Nutrient management of greenhouse grown fruit-vegetables

Wim Voogt, Wageningen UR Greenhouse Horticulture

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Intensive horticulture in the Netherlands

Important issues

- Total nutrient demand
- Nitrogen
- pH root environment
- Crop stage dependent uptake
- Fruit quality K and EC
- Ca problems

Fruit vegetables

- Tomato
- Sweet pepper
- Cucumber
- Egg plant
- Hot pepper
- Melon
- Beans

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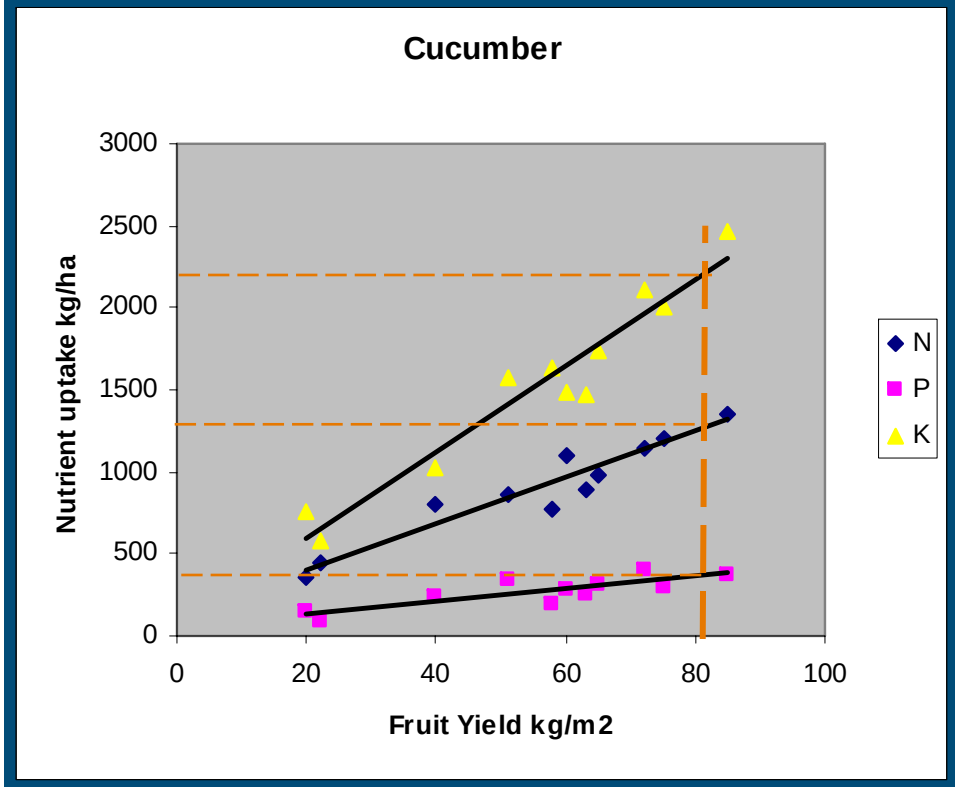
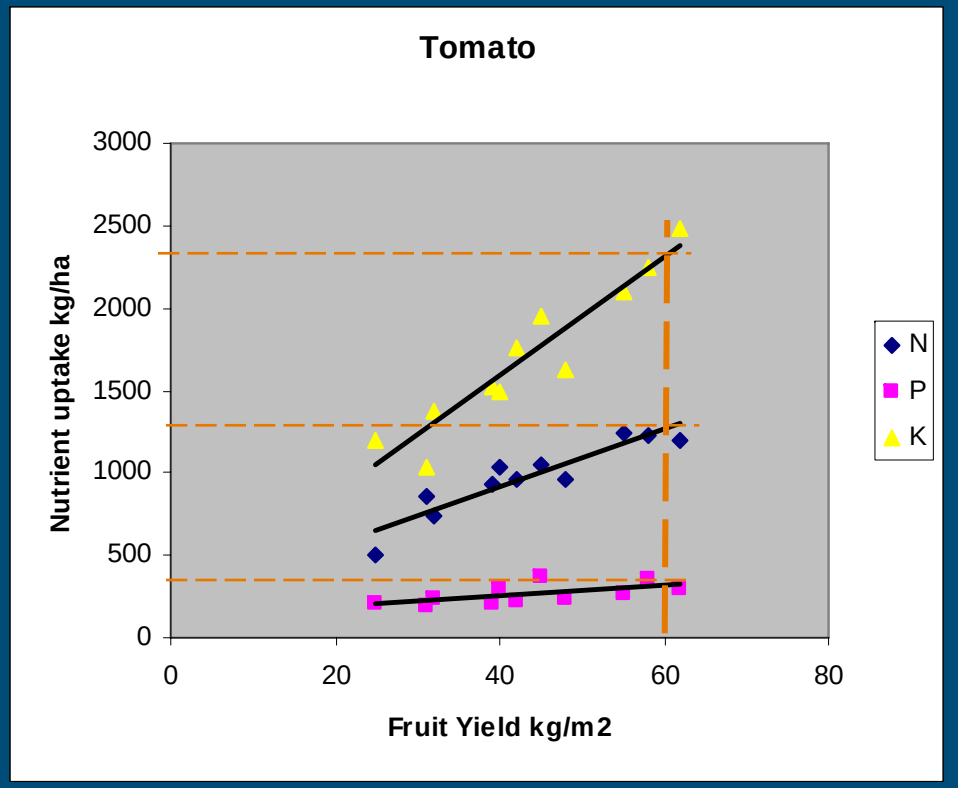
Fruit vegetables characteristics

- Vegetative and generative stage
- Long lasting crops
  - 6 months (cucumber)
  - 14 months (sweet pepper)
- High nutrient demands, K in particular
- Fertilisation - fruit quality
- Ca related problems (Solanaceae)

Total nutrient demand





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Nitrogen

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Nitrogen uptake and translocation

- NO_3 uptake
  - preferential N-source
  - uptake, metabolic process (energy)
  - influx - efflux regulation (energy)
  - low pH uptake increase
  - temperature dependent

- NH_4 uptake
  - secondary N-source
    - (application often is NO3 uptake)
  - Rapid uptake
  - Non -metabolic process (?)
  - low pH strong reduction in uptake
  - high pH toxic (NH_3)
  - Less temperature dependent

NH_4 ⌦ NO_3 interactions

- High NH_4 depresses NO_3 uptake
- Zero NH_4 depresses NO_3 uptake
- small quantities of NH_4 beneficial

Urea

- Organic N-form ($CO\text{-}(NH_2)_2$)
- converted to NH_4 -N in the soil
- small quantities absorbed by roots
- 4 times less effective than NO_3

NH_4 fertilisers

Chemical acid (weak base)

$$NH_4^+ + H_2O \leftrightarrow NH_3 + H^+ + H_2O$$

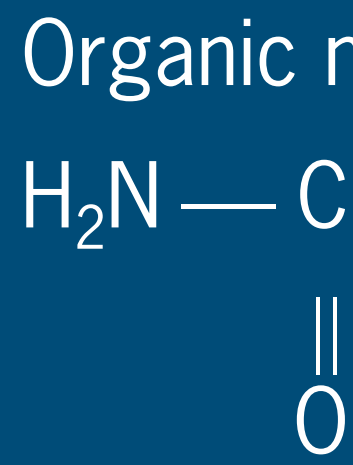
Bacteriologial acid

$$2\ NH_4^+ + 3O_2 \rightarrow 2\ NO_2^- + 4H^+ + 2H_2O \rightarrow$$

$$2\ NO_2^- + O_2 \rightarrow 2\ NO_3^-$$

Urea fertilisers

Organic nitrogen compound



$$Co(NH_2)_2 + 2H_2O \rightarrow (NH_4)_2\,CO_3$$

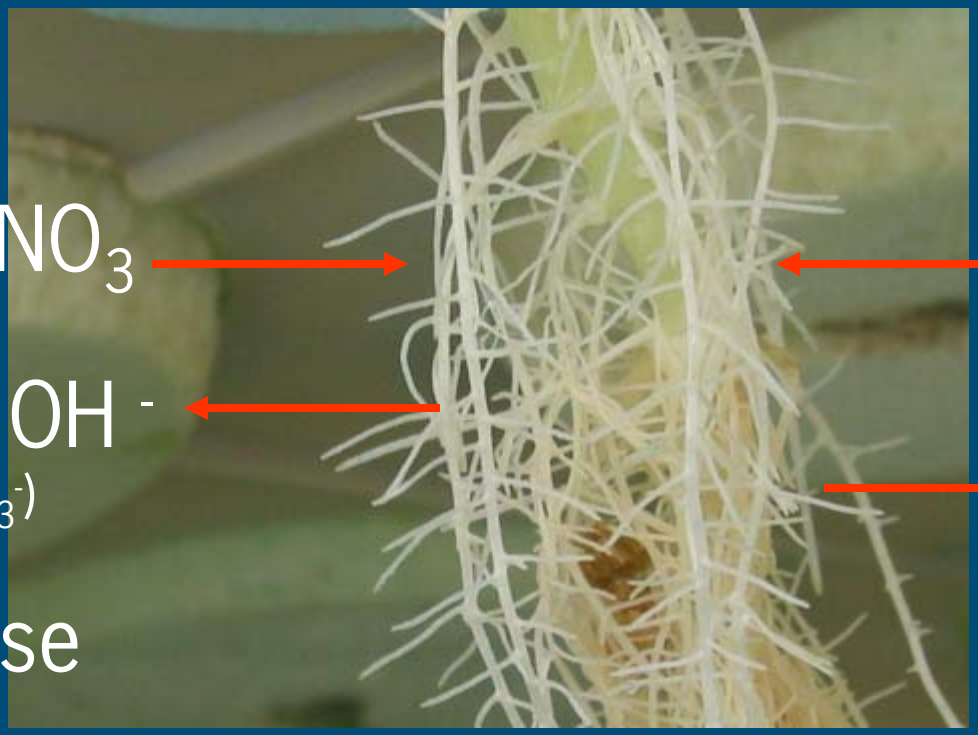
$$(NH_4)_2\,CO_3 \rightarrow 2NH_3 + CO_2 + H_2O$$

$$2NH_3 + 2H_2O \rightarrow 2NH_4^+ + 2OH^-$$

(Greenhouse) soils

Rapid conversion

NH_4 and NO_3 uptake effect



NO_3

OH^-

(HCO_3^-)

