Optimizing nutrition and climate

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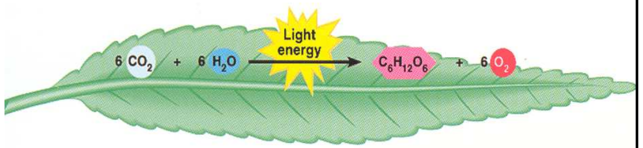
Content

- Climate→ growth → nutrient demand
- Nutrient uptake concentration
- Air humidity
- EC
- pH
- Conclusions

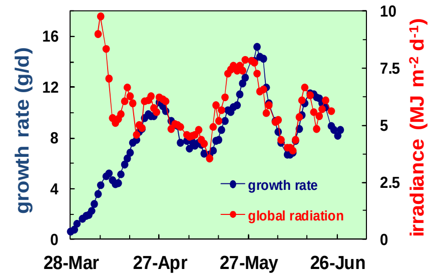
Climate → growth → nutrient demand

Plant growth strongly depends on climate (unless insufficient nutrients)

- Light is driving force
- Light is absorbed by leaves
  → photosynthesis
  → sugars
  →growth of root, stem, leaf, flower, fruit

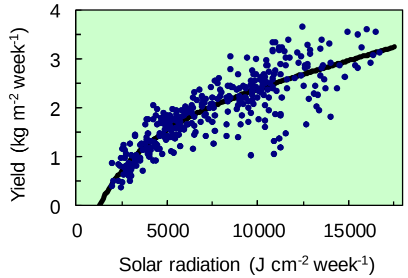


Time course of plant growth follows that of radiation

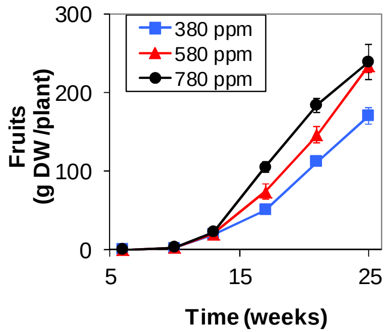


Growth and yield depend on radiation

Data from 14 growers during 17 months



Effect of CO_2 concentration on fruit production in sweet pepper



From: Dieleman et al,

Climate determines potential growth of plant organs

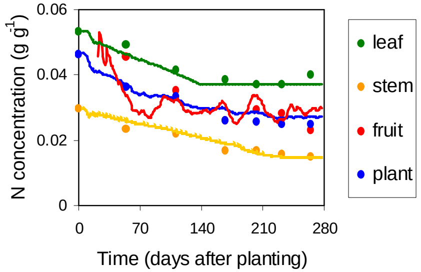
- Growth of plant organs determines the needed amount (gram per plant) of nutrient uptake

Climate determines <u>potential</u> growth of plant organs

- Growth of plant organs determines the needed amount (gram per plant) of nutrient uptake
- Climate determines amount of needed nutrients

Nutrient demand of plant

- Needed uptake depends on growth and concentration of each organ
- $Upt = c_{leaf} * Mass_{leaf} + c_{stem} * Mass_{stem} + c_{fruit} * Mass_{fruit} + c_r * Mass_r$



From: Marcelis et al, 2005. Acta Hort. 691

Effects of climate on nutrient concentration

Light, CO_2 and temperature

- strong effects on growth
- Limited effects on (demanded) nutrient concentrations in plant
  - High light: N concentration slightly lower

Active uptake of nutrients (e.g. N,P,S, K)

- As long as nutrients at root surface:
  - uptake according to needs of plant
- When nutrients at root surface are limited:
  - More water uptake may lead to more nutrient flow towards roots

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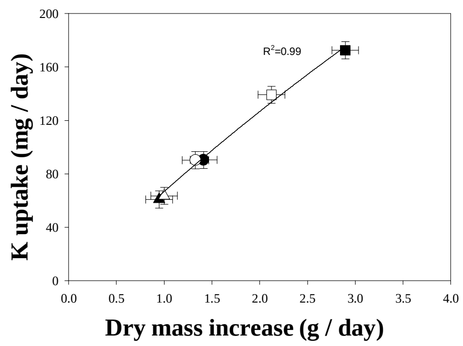
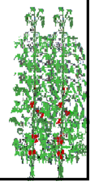
Potassium uptake related to growth rate





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From: Del Amor & Marcelis

Passive uptake of nutrients (e.g. Ca, Mg)

