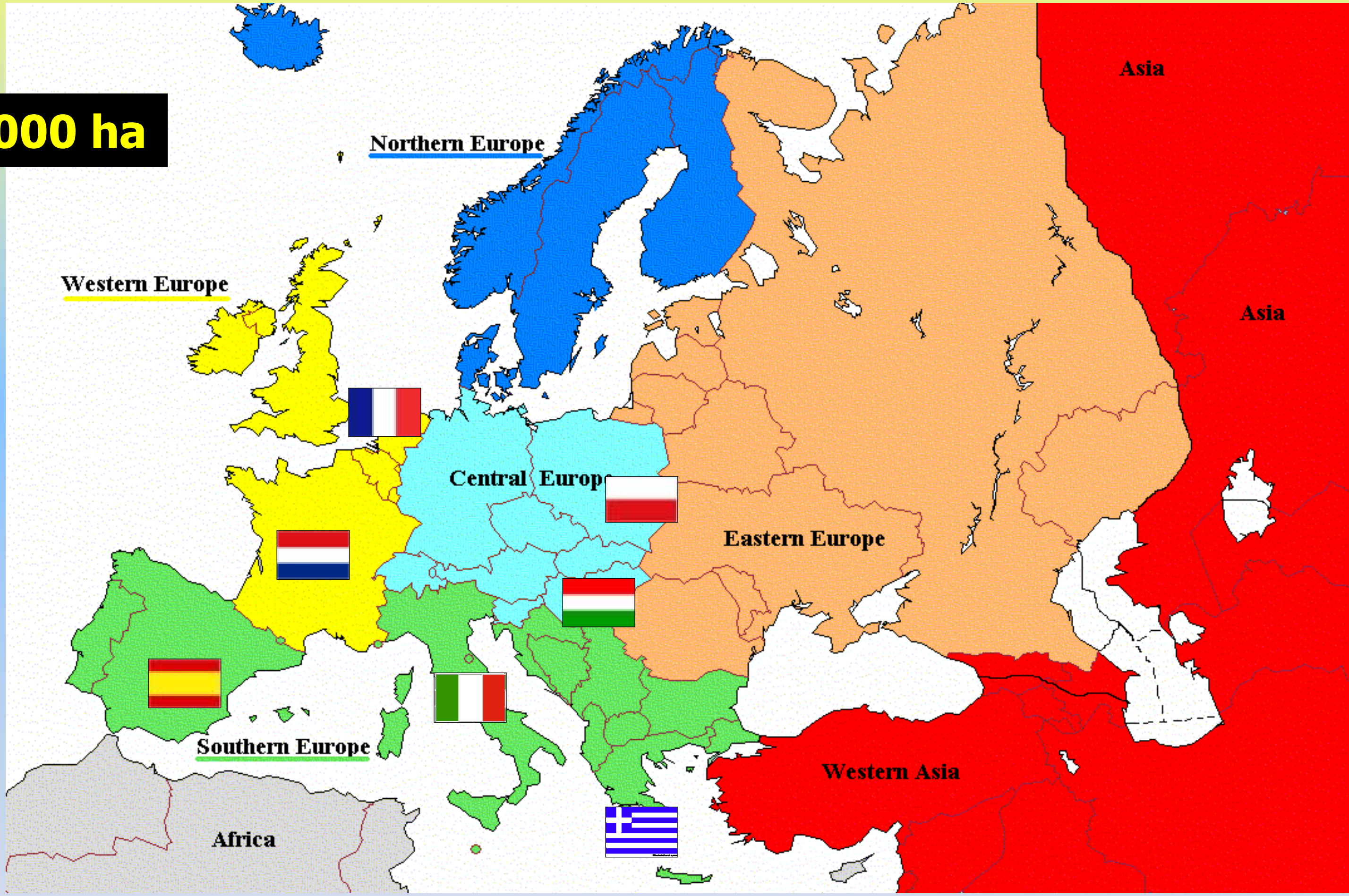
Greenhouse industry in Italy

Major greenhouse crops in Italy

		Solanacea (tomato, pepper)	**Cucurbits** (zucchini, cucumber, melon)	**Leafy vegetables**	**Cut flowers**
ITALY		**7805.3**	**4294.2**	**2711.2**	**3987.6**
Veneto	NORTH	718	397	358	126
Piemonte	NORTH	303	83	98	47
Lombardia	NORTH	75	130	**1,500**	97
Liguria	NORTH	7	2	1	438
Lazio	CENTRE	869	1,628	284	412
Toscana	CENTRE	75	56	38	279
Campania	SOUTH	**1,467**	**1,122**	**269**	**1,039**
Puglia	SOUTH	198	127	13	676
Sicilia	ISLANDS	**3,402**	**403**	13	**522**
Sardegna	ISLANDS	228	33	10	85