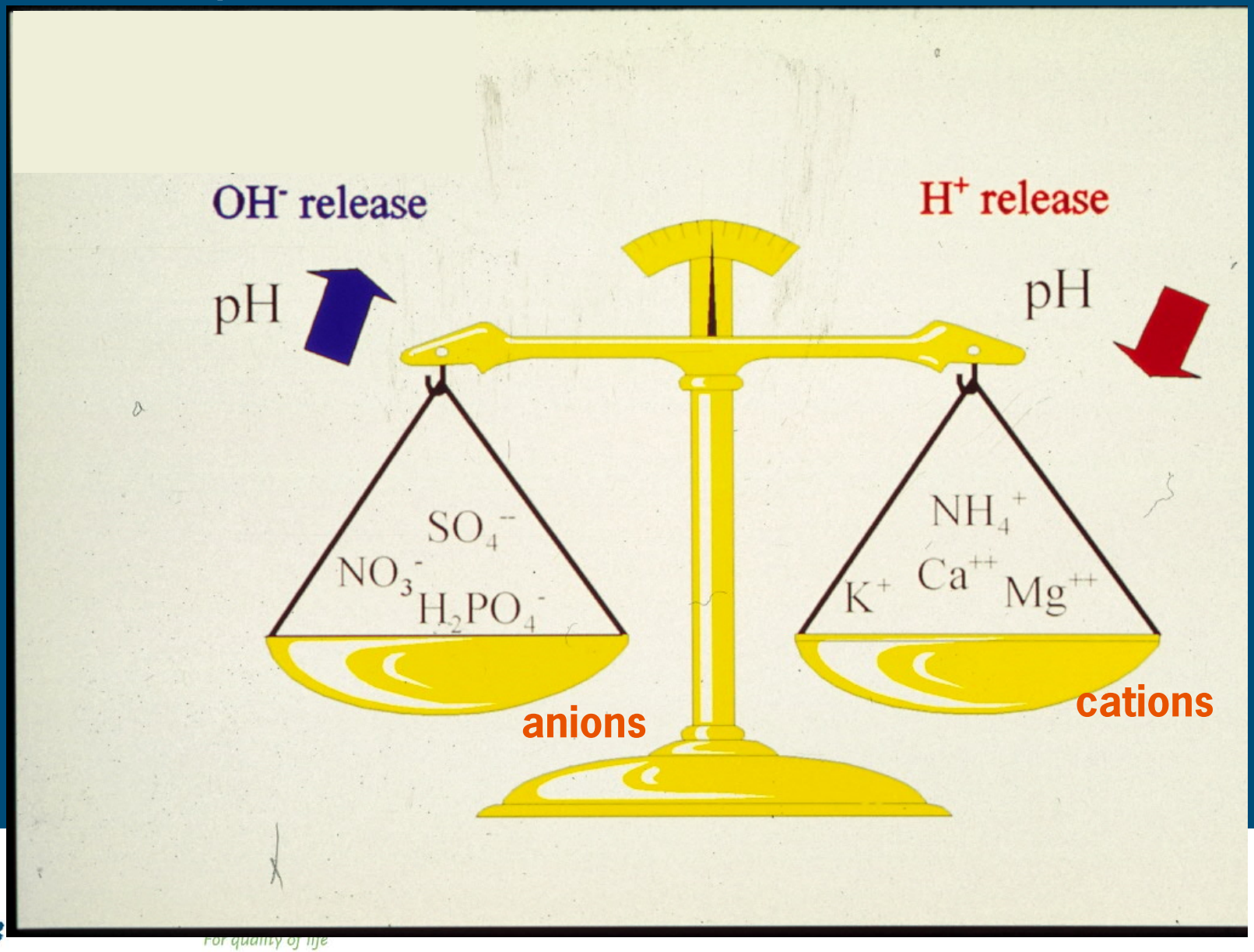
NH_4

H^+

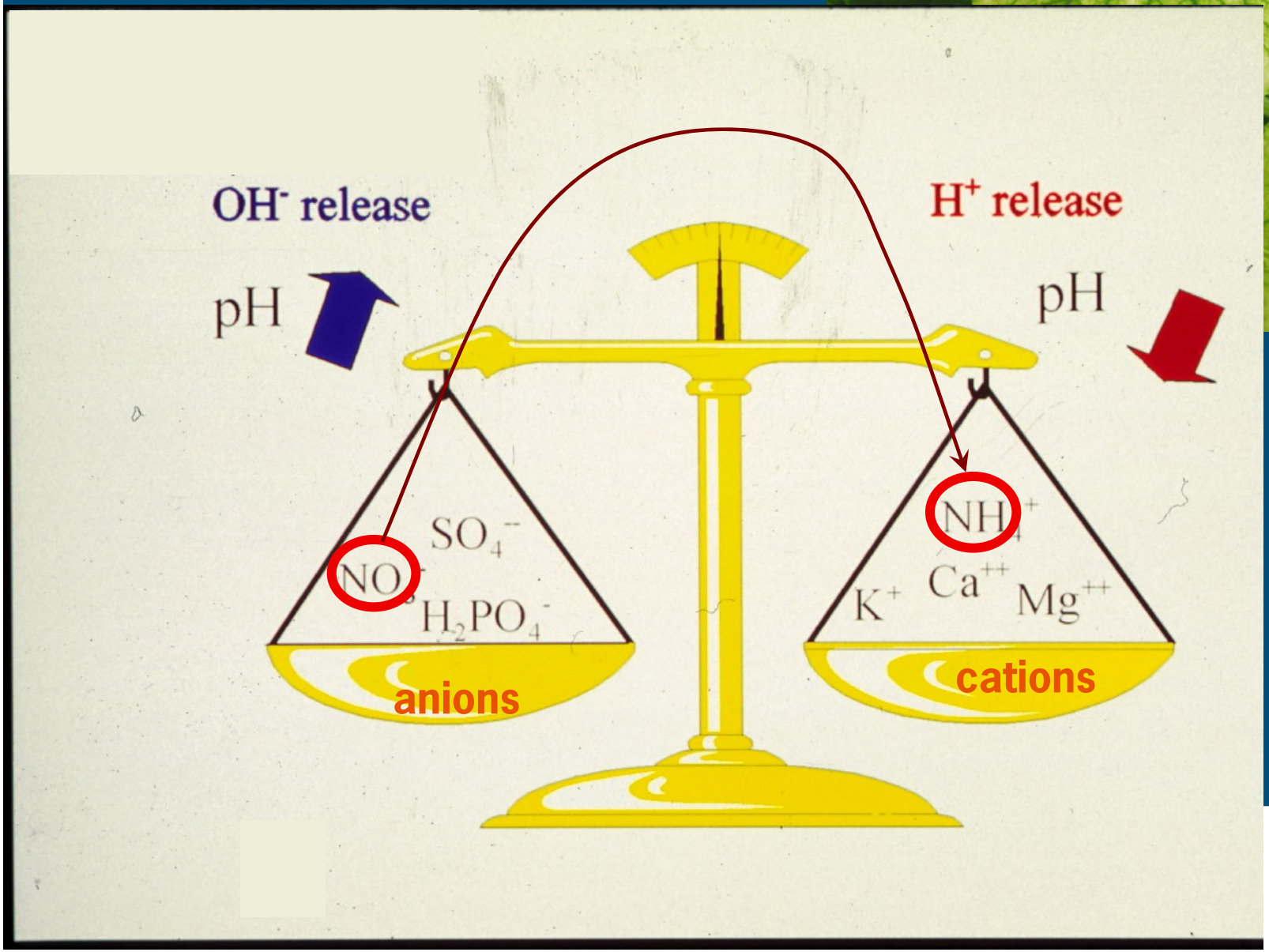
pH increase

pH decrease

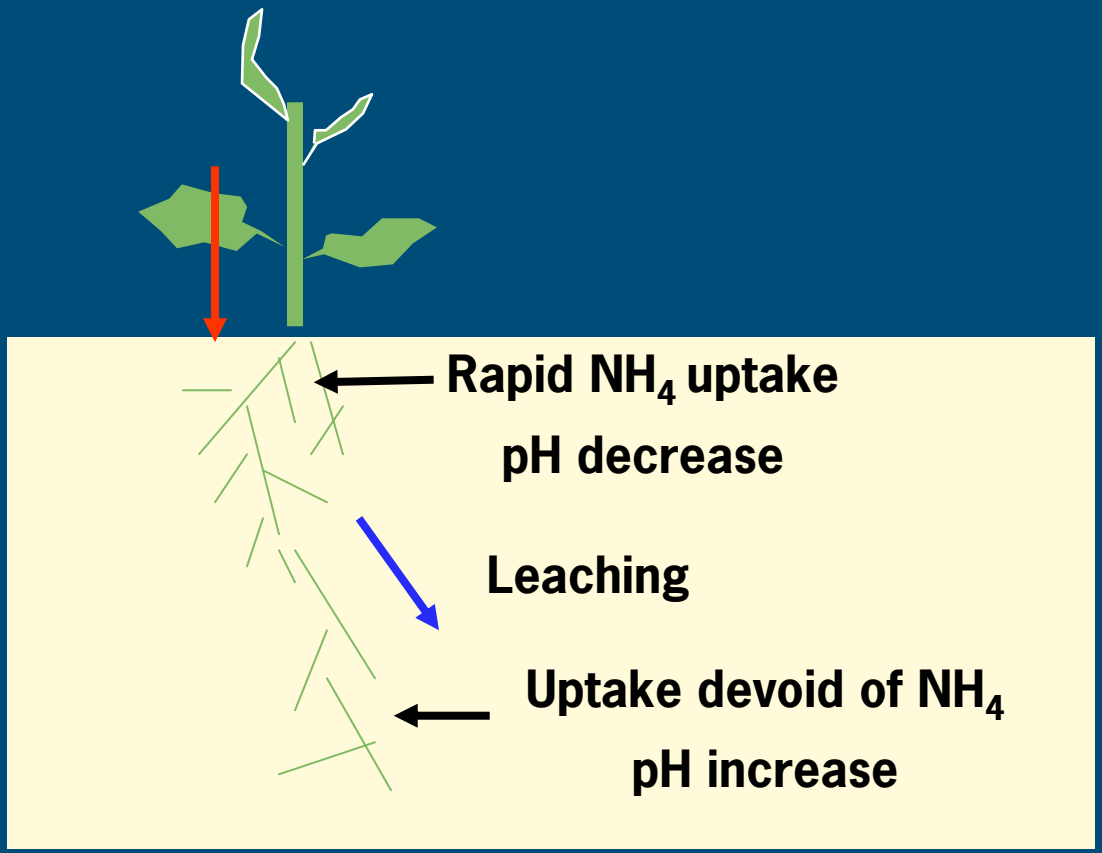
The ion uptake balance



Dynamic fluctuations



Local pH effect in substrate



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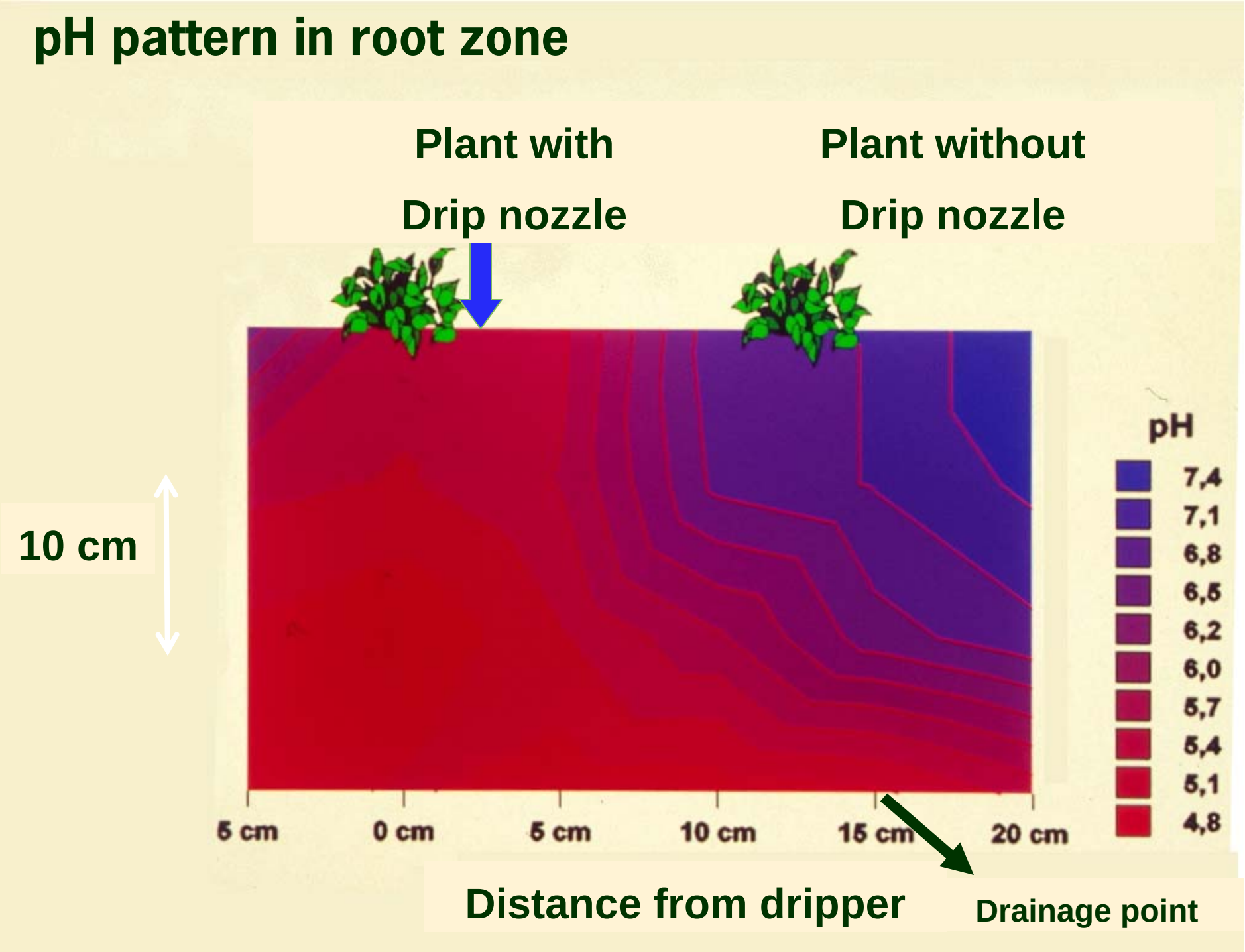
pH pattern in root zone

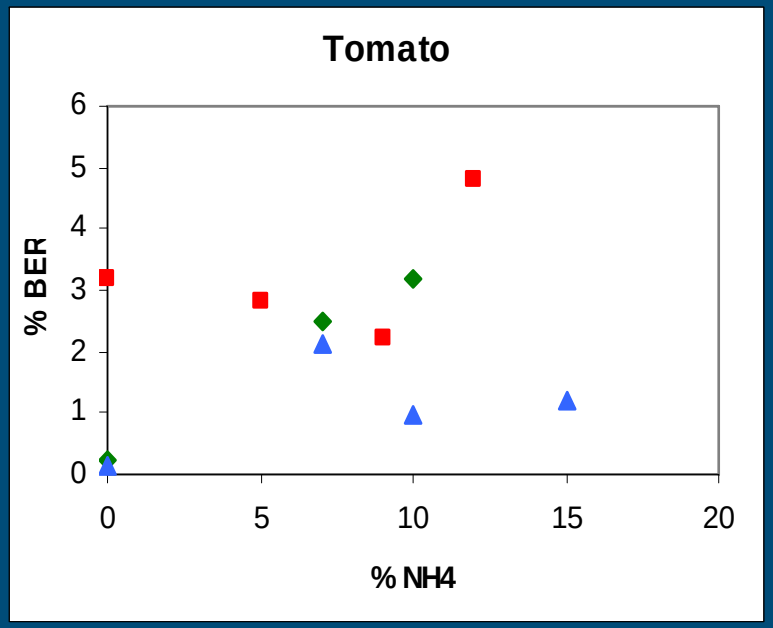


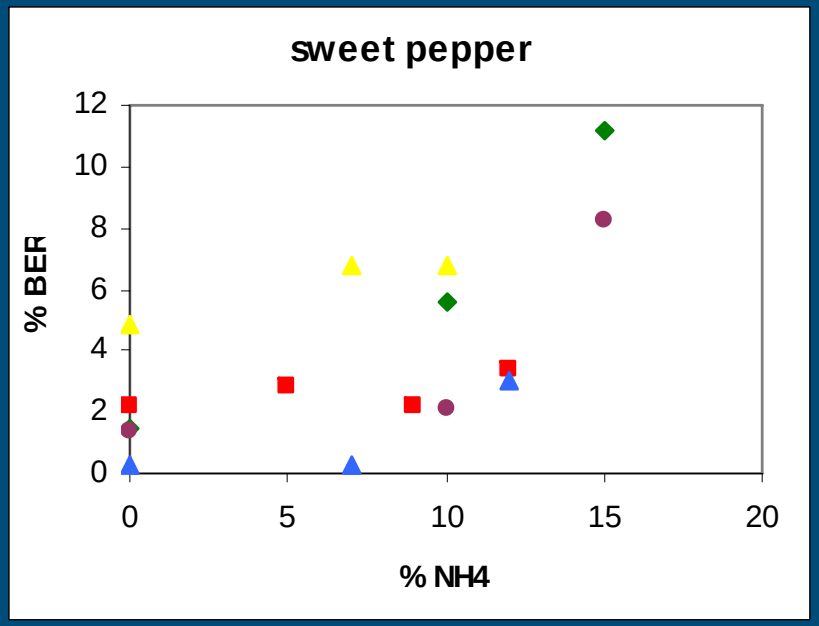