- Uptake strongly dependent on
  - Water uptake (transpiration)
  - Root tips
  - Ratio between ions
- Nutrient distribution in plant related to water flow

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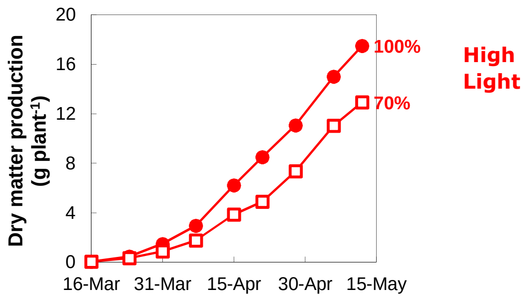
At high growth rates, plants more vulnerable to low nutrient supply

N supply in lettuce: 70% of demand



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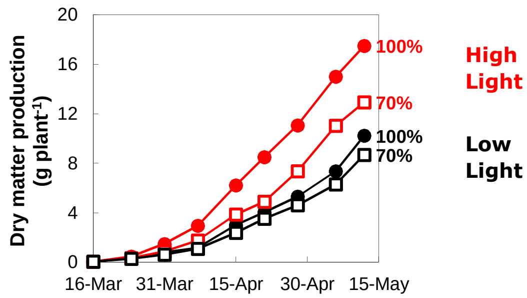
From: Henriques & Marcelis, 2000

At high growth rates, plants more vulnerable to low nutrient supply

N supply in lettuce: 70% of demand



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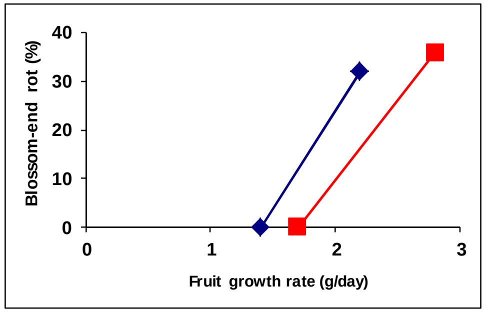
From: Henriques & Marcelis, 2000

Blossom-end rot

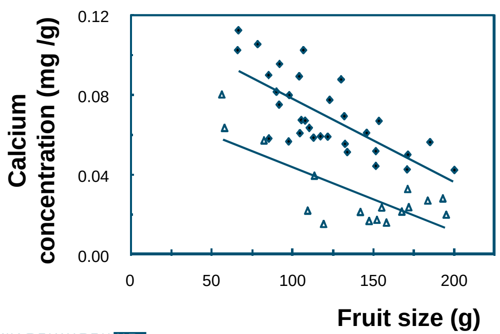
More blossom-end rot when high fruit growth rate in sweet pepper

e.g. high temperature x radiation



From: Marcelis and Ho, 1999

High fruit growth rate → low calcium concentration



From: Marcelis and Ho, 1999

Summary on nutrient demand

- Climate affects growth rate
- Higher growth rate → higher demand of all nutrients
- Transpiration important for water uptake
  - → Important for passive uptake (Ca, Mg)
- High growth rate: more vulnerable to nutrient shortage

Nutrient uptake concentration
(Ratio nutrient uptake : water uptake)

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Water supply is often based on radiation.
How is water uptake related to radiation?

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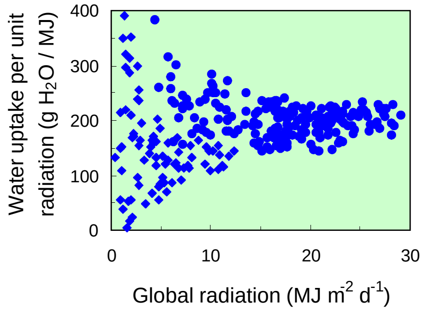
How is water uptake related to radiation?