Hydroponics in EU greenhouse industry

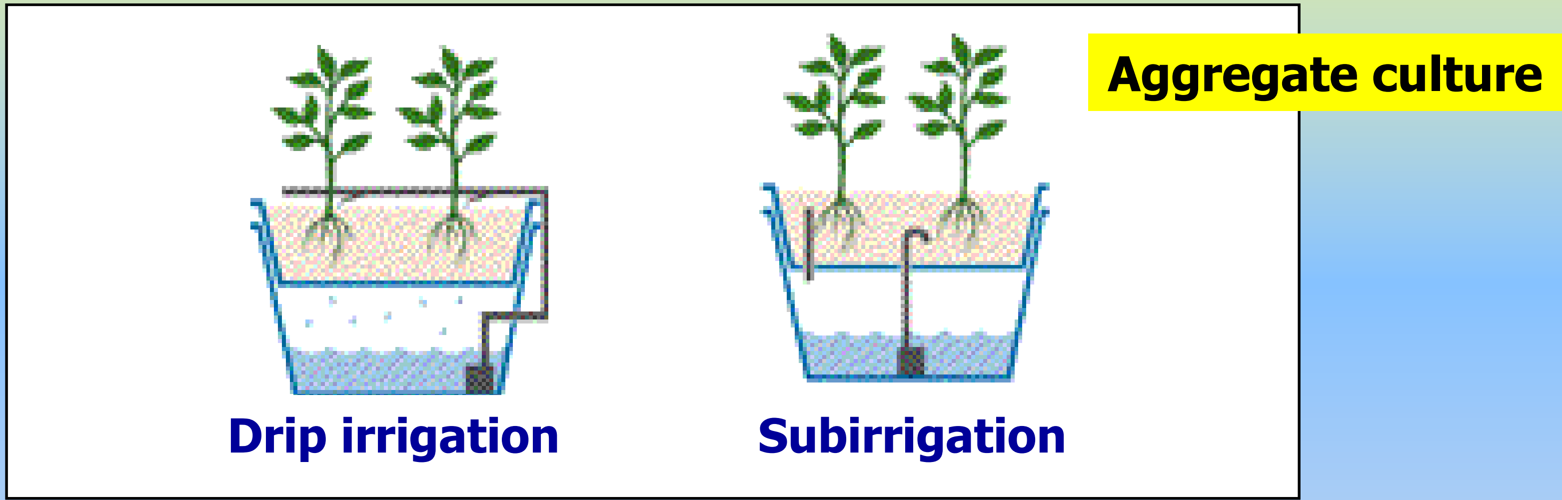
~ 200.000 ha

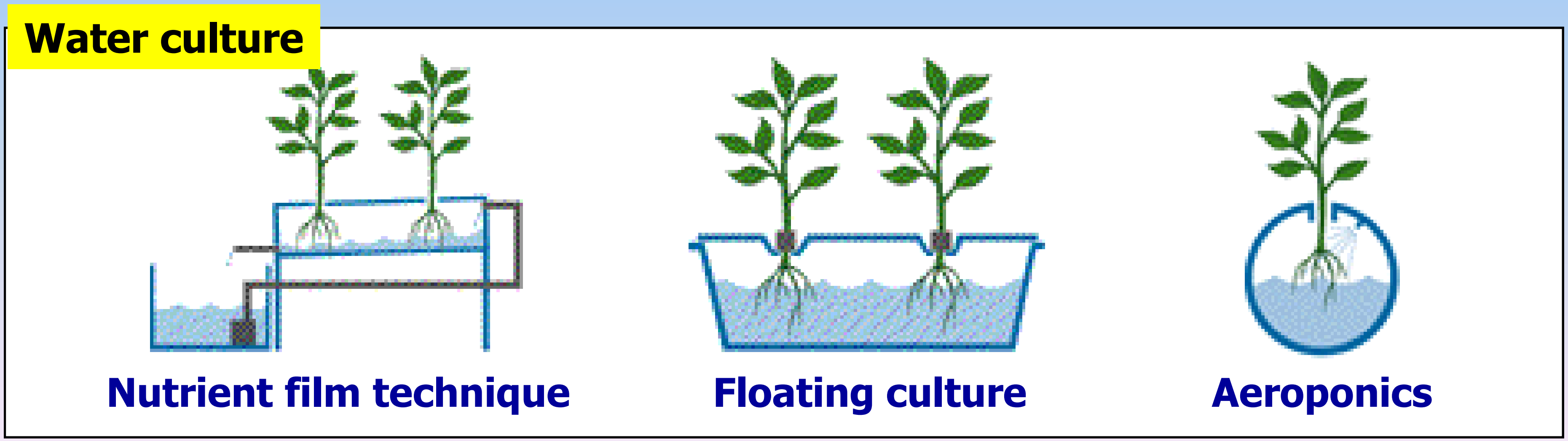


(Estimated percentage on greehouse area)

Netherlands: >90% **Spain: >20**
Poland: >20% **Italy: <10%**
France: <20% **Greece: <20%**

Hydroponic technology (2)





Hydroponic technology (2)

Fresh-cut basil production
in (fairly-stagnant) water culture
(Novellara, RE, Italy)

Hydroponics: pros & cons.

- ✓ Ban of soil fumigants
- ✓ Soil salinization
- ✓ Labour shortage
- ✓ High-quality demanding consumers

- ✓ High investment costs
- ✓ Know-how
- ✓ Skilful labour
- ✓ Water salinization
- ✓ “Green-minded” consumers

Strawberry

One of the reason of hydroponics' flop!

The right way!

Soilles culture of tomato (2 crops/year)

(Incrocci, 2011)

- Water = 6,950 m^3/ha
- Nitrogen = 1,330 kg (N)

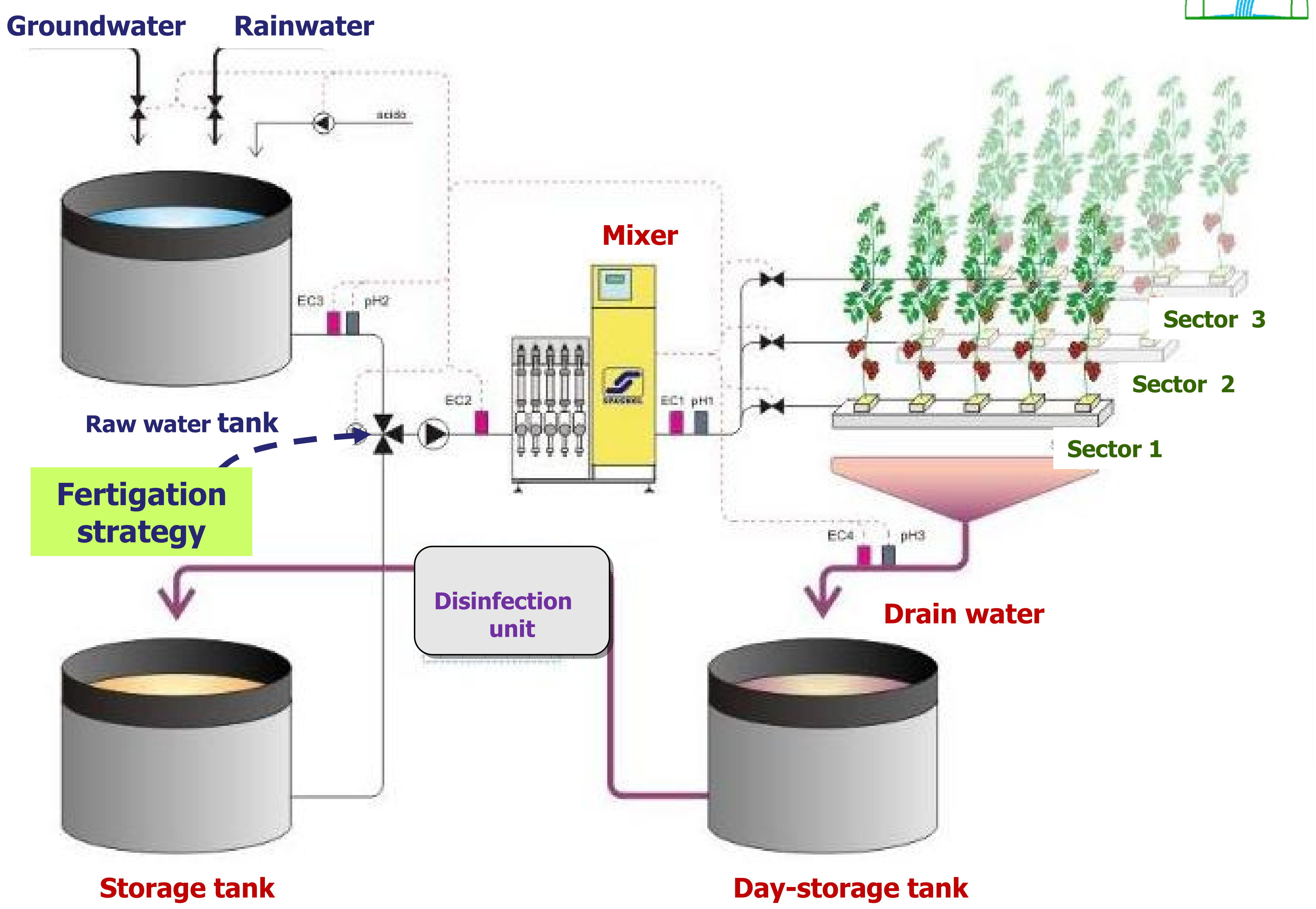
- Water = 8,630 m^3/ha
- Nitrogen = 1,600 kg (N)

Yield = 19.9 kg/m^2

Leaching fraction < 0.20

- Water = 1,680 m^3/ha
- Nitrogen = 270 kg/ha N

(Semi)-closed system



Closed-loop soilless culture: drawbacks.