Response to N fertilisation

Tomato

NO3	NH4	Urea	Relatieve Yield	Fruit weight	Blossom end rot	Chlorosis index	Soil pH
100			100	100	0.2	5.2	7.2
75	25		101	100	3.0	3.5	6.9
50	50		96	90	2.8	2.7	6.5
75		25	94	94	2.2	4.4	7.1
50		50	104	97	2.2	1.0	6.9
75	25		96	94	2.7	3.6	6.9
50	50		101	93	2.1	2.0	6.6

NH4 and Blossom End Rot in tomato and pepper





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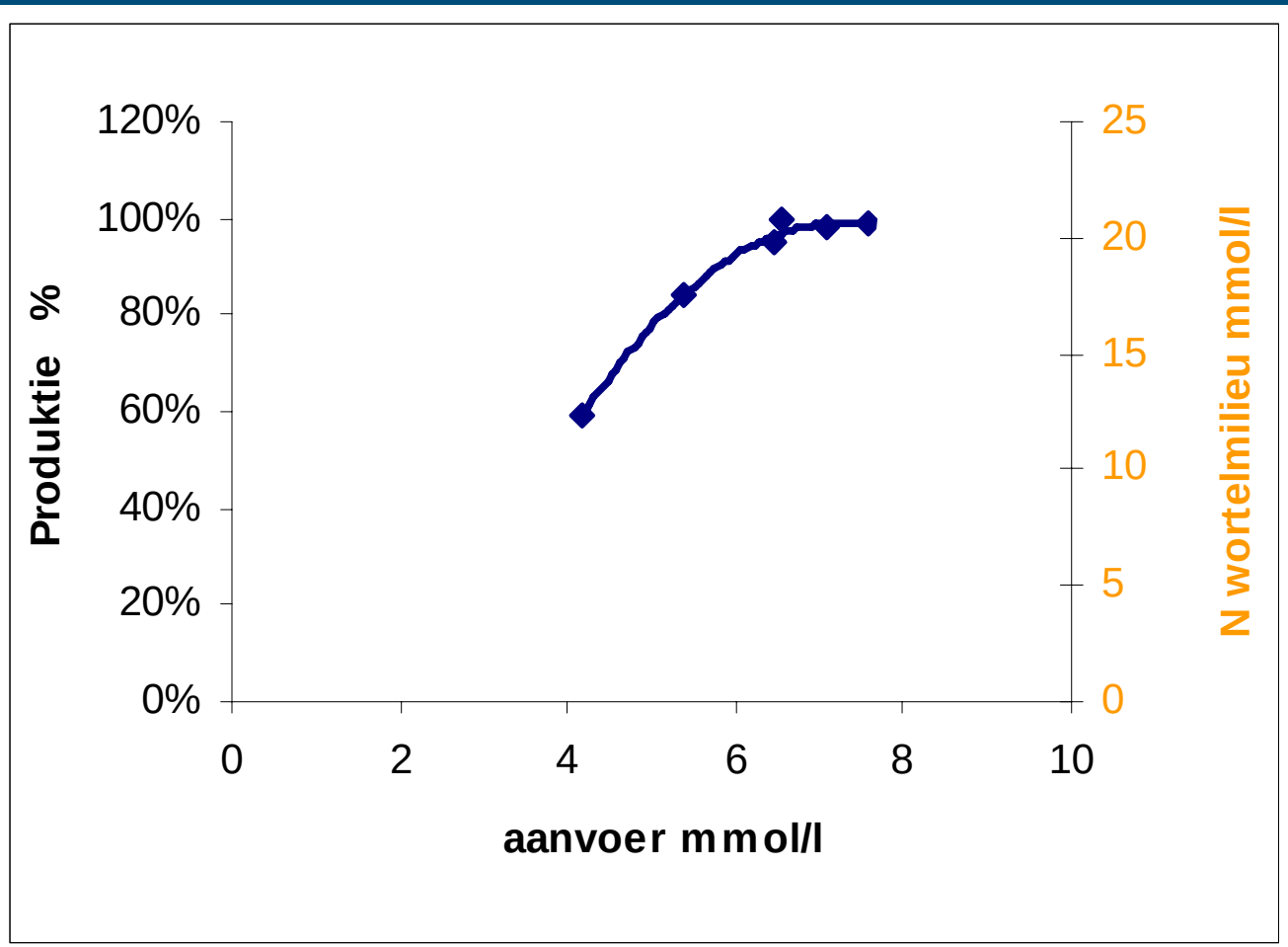
NH4: NO3 recommendation