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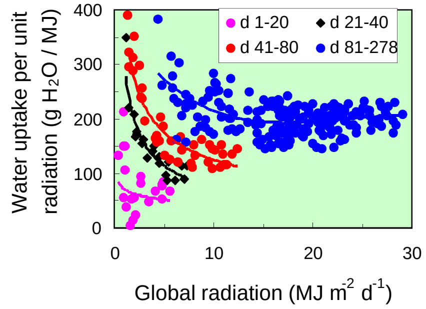
Water supply is often based on radiation.
How is water uptake related to radiation?
(four periods from planting)



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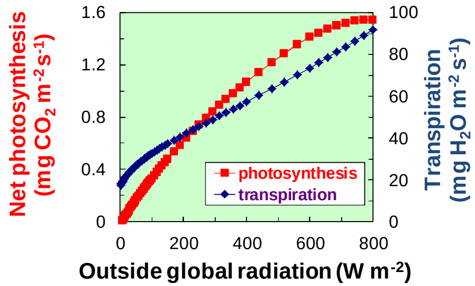
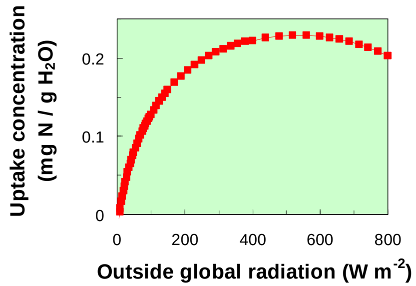
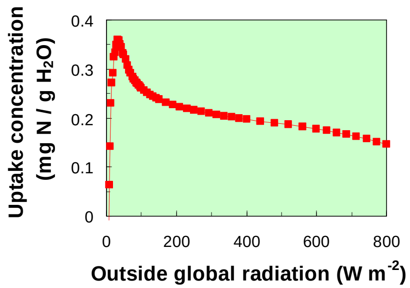
Effect of radiation on photosynthesis and transpiration



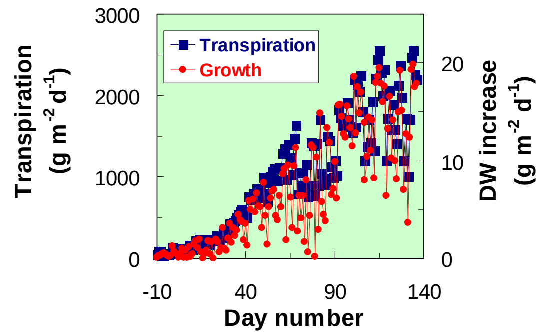
Effect of radiation on N uptake concentration (ratio N uptake : water uptake)



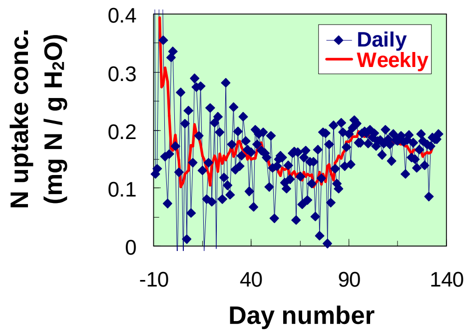
Increase radiation <u>and</u> decrease humidity: effect on N uptake concentration

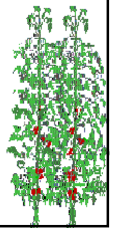


Daily transpiration and growth



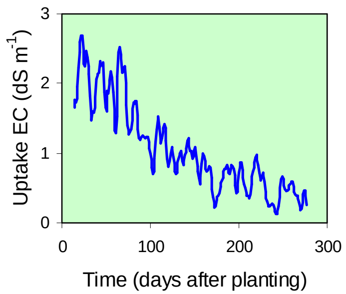
Nutrient uptake concentration is not constant



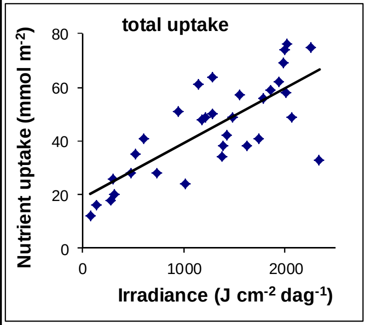


EC of the water taken up by plants

(ratio nutrient uptake to water uptake)

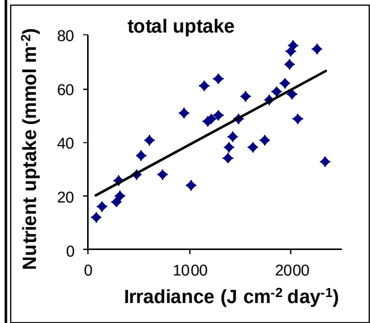


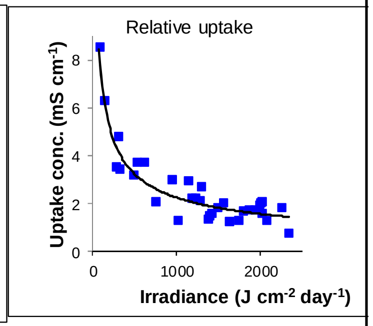
Nutrient uptake relates to radiation



Nutrient uptake relates to radiation

EC of the water taken up drops at high radiation





Air humidity

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Low air humidity stimulates
→transpiration
→ water uptake
→nutrient transport to roots