✓ Nutrient imbalance → **Off-line/on-line analysis**

✓ Rapid dispersal of root-borne pathogens

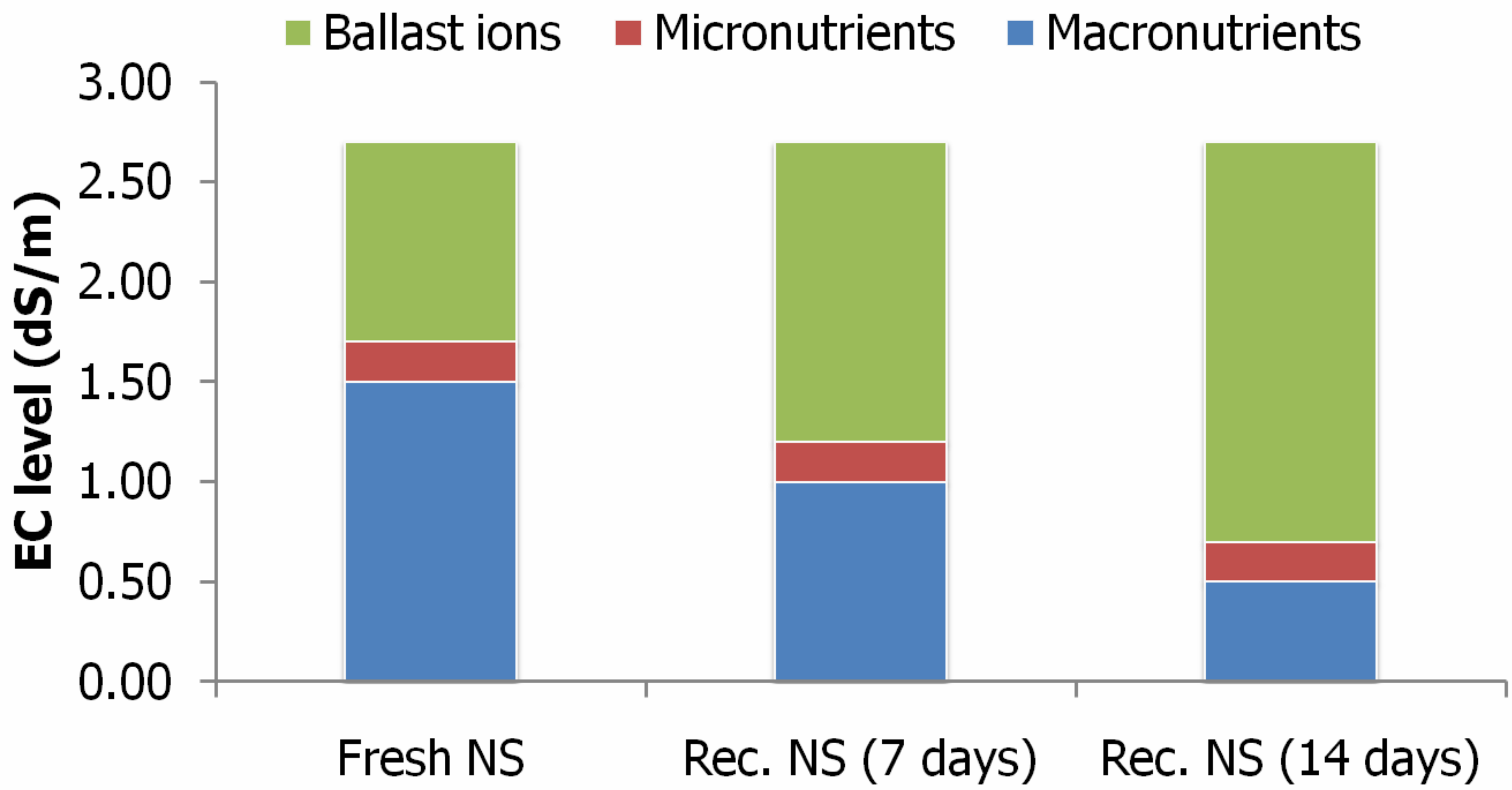
✓ Accumulation of organic compounds (*microbial metabolites, root exudates*)

→ **Disinfection**

✓ Salinity build-up (*accumulation of ballast ions*) → **Water quality** / **Fertigation strategy**




Accumulation of ballast ions in recirculating nutrient solutions



Contribution of different types of ions to the EC of nutrient solution (NS) in closed substrate culture of greenhouse tomato. The values refer to newly-prepared NS or NS that was recirculated for 1-2 weeks.

Journal of Plant Nutrition, 28: 431–445, 2005
ISSN: 0190-4167 print / 1532-4087 online
DOI: 10.1081/PLN-200049163