- Standard 85 : 15 NO3 : NH4 (% as N)
  - High pH 75 : 25
  - Occasionally 50:50
- Heavy fruit bearing
  - Max 90 : 10
- Cucumber, Melon, higher NH4
- Sweet pepper, lowe

N in hydroponic system, tomato



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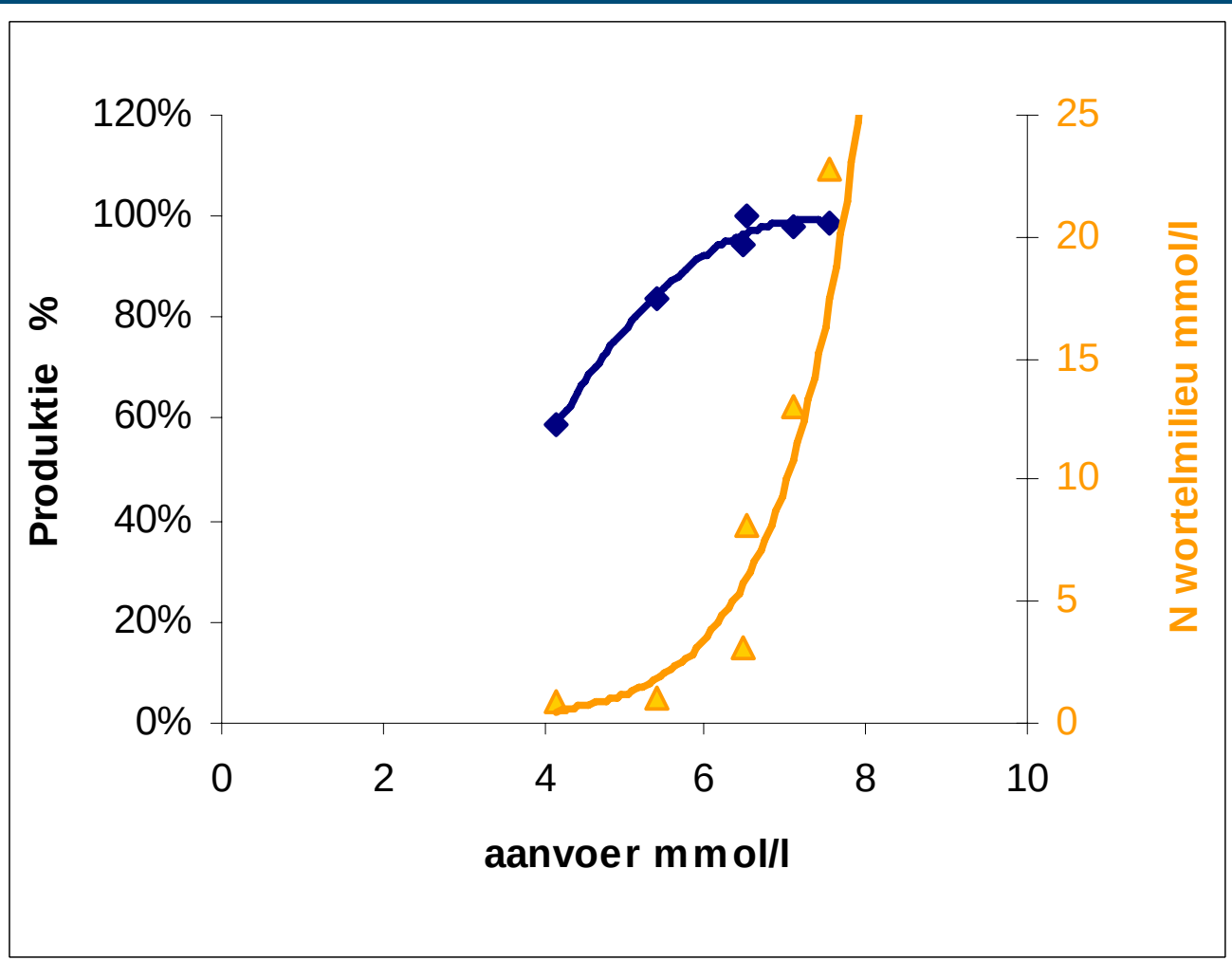
N in hydroponic system, tomato



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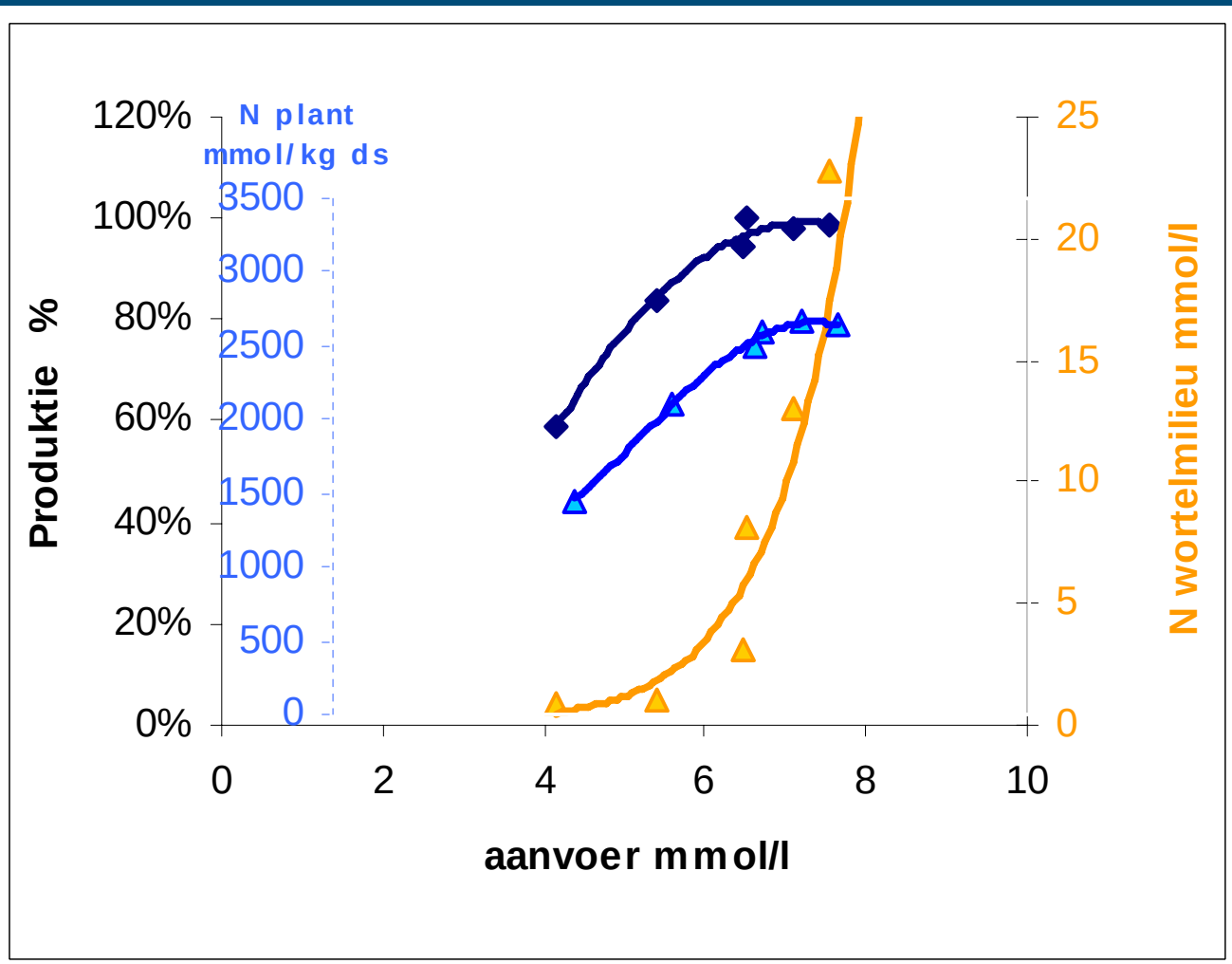
N in hydroponic system, tomato