Air humidity

Low air humidity stimulates
→transpiration
→ water uptake
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→passive uptake (Ca, Mg)
→Ca, Mg in high transpiring parts (leaves)
→less Ca, Mg in fruits, meristems, leaf tips

Tipburn
Insufficient calcium in leaf tips

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- High air humidity night → less tipburn
- Long night → less tipburn
  - High root pressure → more Ca in leaf tips

From: Peter Bleyaert
Inagro, Belgium

Tipburn
Insufficient calcium in leaf tips

- High air humidity night → less tipburn
- Long night → less tipburn
  - High root pressure → more Ca in leaf tips
- Supplementary light
  - Contradictory results
  - (in tomato more tipburn)

From: Peter Bleyaert
Inagro, Belgium

EC

EC

- EC= Electrical Conductivity
- Measure for total nutrient concentration
- High EC → high osmotic pressure

Too low EC

- Nutrient shortage
- Weak plants

High EC

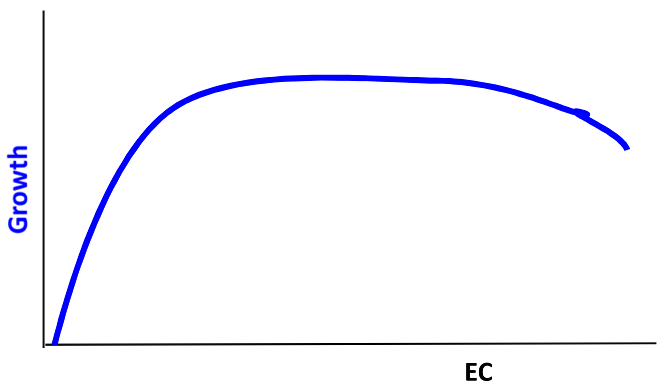
- Salt stress
- High osmotic pressure
- Water shortage

High EC

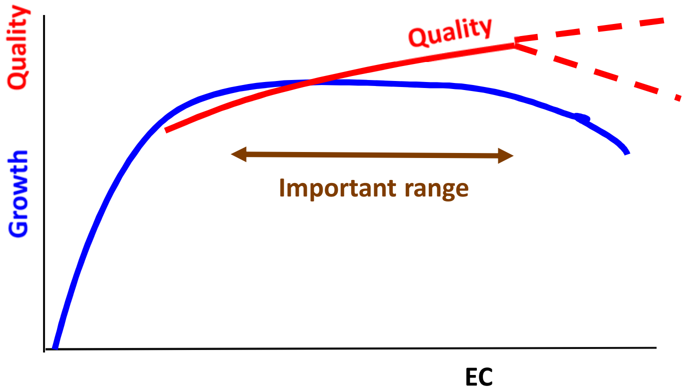
- Salt stress
- High osmotic pressure
- Water shortage

- Less water uptake
- Yield reduction
- Firm tissue (plant, fruit)
- Physiological problems related to calcium
  (Blossom-end rot, tipburn, leaf necrosis)
- High dry matter percentage
- Better taste

Plant response to EC

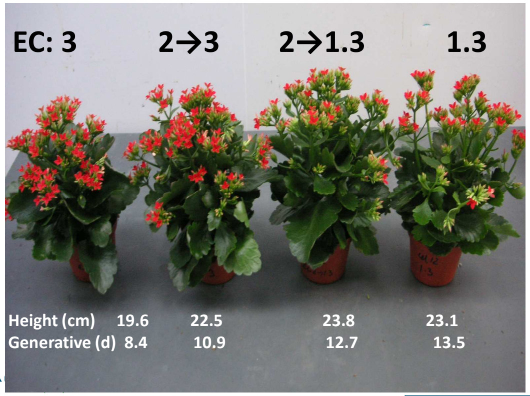


Plant response to EC



High EC in kalanchoe

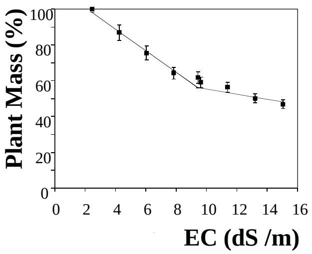
Earlier flowering, compact plant

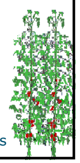


From: Heuvelink et al.