Taylor & Francis

Modeling Salinity Build-Up in Recirculating Nutrient Solution Culture

G. Carmassi, L. Incrocci, R. Maggini, F. Malorgio, F. Tognoni, and A. Pardossi

10 meq/L NaCl

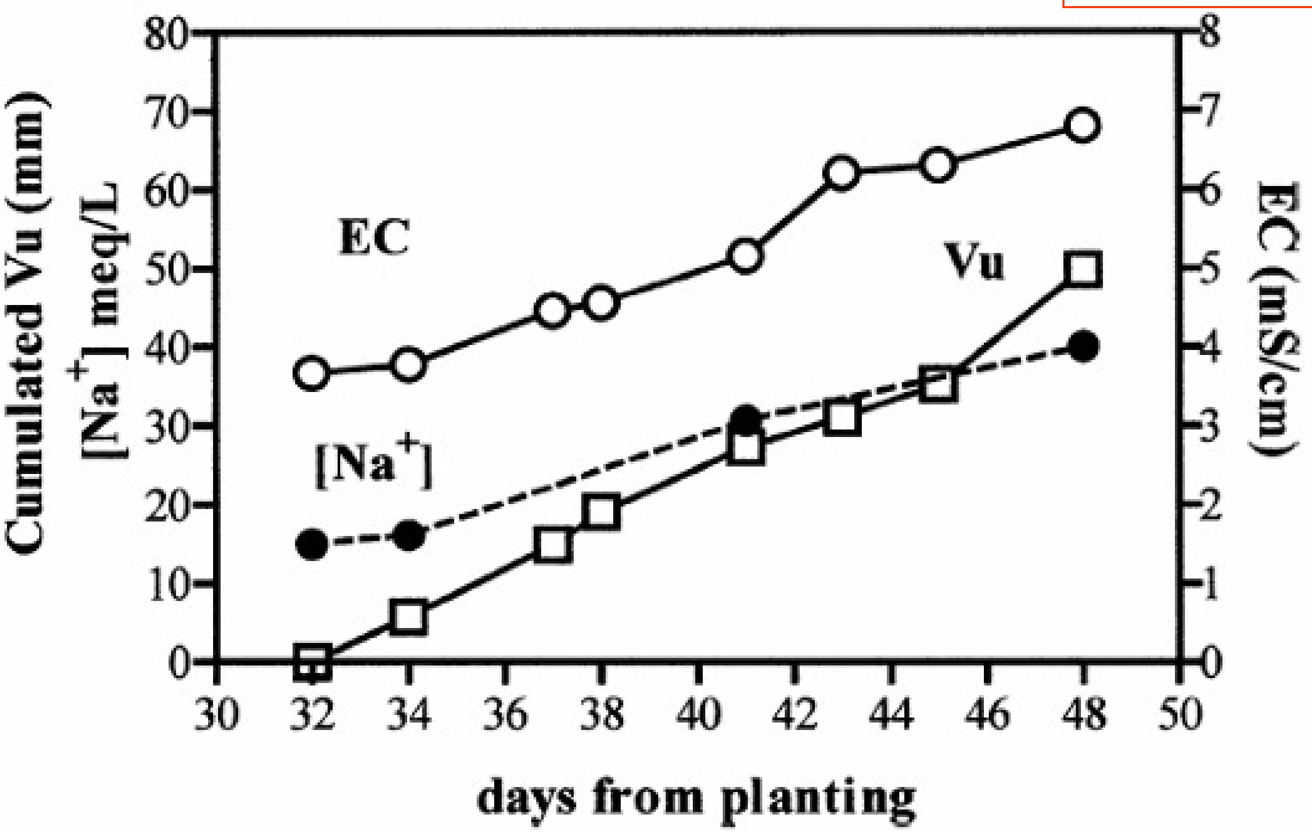
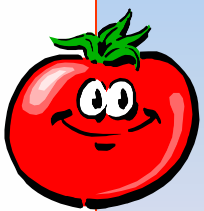


Figure 2. Changes in crop water uptake (V_U), electrical conductivity (EC) and Na^+ concentration of the recirculating water in closed-loop rockwool cultures of tomato. Data from a representative experiment (Experiment 4, Table 1) conducted using irrigation water with 10 meq/L NaCl concentration.



B toxicity

Greenhouse experiment (1): tomato and boron.

- Growing period: **mid March – late August 2009**
- Tomato cv. Caramba (beef-steak); **13 trusses.**
- Recycling water substrate culture with **perlite bags**.
- EC threshold for flushing: **6.0 dS/m**

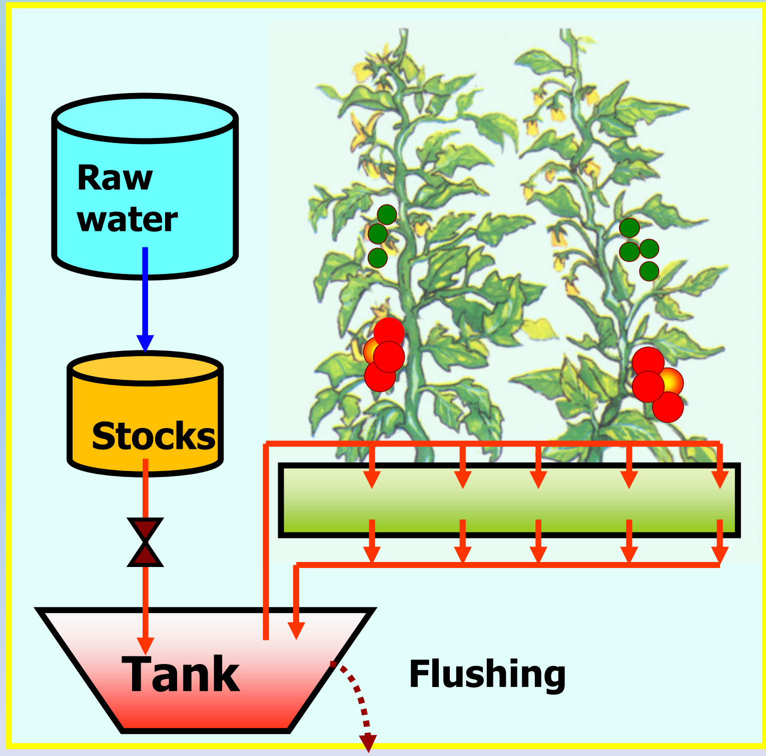
Treat.	Mean EC (dS/m)	Mean [B] (mg/L)	Fruit dry matter (%)	**Fruit yield (Kg/m^2)**	Fruit size (g/fruit)	**Leaf scorch (%)**
LS-LB	3.6	0.99	5.54	**21.7**	187.3	**1.2**
LS-HB	3.5	6.55	5.79	**20.5**	173.7	**24.5**
HS-LB	4.8	0.78	6.11	**19.3**	180.4	**-**
HS-HB	4.3	5.20	5.61	**19.7**	168.7	**15.0**

LS-LB = low EC + low [B]
LS-HB = low EC + high [B];
HS-LB = high EC + low [B]
HS-HB = high EC + high [B];

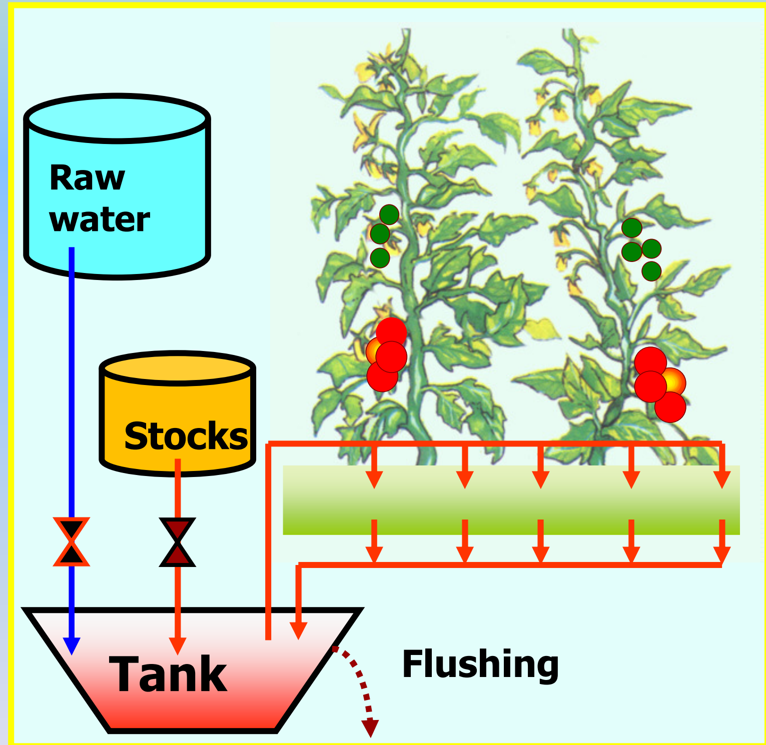
Greenhouse experiment (2): tomato and boron.