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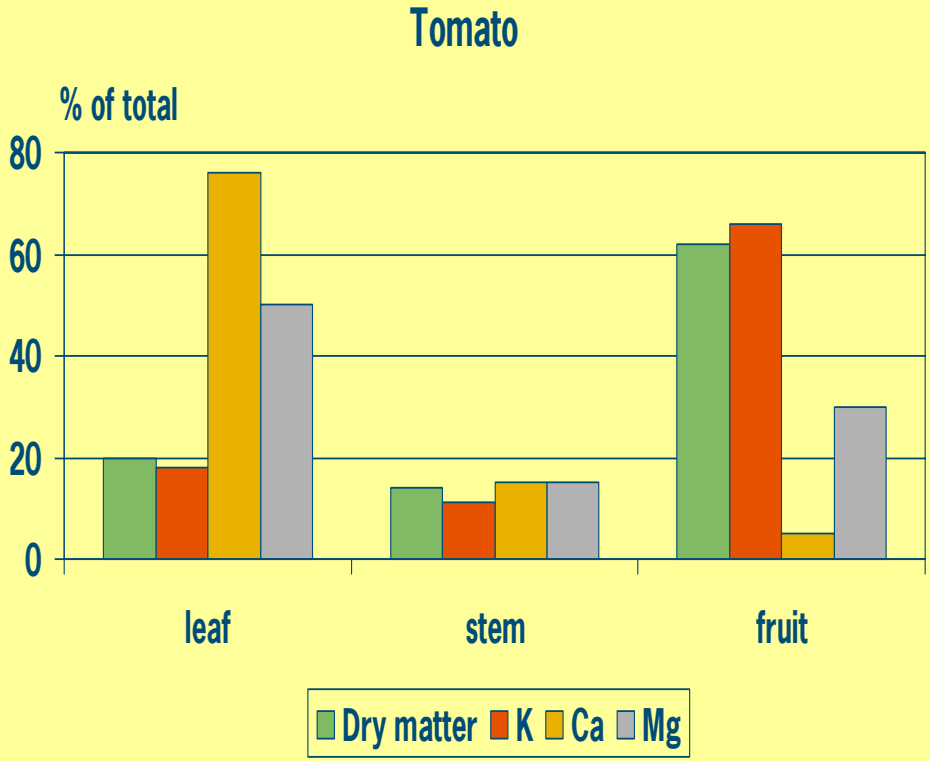
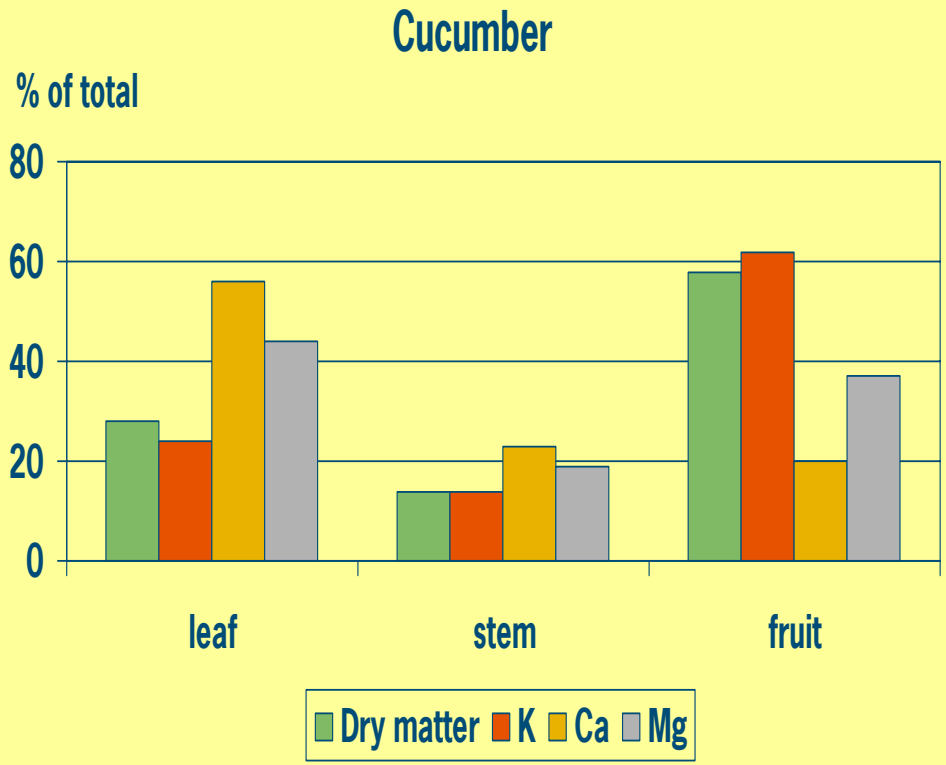
Effect of NO3 : Cl ratios on Ca problems

NO3	Cl	Blossom end rot % fruits	Gold speck index 0-3
10	0	5.6	0
8	2	5.1	1.5
6	4	3.2	1.8
4	6	1.5	2.8
2	8	0.3	3

Distribution of d.m., K, Ca and Mg % of total uptake

(Voogt (1993), Roorda van Eysinga and Van Haeff (1964) and Voogt (2005))





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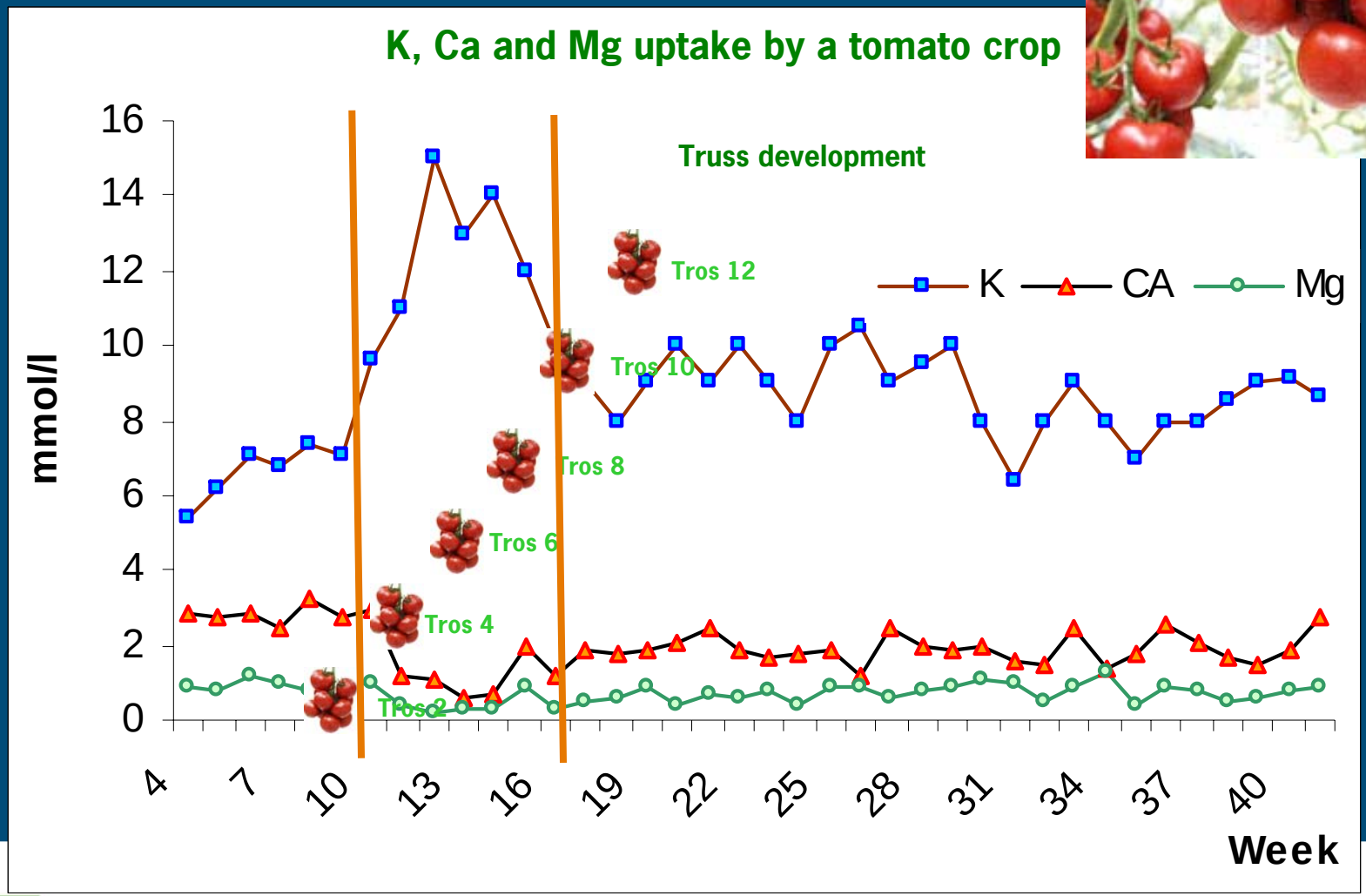
Uptake during growth



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Fertilisation and produce quality: K