High EC (salinity)

→ less growth, more roots





From: DePascale, Univ Naples

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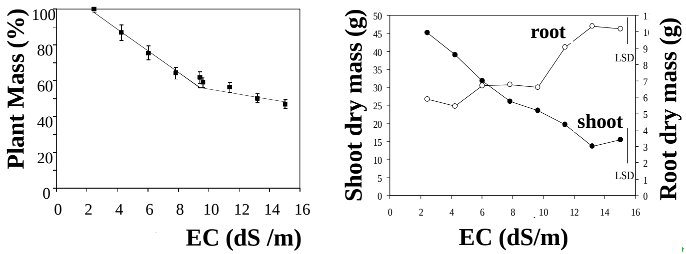
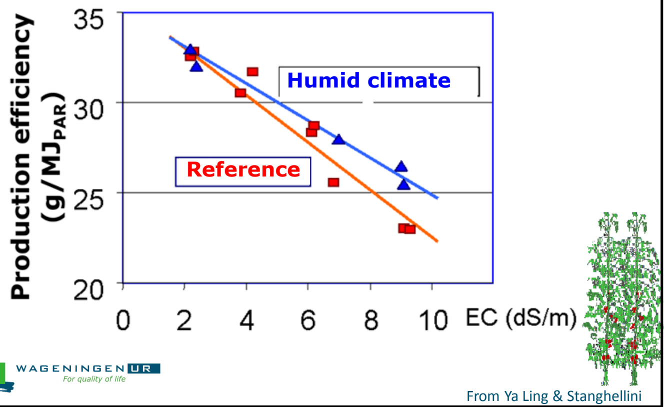


From DePascale, Univ Naples

Negative effect of high EC smaller at high air humidity



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From Ya Ling & Stanghellini

Effect of EC on tomato quality

	EC 2.6	EC 3.5
Fruit yield (kg m^{-2})	12.7	11.9
Shelf life (days)	17.5	19.2
Acids in fruit sap (mmol l^{-1})	75	84
Refraction in fruit sap (% Brix)	4.8	5.0

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From: Sonneveld and Welles, 1988.

EC: all nutrients or NaCl

EC increased by

- Nutrients: all nutrients increased proportionally
- NaCl: above EC 2.3 all is NaCl

	Tomato yield (%)	
EC (dS/m)	Nutrients	NaCl
2.5	100	100
3.7	94	95
5.2	83	84

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EC: all nutrients or NaCl

EC increased by

- Nutrients: all nutrients increased proportionally
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	Tomato yield (%)		Cucumber yield (%	
EC (dS/m)	Nutrients	NaCl	Nutrients	NaCl
2.5	100	100	100	100
3.7	94	95	92	91
5.2	83	84	78	74

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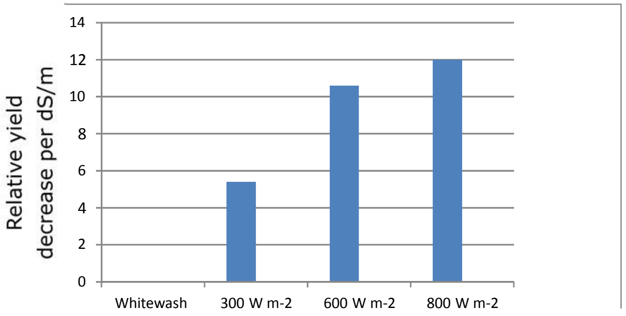
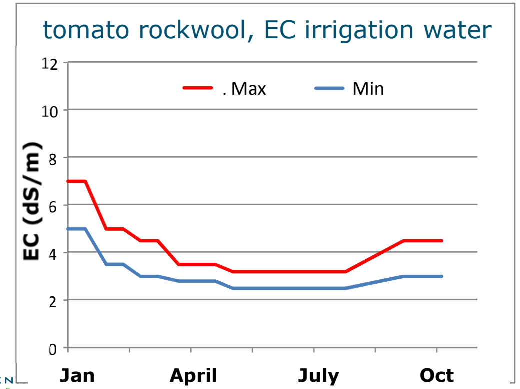
Effect of high EC larger at high radiation (cyclamen)



Left to right: less screening (=more radiation)