Fertigation strategies in tomato soilless culture (1):

Semi-closed systems



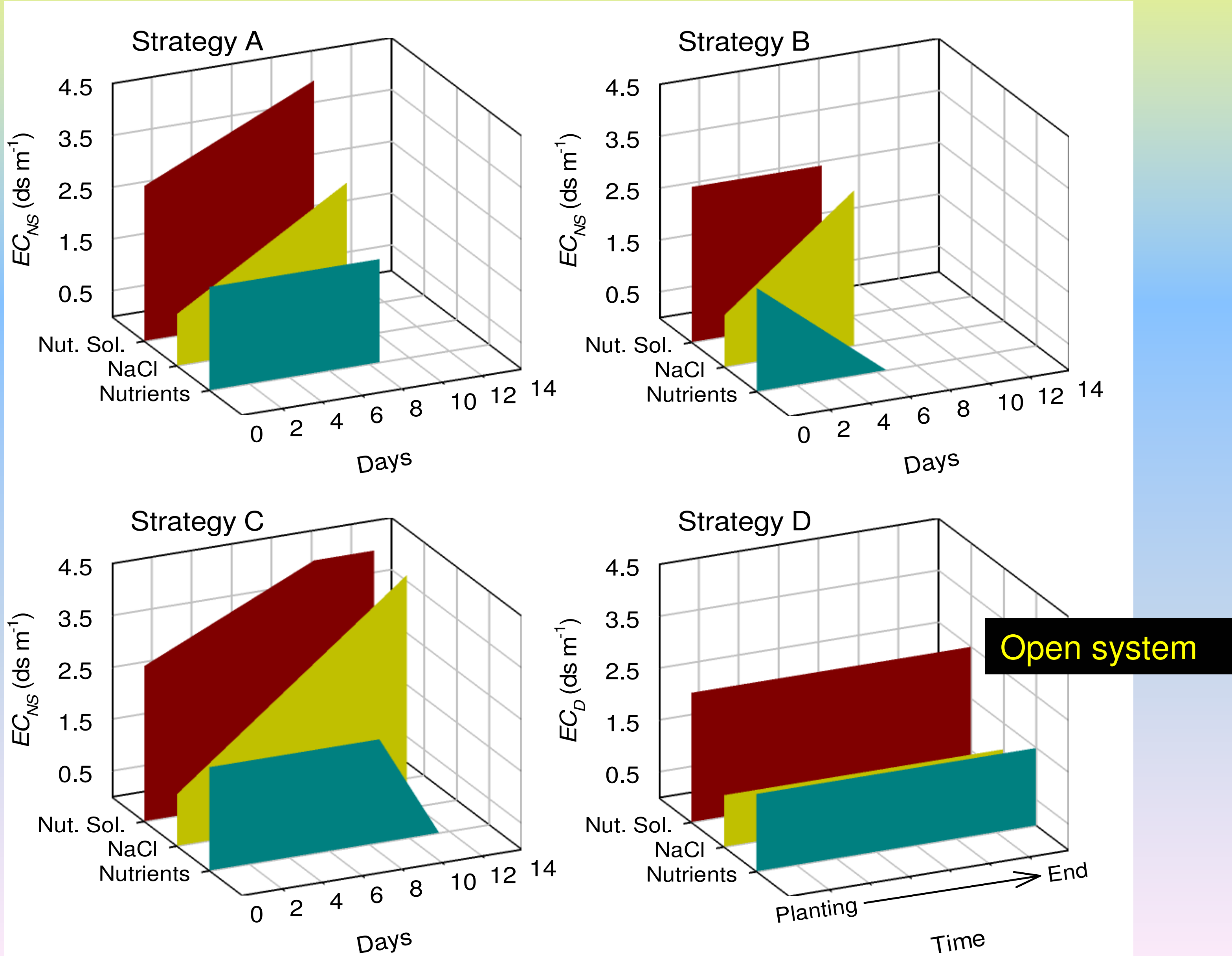
Strategy A



Strategy B

Fertigation strategies in tomato soilless culture (2):

Semi-closed vs open systems

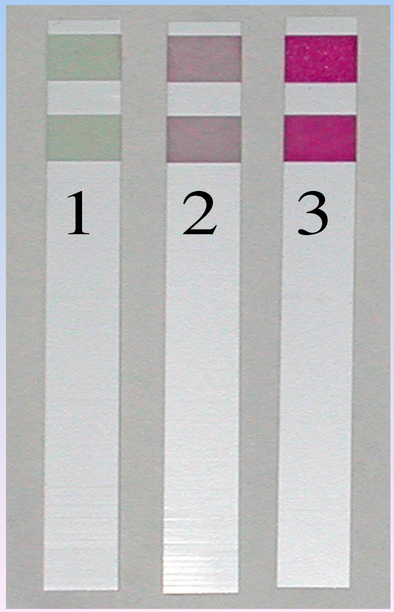


Fertigation strategies in tomato soilless culture (3)

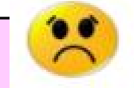
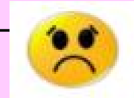
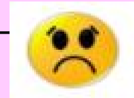
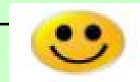
	Strategy A	Strategy B	Strategy C	Strategy D (open)
Experiment I				
Marketable yield (t ha^{-1})	99.2	90.2	90.8	99.2
Water use (m^3 ha^{-1})	5,477	6,108	5,006	10,841
N-NO_3^- use (kg ha^{-1})	600	398	477	1215
N-NO_3^- leaching (kg ha^{-1})	168	14	22	715
Experiment II				
Marketable yield (t ha^{-1})	188.0	200.1	182.9	
Water use (m^3 ha^{-1})	9,670	10,524	8,882	
N-NO_3^- use (kg ha^{-1})	1,250	587	684	
N-NO_3^- leaching (kg ha^{-1})	371	23	24	

- Tomato, cv Jama F_1, 3.0 pt m^{-2}, spring (85 days) or fall (167 days), 5 or 13 trusses
- Irrigation water with **10 mM NaCl** (**EC = 1.53 dS/m**)