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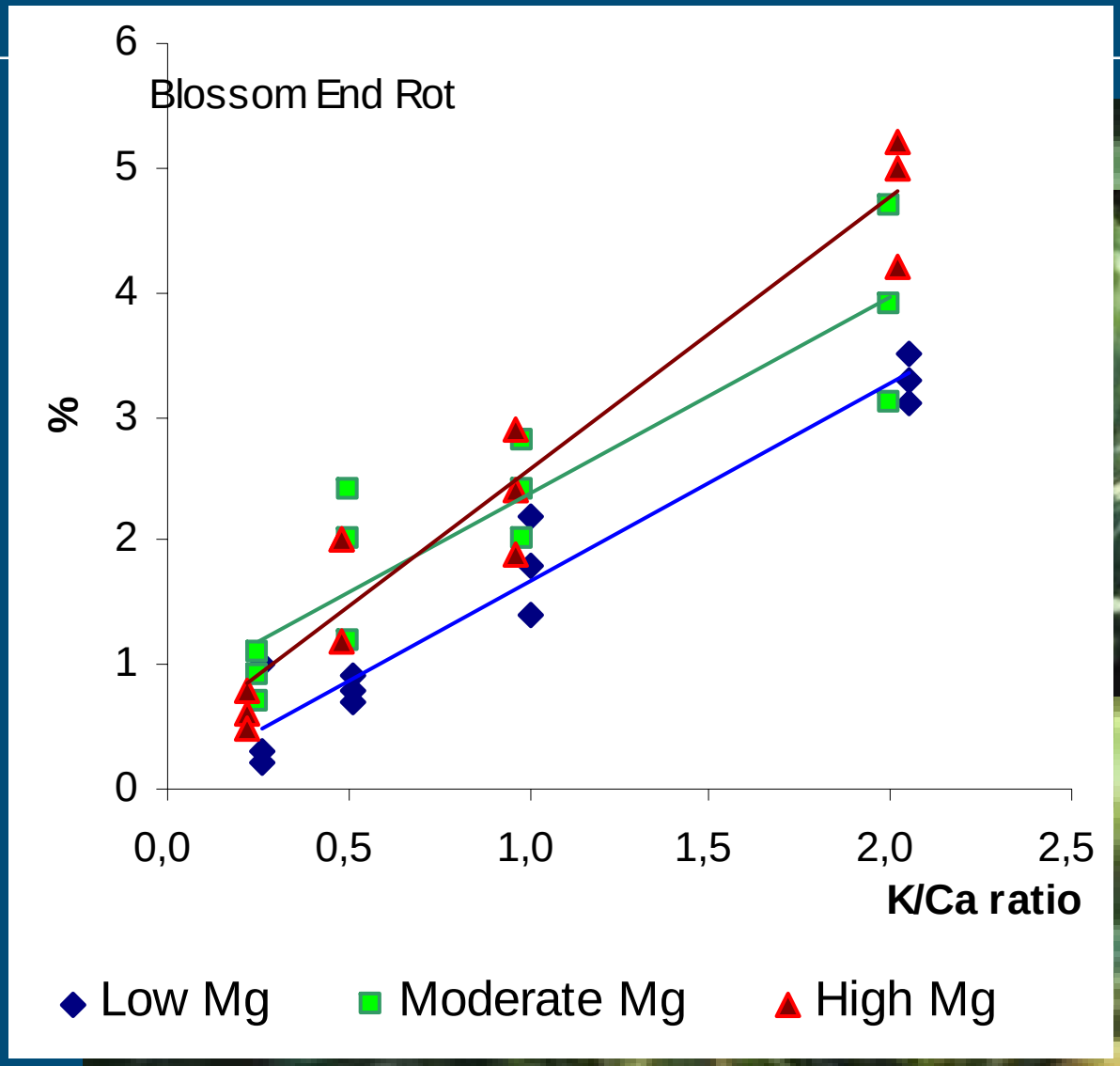
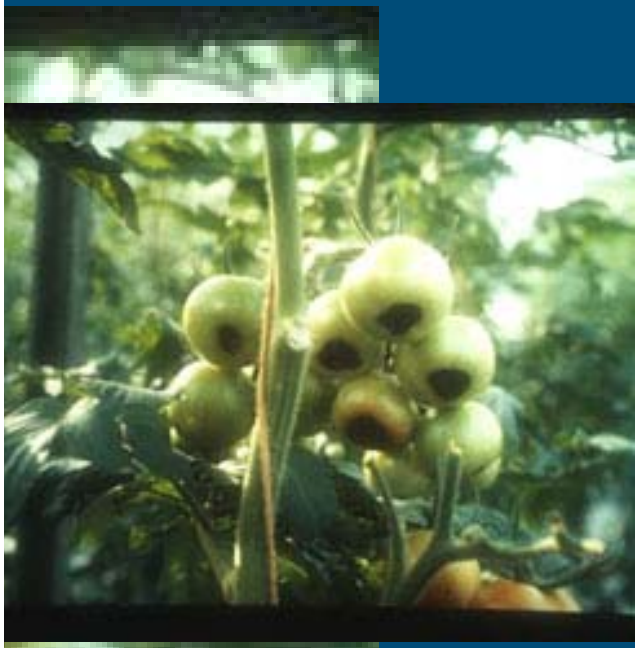
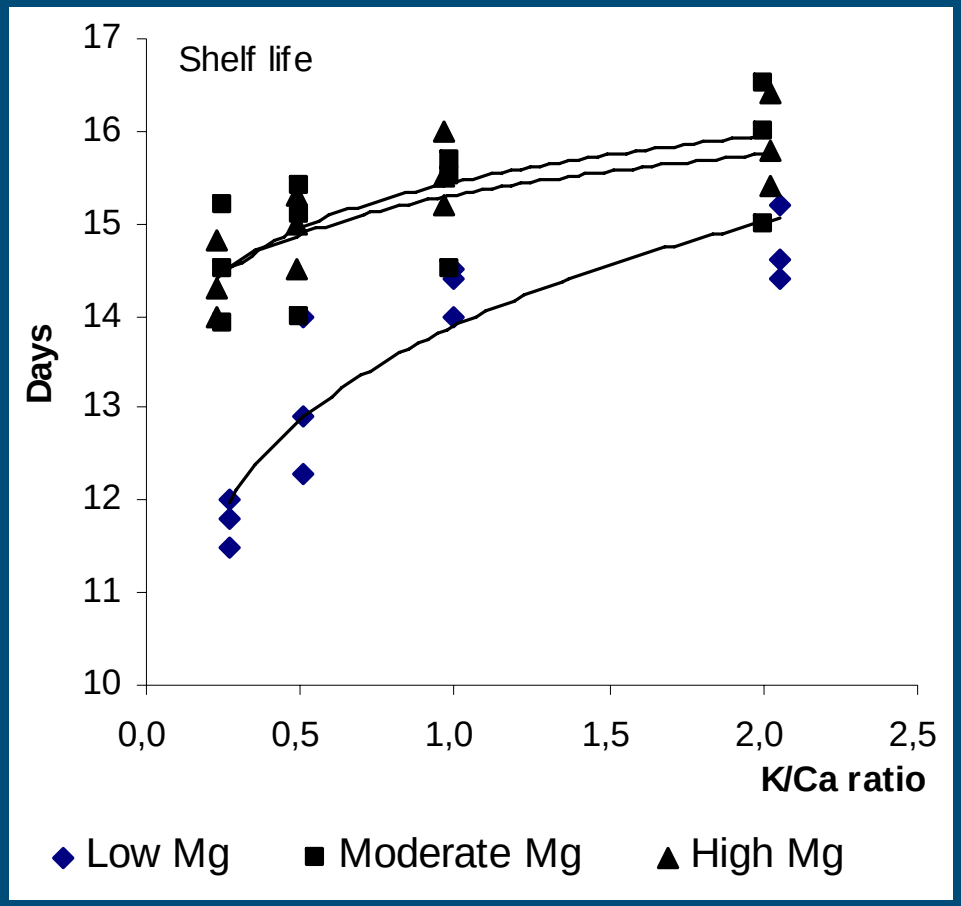
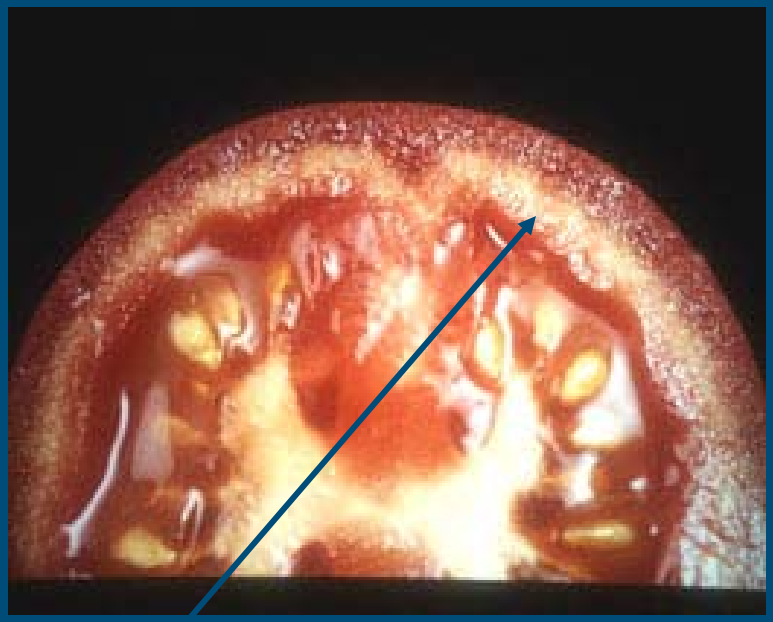

Blossom End Rot
%
6
5
4
3
2
1
0
0,0
0,5
1,0
1,5
2,0
2,5
K/Ca ratio
Low Mg
Moderate Mg
High Mg