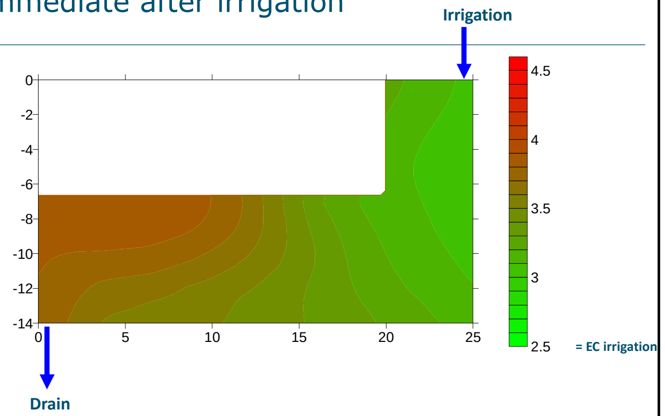
From: Verberkt, 1997)

EC recommendation depends on season



EC distribution in rockwool slab

Immediate after irrigation



From: Heinen, Alterra. Wageningen

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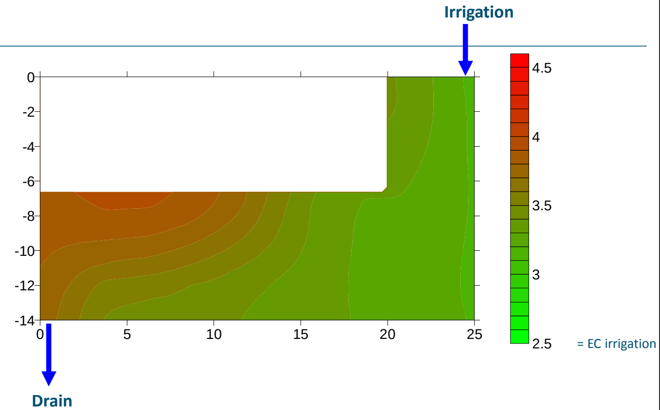

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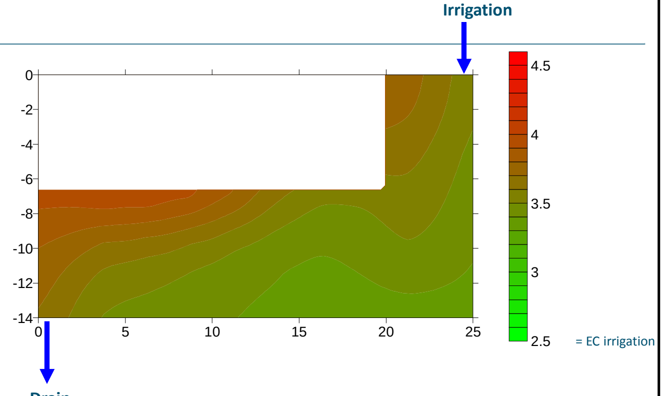

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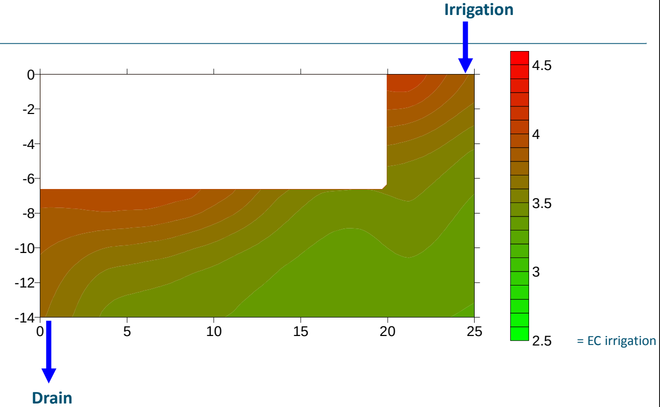

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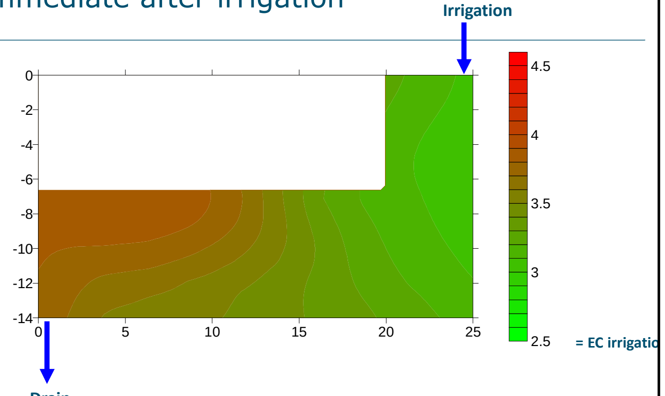