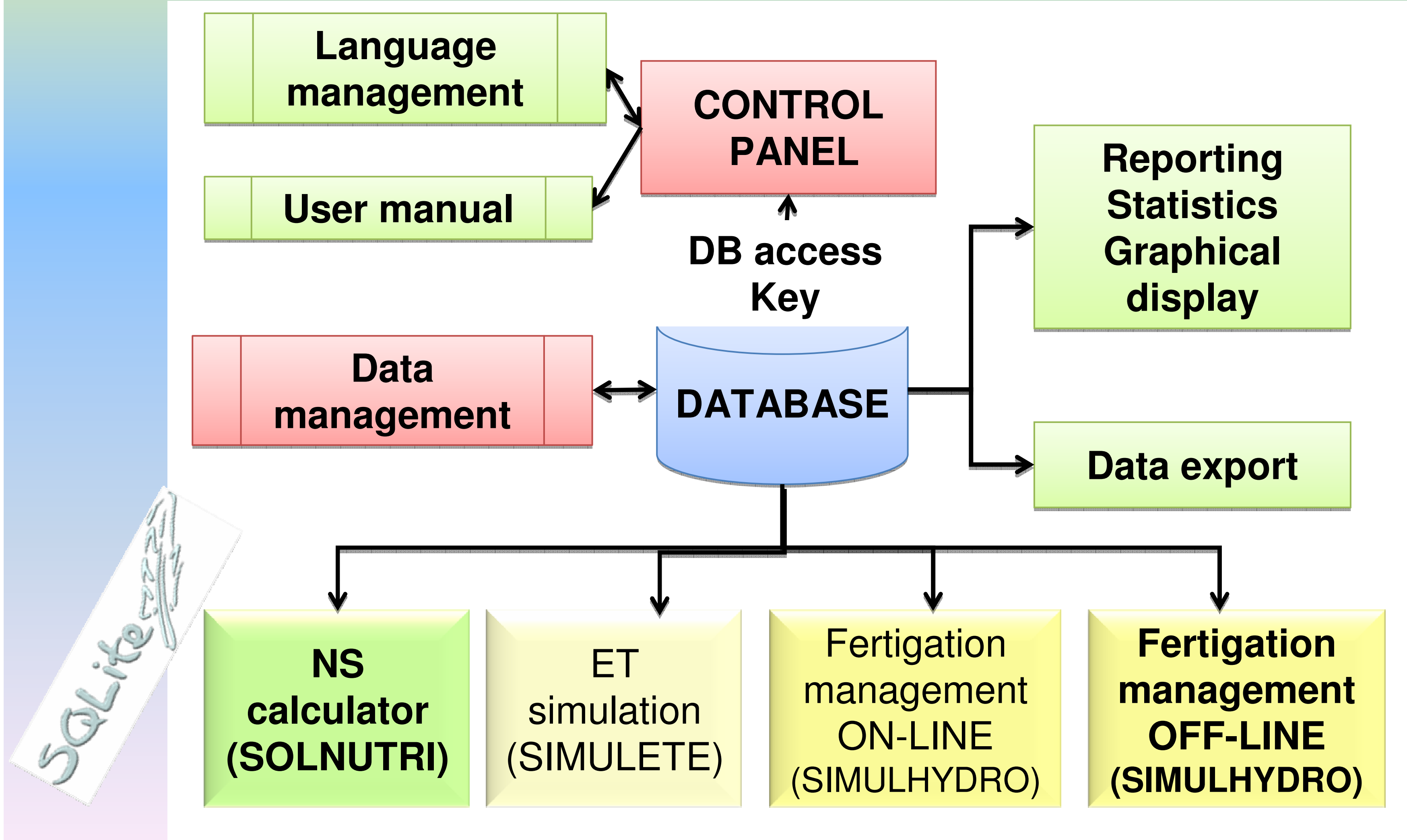
Monitoring nutrient solution (1)



Monitoring nutrient solution (2):
Evalutation of quick tests

Element/ion	Method	Range (mg/L)	Reliability
Ammonium	Reflectometry	0 – 7	
Boron	Titration	0 – 5	
Potassium	Reflectometry	1 - 15	
Chloride	Reflectometry	50 - 1000	
Nitrate	Reflectometry	0 - 225	
Phosphate	Reflectometry	5 - 120	 **(<80 mg/L)**

Fertigation DSS (1)



Fertigation DSS (2): main routines.

NS Calculator

Irrigation water

Crop nutrient solution (NS)