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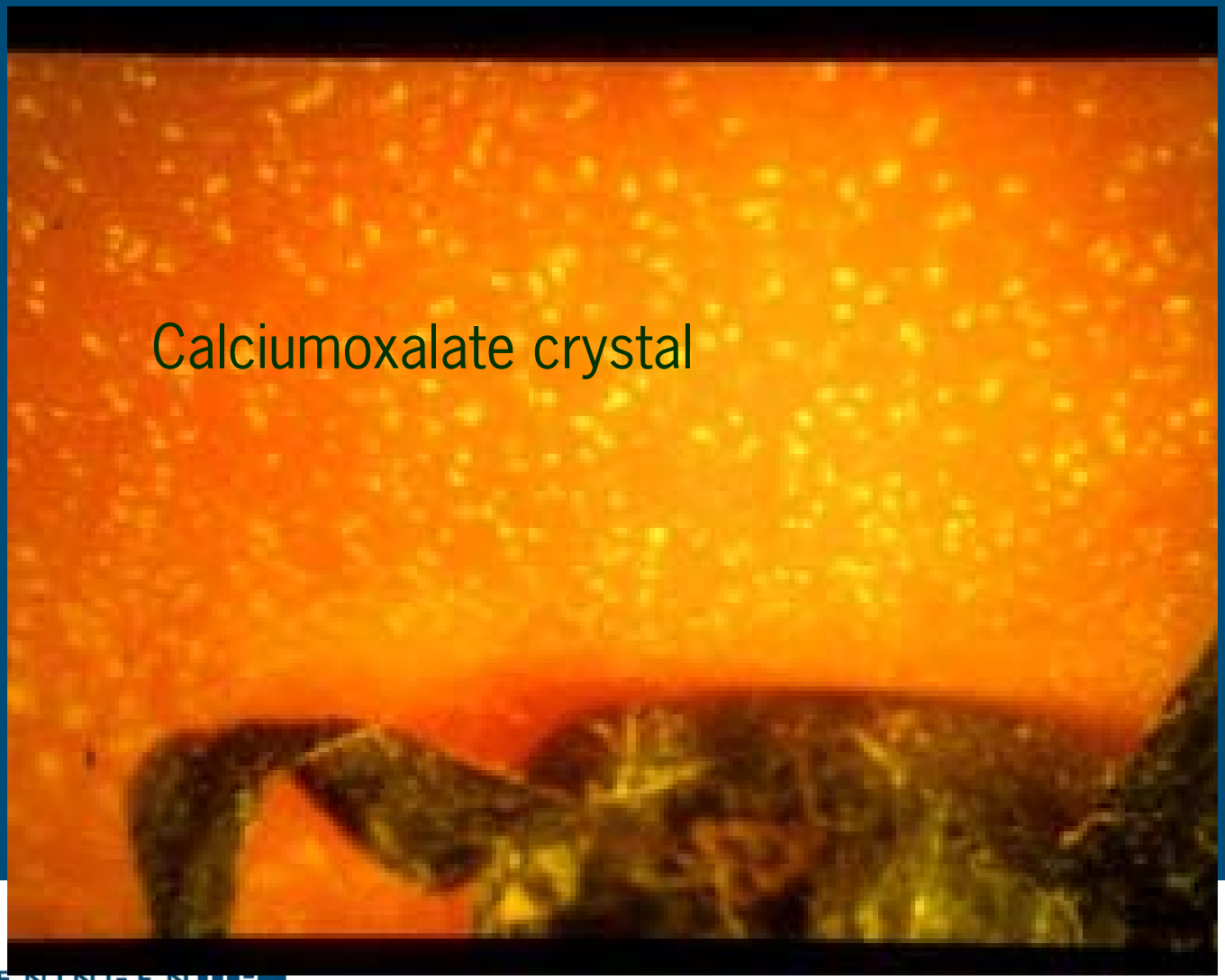
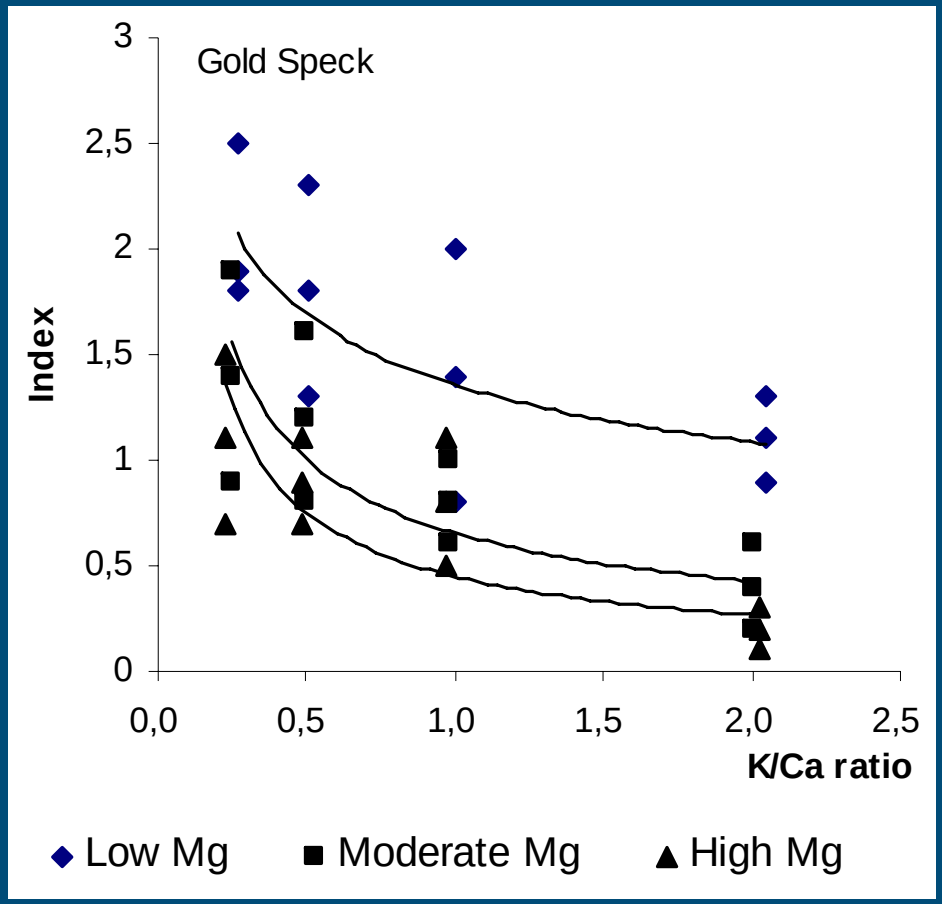
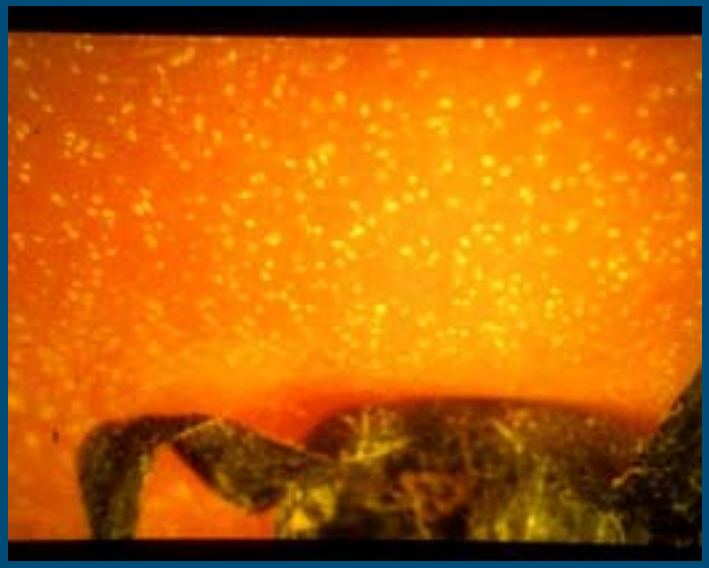
Gold speck







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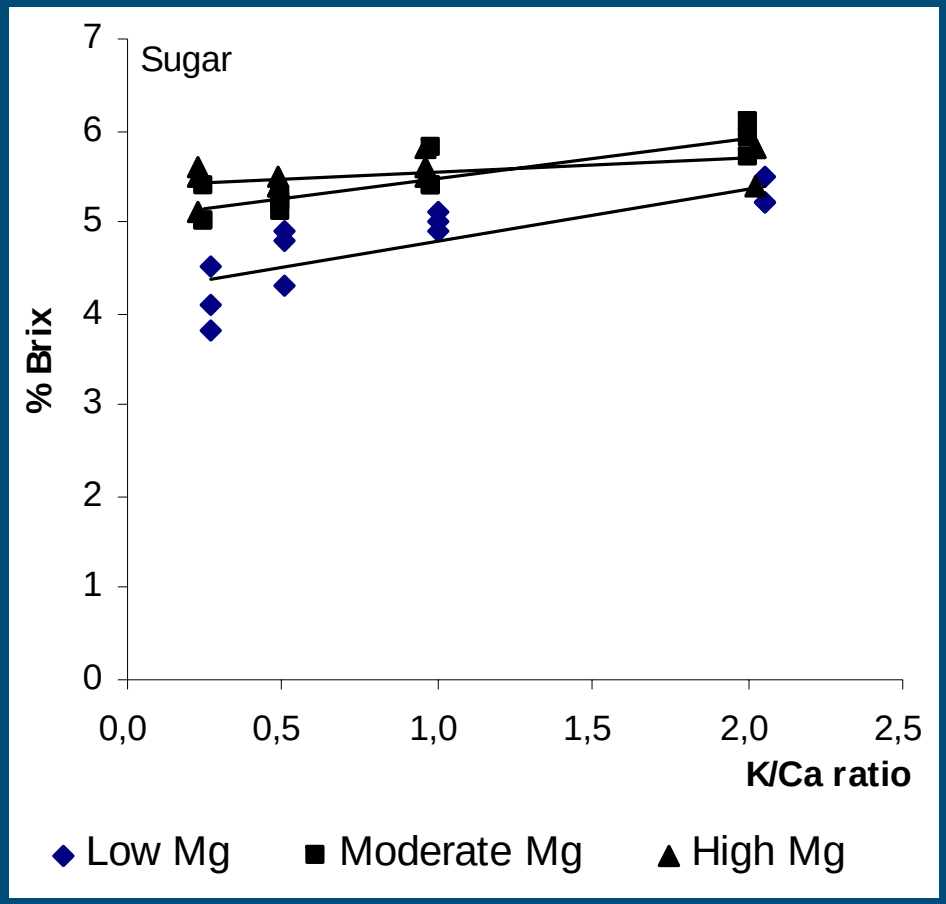

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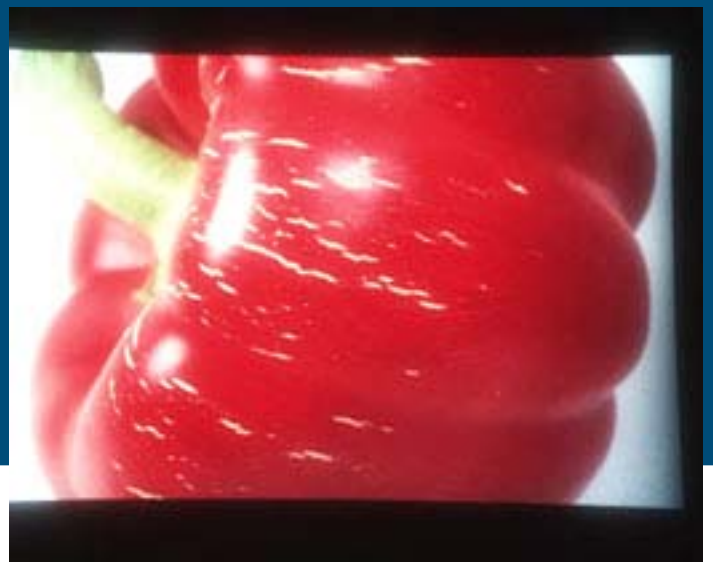
K and quality

- Sweet pepper
  - less fruit cracking
  - higher risk of BER (Na)
  - lower risk of black spot