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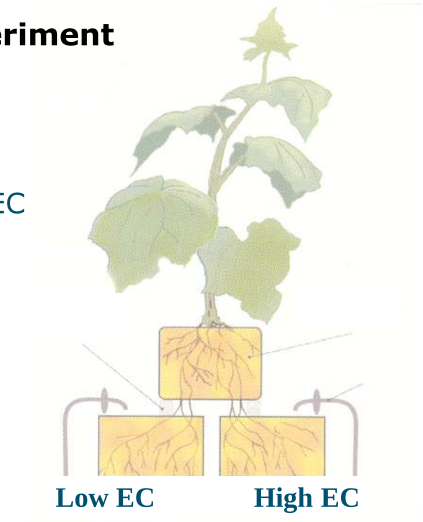
From: Heinen, Alterra. Wageningen

Split root experiment

Two root parts
Each a different EC



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Effects of two root halves with different EC (split-root)

EC	Yield (kg/m²)	Yield (%)
2.5 / 2.5	24.0	100
5.0 / 5.0	21.1	88
5.0 / 2.5	23.7	99

From: Sonneveld (2000)

Effects of two root halves with different EC (split-root)

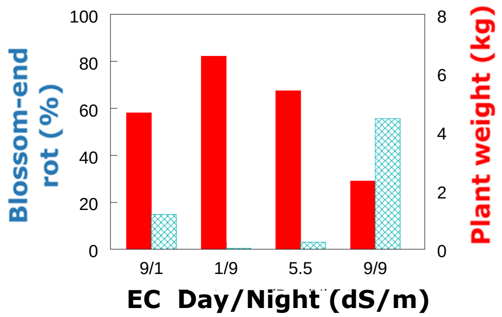
EC	Yield (kg/m²)	Yield (%)
2.5 / 2.5	24.0	100
5.0 / 5.0	21.1	88
5.0 / 2.5	23.7	99

Uniform EC distribution not that necessary.
Response most related to low EC spots (close to drip irrigation)

From: Sonneveld (2000)

EC: Day versus night

- Daytime: lower EC to ease water uptake
- Night: higher EC for sufficient nutrients



From: Wim van Ieperen

pH

pH

- pH = - log [H^+]   Where [H^+] in mol/l
- Low pH → high acidity

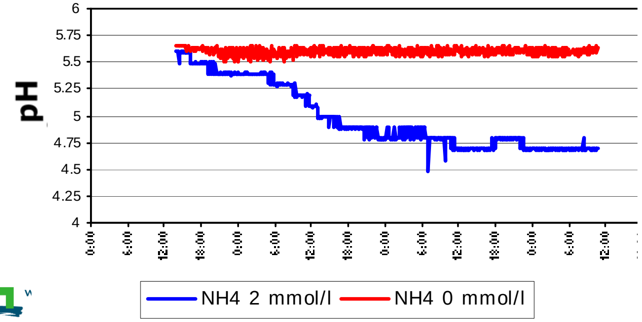
Important for
- Availability of nutrients (pH 5-6)
- Precipitation
- Blocking irrigation system

pH decrease in standing nutrient solution with ammonium (NH_4)

pH decrease by conversion of NH_4

→ NO_3 (nitrification)

→ NH_3 (volatilisation at high pH)

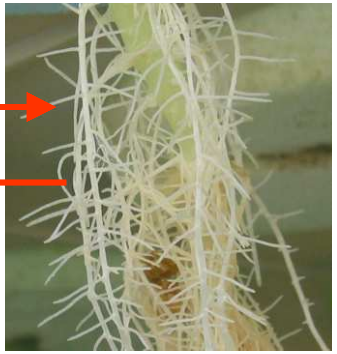


NO_3 uptake affects pH at roots

NO_3 →

← OH^- (HCO_3^-)

pH increase

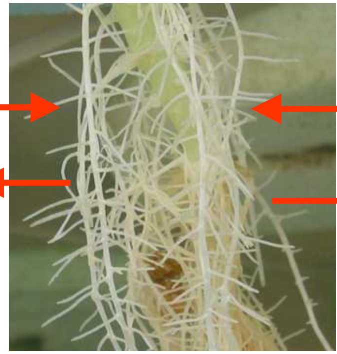


NH_4 and NO_3 uptake affects pH at roots

NO_3 →

← OH^- (HCO_3^-)