Reference nutrient solution

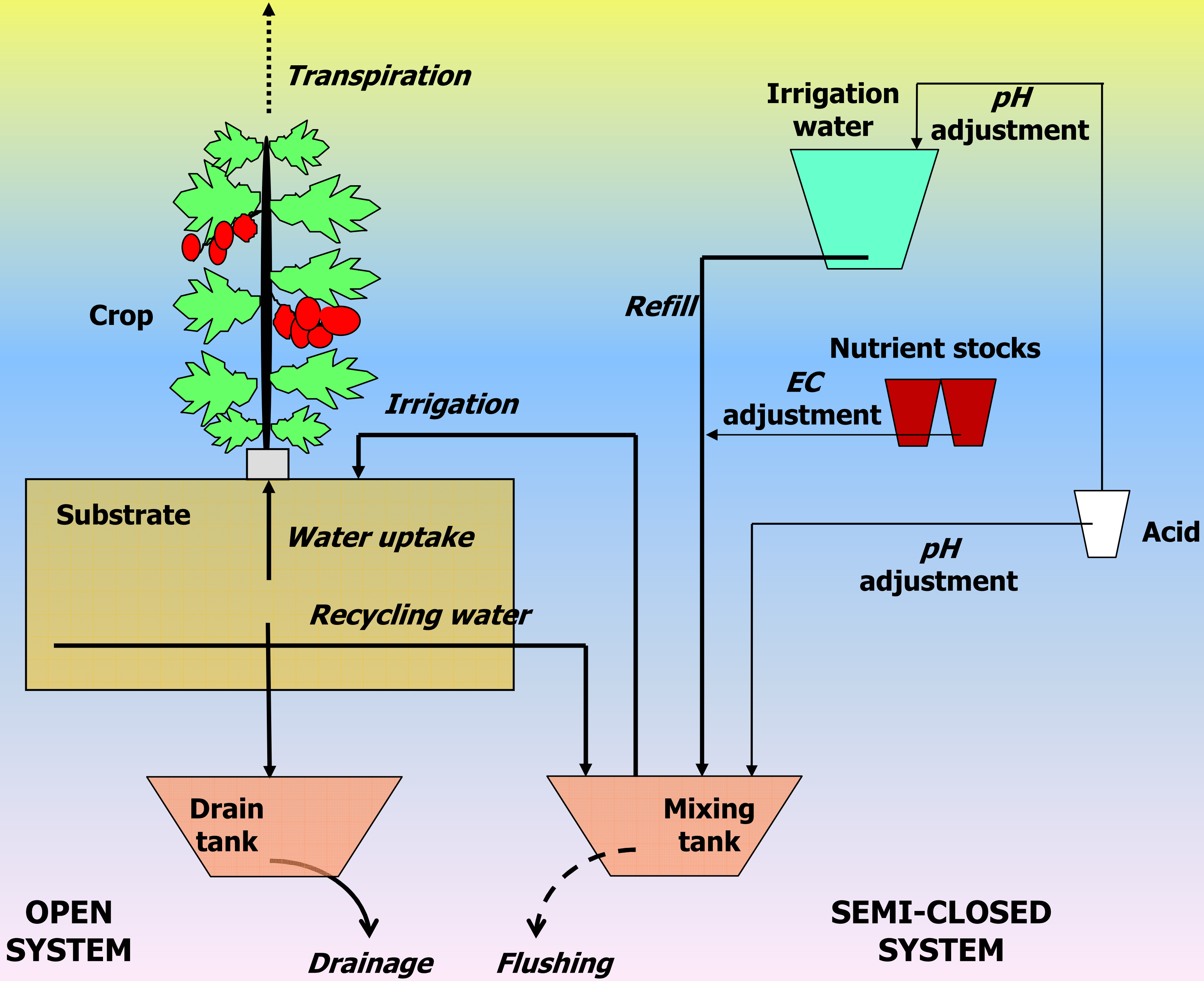
Crop water and mineral uptake

Drainage NS

Fertigation strategy

NS Simulator

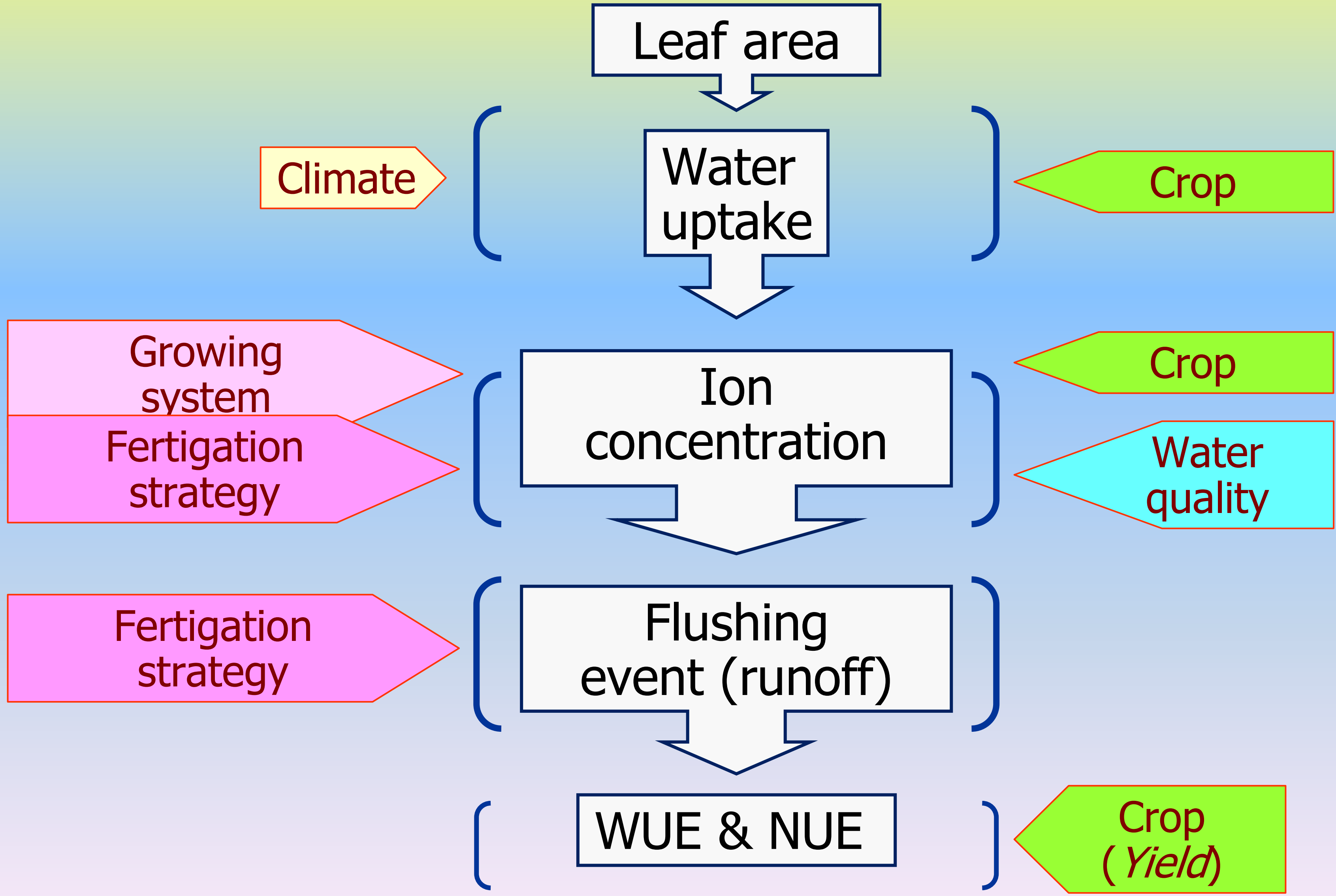
Fertigation DSS (3): system layout



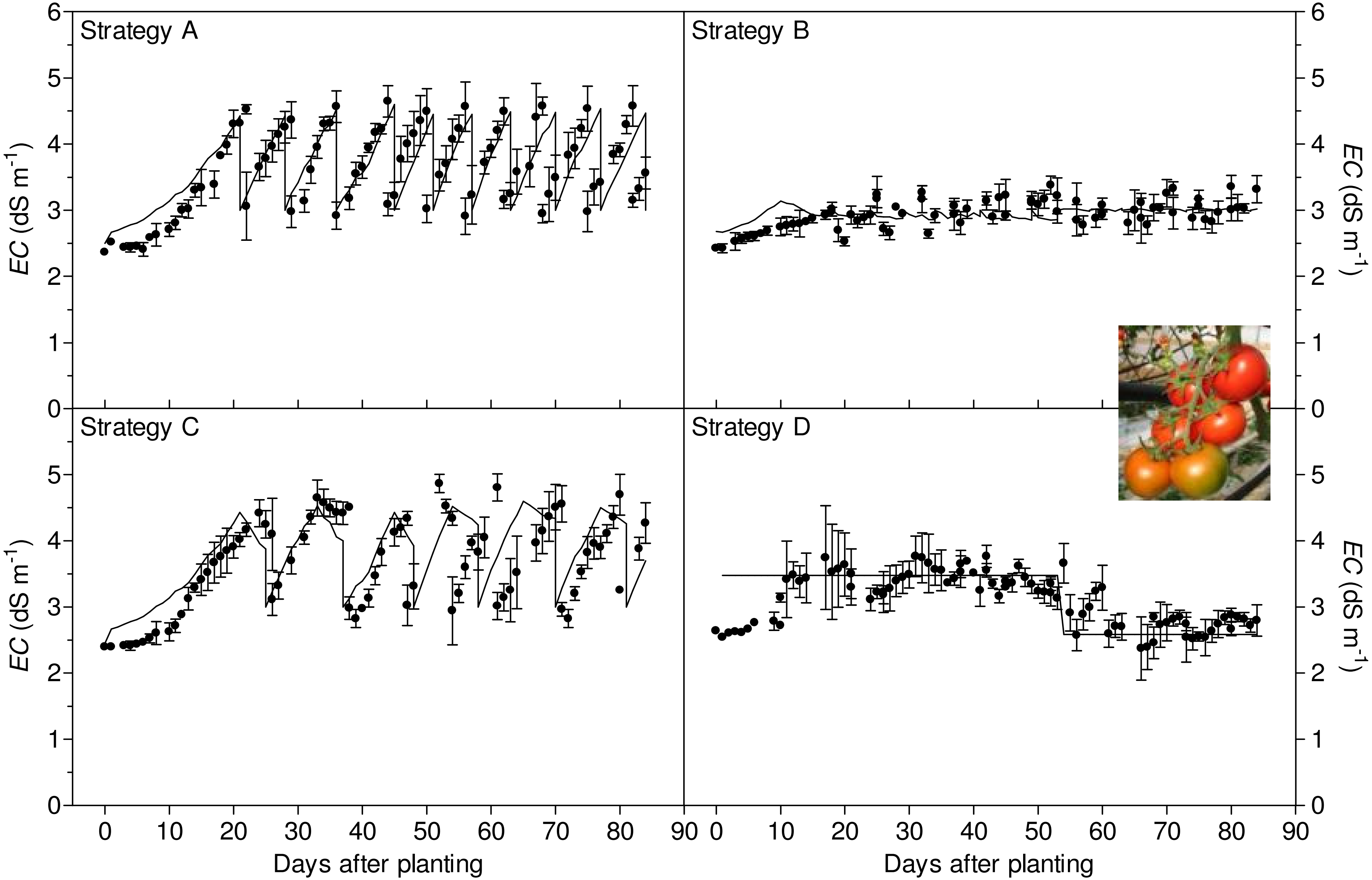
Fertigation DSS (3): model description.

Input

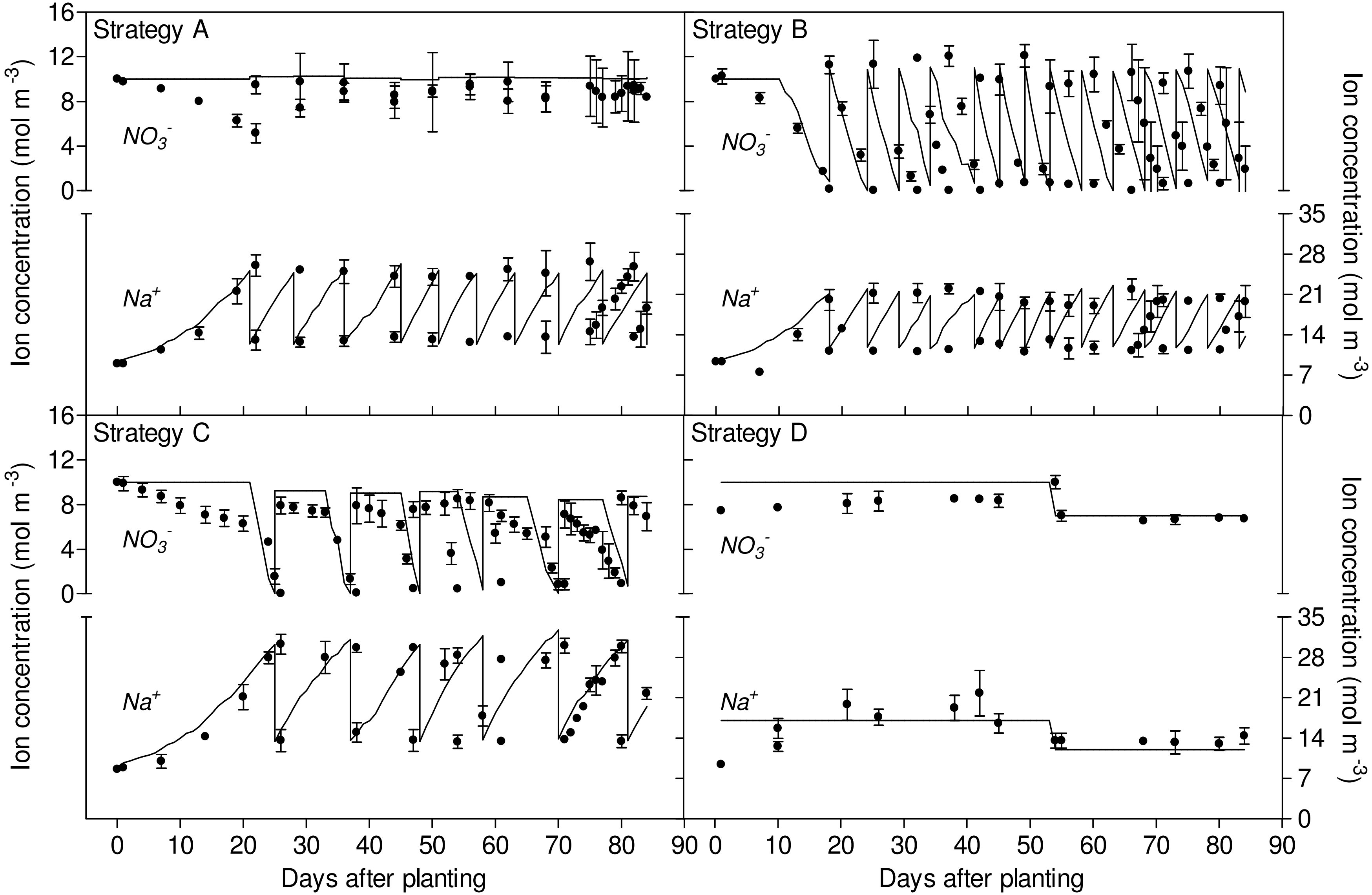
Output



Fertigation DSS (3): model validation (EC).



Fertigation DSS (3): model validation (ion content).



Conclusions

- ✓ Closing irrigation loop is feasible.
- ✓ Monitoring nutrient solution is necessary.
- ✓ Fertigation strategy may be adapted to growing conditions.
- ✓ Quick tests are suitable for NS monitoring.
- ✓ Simulation models are useful (off-line) management tool (off-line management)

Thank you very much!

Dip. Biologia Piante Agrarie – Villa Victorine (Le Piagge, Pisa)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