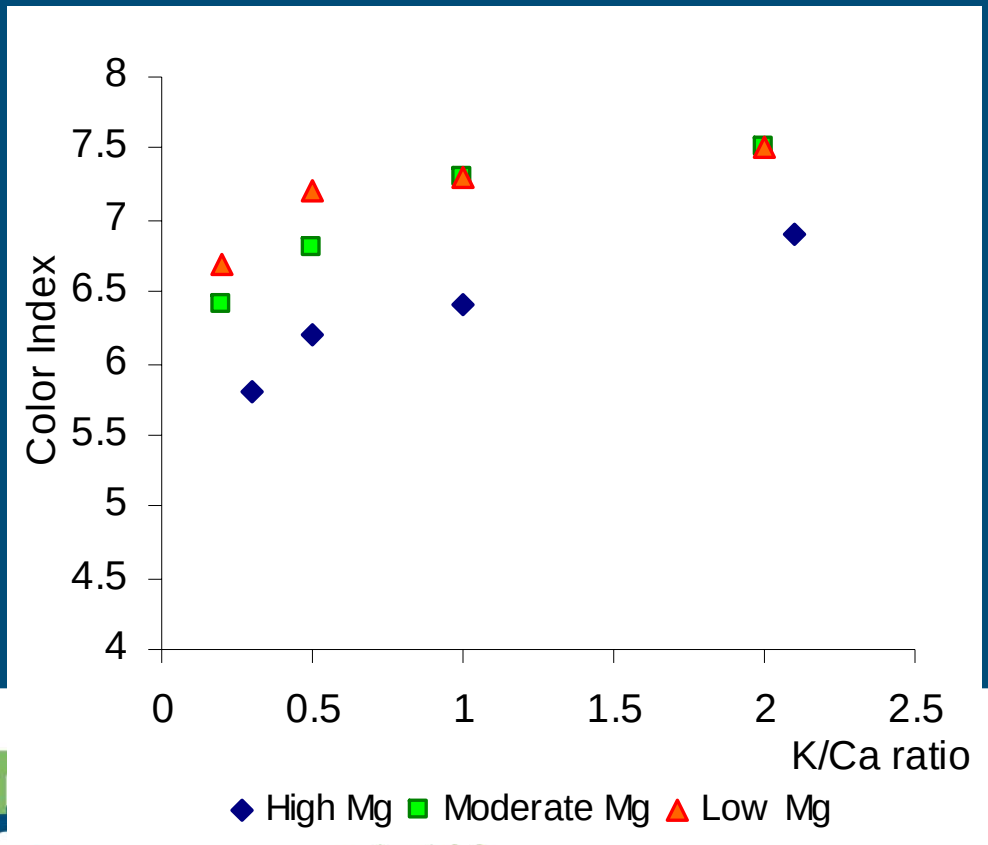


K and quality

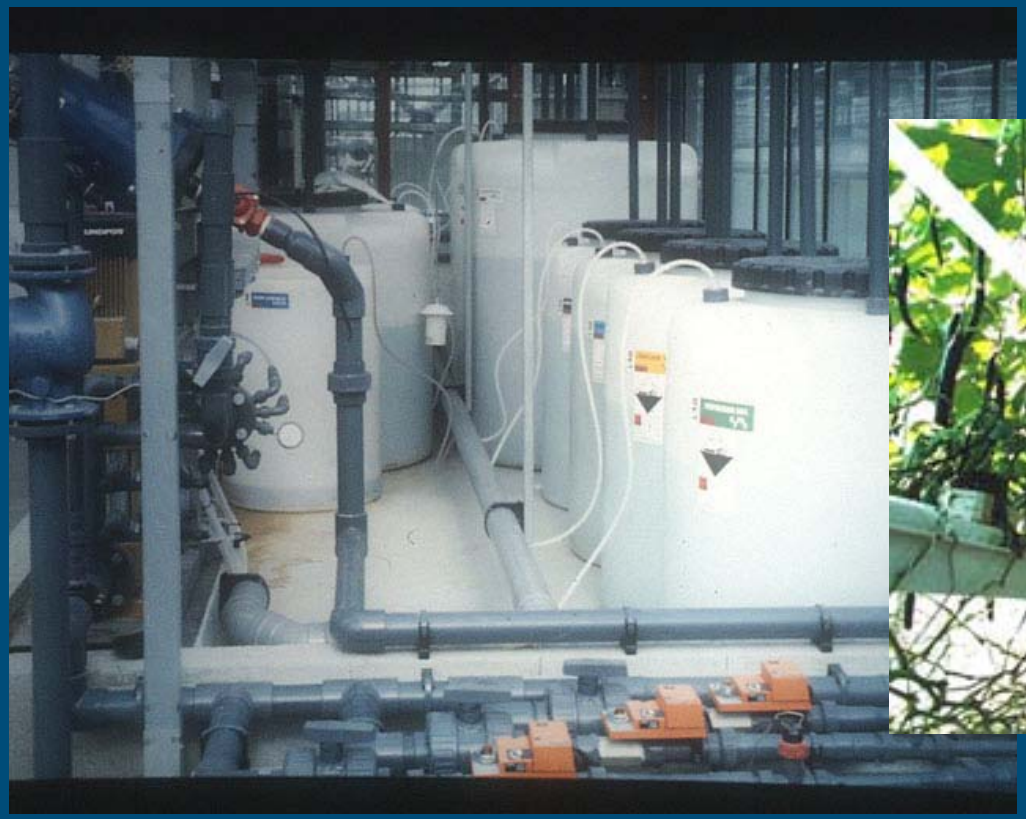
- Egg plant
  - higher risk of BER (fruit rot)

K and quality

- Cucumber
  - increasing K, darker fruits ↑ shelf life



Ca distribution



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Daytime

Growing point
Low Ca

Transpiration
High Ca

assimilation

Phloeem
Low Ca
transport

Fruitgrowth
Low Ca

High Ca Xyleme
transport

High Ca
Wateruptake

Root respiration

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Night

Transpiration

= zero

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Night

Growing point
Low Ca

Transpiration

= zero
assimilation

Phloeem
transport

Low Ca

Fruitgrowth

High Ca

High Ca Xyleme
transport

Root pressure

High Ca
Wateruptake

Root respiration

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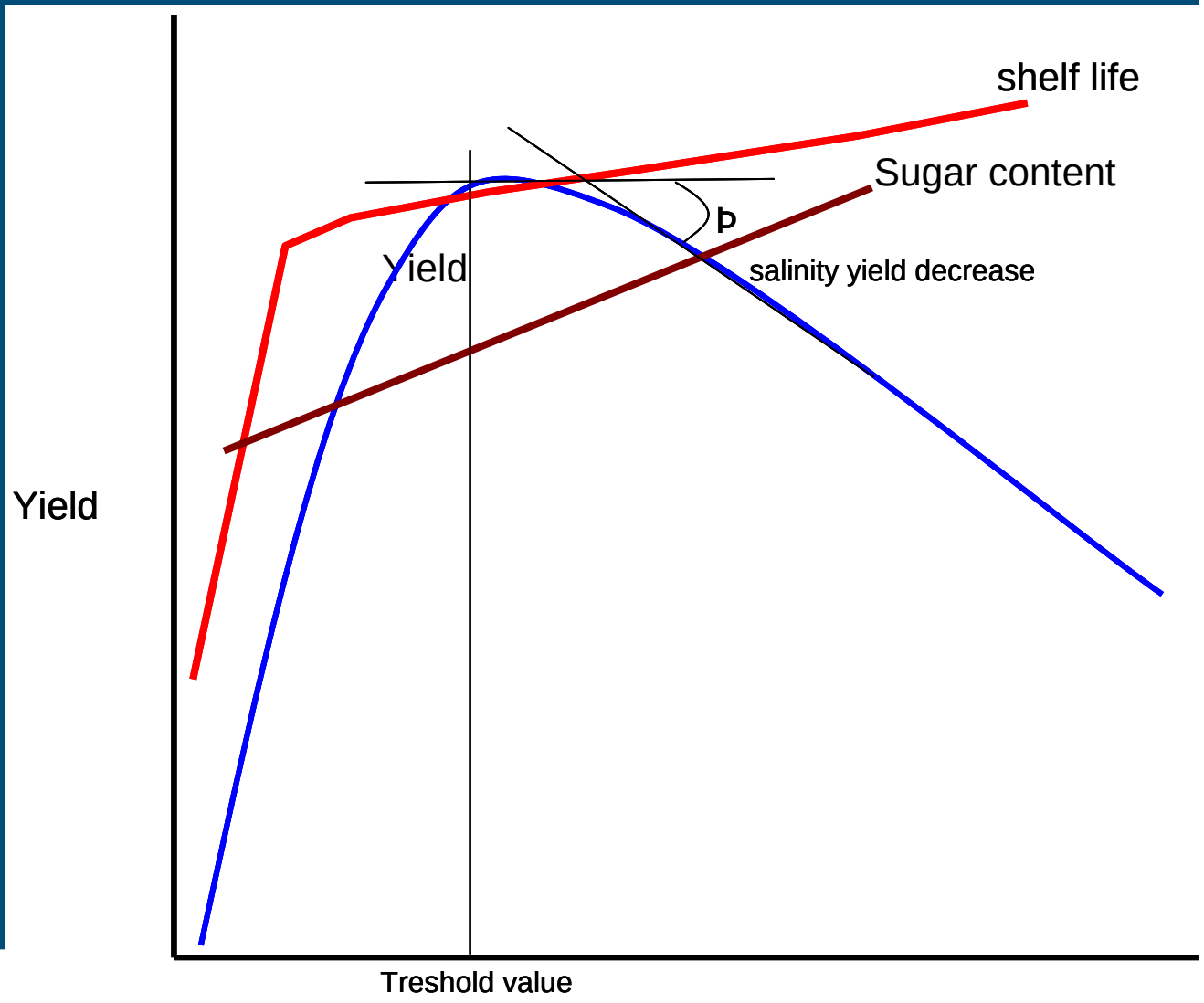
EC effects on quality



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EC and fruit quality tomato

Characteristics	EC 1.8	EC 2.6	EC 3.5
Number of fruits, m^{-2}	220	224	222
Fruit yield, kg m^{-2}	12.5	12.7	11.9
Average fruit weight, g	57	56	54
Fruit shape index	6.4	6.4	6.6
Colouring in days	5.2	4.4	4.1
Shelf life in days	14.2	17.5	19.2
EC fruit sap dS m^{-1}	5.2	5.8	6.2
Acids in fruit sap, mmol l^{-1}	72	75	84
Refraction in fruit sap, % Brix	4.5	4.8	5

Effects of an increased EC value in the root environment on yield and quality of tomato fruits. After Sonneveld and Welles, 1988.

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Effects of Na en Cl

	Blossom end rot %		
		Nutrients	NaCl
EC	2.5	11	11
	3.7	14	13
	5.2	23	21

		Shelf life	
		Nutrients	NaCl
EC	2.5	7.9	7.9
	3.7	9.5	7.8
	5.2	9.5	9.8

To summarize

- Fruit vegetables require high quantities of nutrients
  - Growing stage dependend adjustments
- Fruit quality can be stimulated
  - High K
  - High EC
- However BER risk therefore important
  - NH4 : NO3 ratio
  - K: Ca ratio
  - If Cl is low, increase Cl
  - Climate : D/N regime
- pH root environment can be managed
  - NH4 : NO3 ratio
  - Growth stage

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For those who want to know more….

Cees Sonneveld
Wim Voogt

Plant Nutrition of Greenhouse Crops

Greenhouse cultivation is noted for its high uptake of minerals, consistent climatic conditions, exclusion of natural precipitation and control of salt 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 tissue tests, and crop responses on salinity 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 vegetable and ornamental crops. The subject is especially apt now as substrate growing offers excellent possibilities for the optimal use of water and nutrients, as well as the potential for sustainable production methods for greenhouse crops.

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Plant Nutrition of Greenhouse Crops

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