pH increase

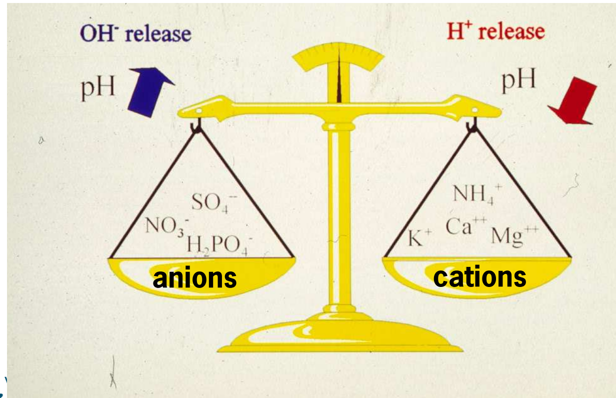


← NH_4

→ H^+

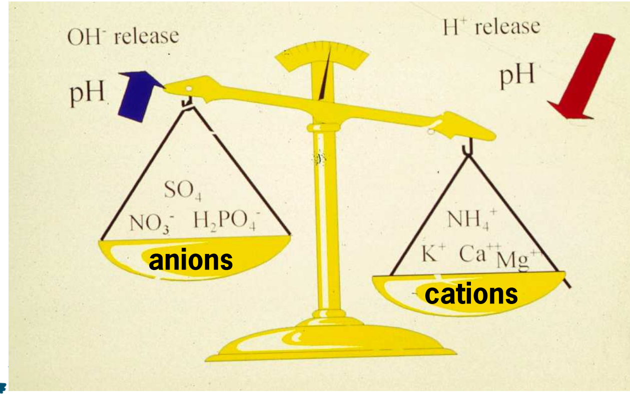
pH decrease

The ion uptake balance



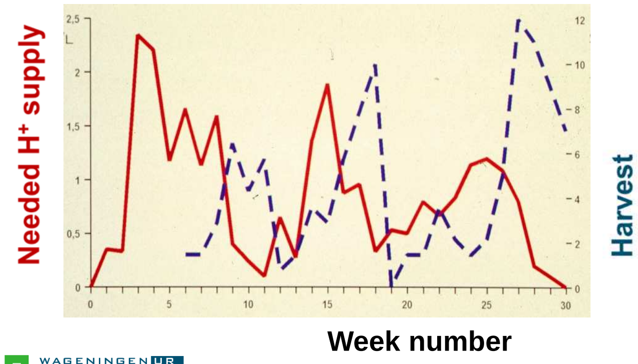
Fluctuations in ion uptake balance

Heavy fruit load tomato → high K uptake



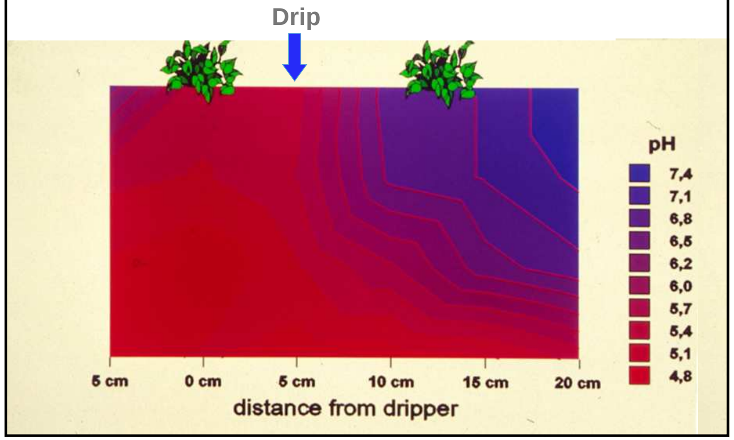
pH fluctuations in cut roses.

Growth in flushes → flushes of NO_3 uptake



pH distribution in rockwool

(NH_4 uptake near dripper)



Rockwool decomposition at low pH (4)

Conclusions

- Climate affects growth of organs
- Higher growth rate: higher demand of all nutrients
- Ratio nutrient : water uptake varies
- EC
  - Too low→ nutrient shortage
  - Too high→ water shortage (-yield, +-quality)
- pH at roots: balance between cations-anions (NH_4 versus NO_3 supply)

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Questions?

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