

# Are growing media a must in organic greenhouse production?

Organic Greenhouse Soil Health, COST WP2D3, Bleiswijk 24-26/06/2013

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WAGENINGEN **UR**  
For quality of life

# Alternatives for soil

- Rooting Media
- Water Culture

## Criteria

1. Nutrient control
2. Disinfection
3. Growth of micro organisms
4. Oxygen supply
5. Plant Hydraulic Conductivity



# Substrate 1. Nutrient control

- +10% FW yield by refreshment (> 10 cycles a day)
- Speedy aeration: required 2mg/h/ gr FW root mass or
- Mass flow in water and air with discontinuous supply
- Because Ca/Mg are not as easily taken in: start schedule required and possible
- Adaptions are on the root within 1-3 cycles
- $\text{NH}_4$  must be regulated dynamically



# Number of irrigation cycles (I.F.)

Harvest	<i>IF</i> (day <sup>-1</sup> )	Stem length (cm)	Shoot fresh weight (g)	Number of roots	Root fresh weight (g)	Root/shoot (FW) ratio
2	1	10.5 ± 0.9 <sup>a</sup>	2.0 ± 0.2 <sup>a</sup>	36 ± 19 <sup>a</sup>	0.27 ± 0.06 <sup>a</sup>	0.13 ± 0.03 <sup>b</sup>
2	6	12.0 ± 0.9 <sup>ab</sup>	2.4 ± 0.1 <sup>b</sup>	41 ± 19 <sup>a</sup>	0.28 ± 0.05 <sup>a</sup>	0.12 ± 0.02 <sup>ab</sup>
2	24	13.3 ± 0.8 <sup>b</sup>	2.7 ± 0.3 <sup>c</sup>	47 ± 16 <sup>a</sup>	0.25 ± 0.06 <sup>a</sup>	0.09 ± 0.02 <sup>ab</sup>
2	96	13.5 ± 1.3 <sup>b</sup>	2.9 ± 0.2 <sup>c</sup>	43 ± 10 <sup>a</sup>	0.22 ± 0.04 <sup>a</sup>	0.08 ± 0.01 <sup>a</sup>



# K/Ca ratio

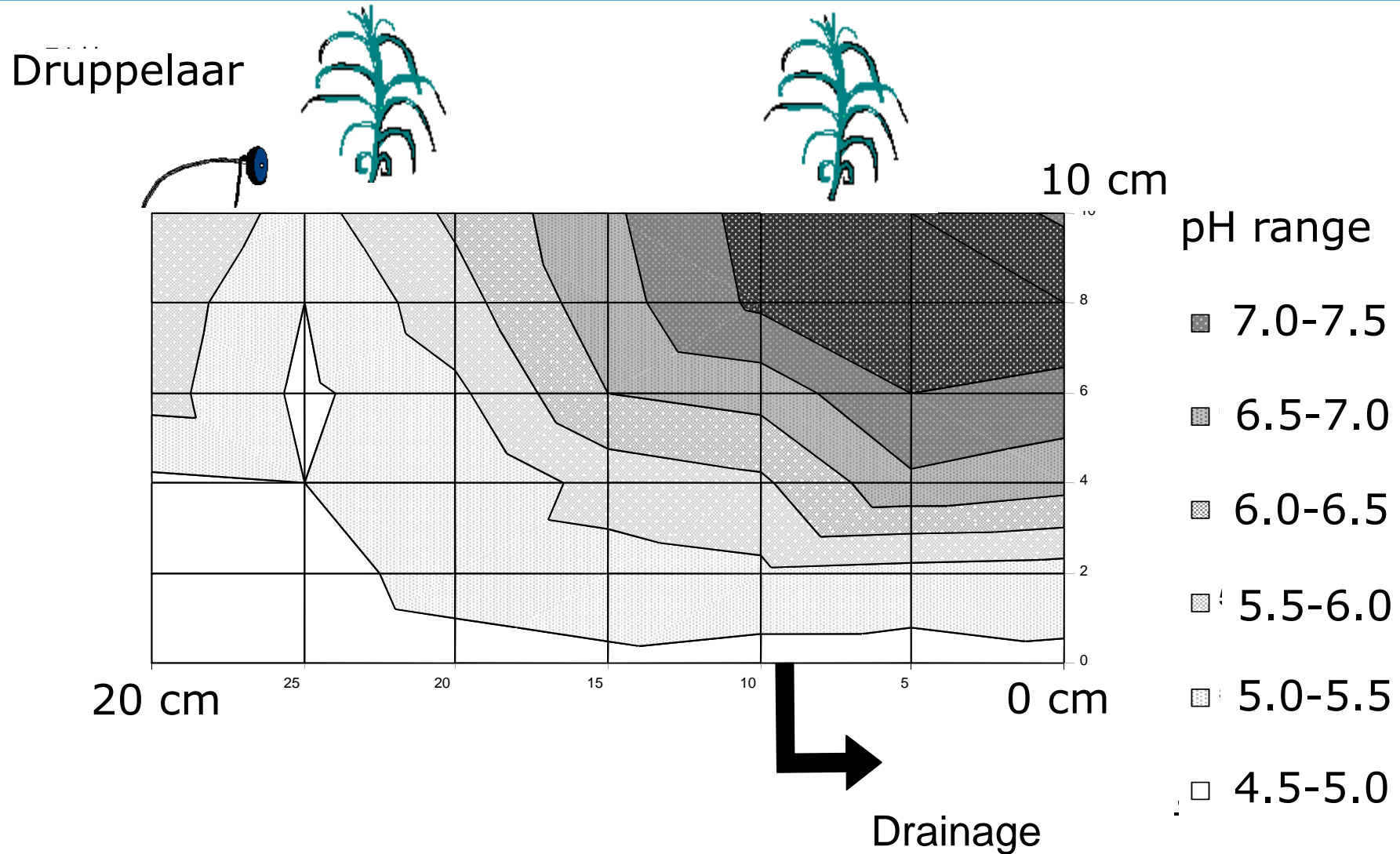
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The uptake of K is easier than for Ca. Thus:

- In a free drain system you supply extra calcium.
- In a closed system you supply what is consumed.
- In both cases the slab ratio is about equal

NB also applies for Mg

# Ammonium is preferred over K



# 2 pH: root damage

Druppelaar

Pot

Mat



# Water 1. Nutrient control

- +10% FW yield by better refreshment
- Pumping is more effective than bubbles
- Mass flow in water and air with pumping
- Because Ca/Mg are not as easily taken in: start schedule required but not possible with high volumes
- Adaptions are on the root within 1 hour (M. vd Knaap)
- $\text{NH}_4$  must be regulated dynamically
- Supply must be symmetrical for each single plant





# PLANT ASPECTS: standard root system



# PLANT ASPECTS: water root system



# Rooting reduced by high water content



# Substrate 2. Disinfection

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- Phytophthora, nematodes, clavibacter
- Methyl Bromide: almost globally banned now
- Steam sterilising: 140 MJ or 4 m<sup>3</sup> gas equivalents per m<sup>2</sup>
- Limited depth (70-100 cm) and uniformity
- Re infestation with dust, water and young plants





# Water 2. Disinfection

- Phytium, phytophthora, Fusarium
- Chemicals visibly harm the crop AND do not always solve the problem (visible particles protect disease)
- Steam sterilising: 4200 MJ or 126 m<sup>3</sup> gas equivalents per m<sup>3</sup> i.e. 42 MJ per 10 l per m<sup>2</sup>
- Material deformation with heat and peroxide
- UV capacity for continuous disinfection
- UV capacity for batched disinfection

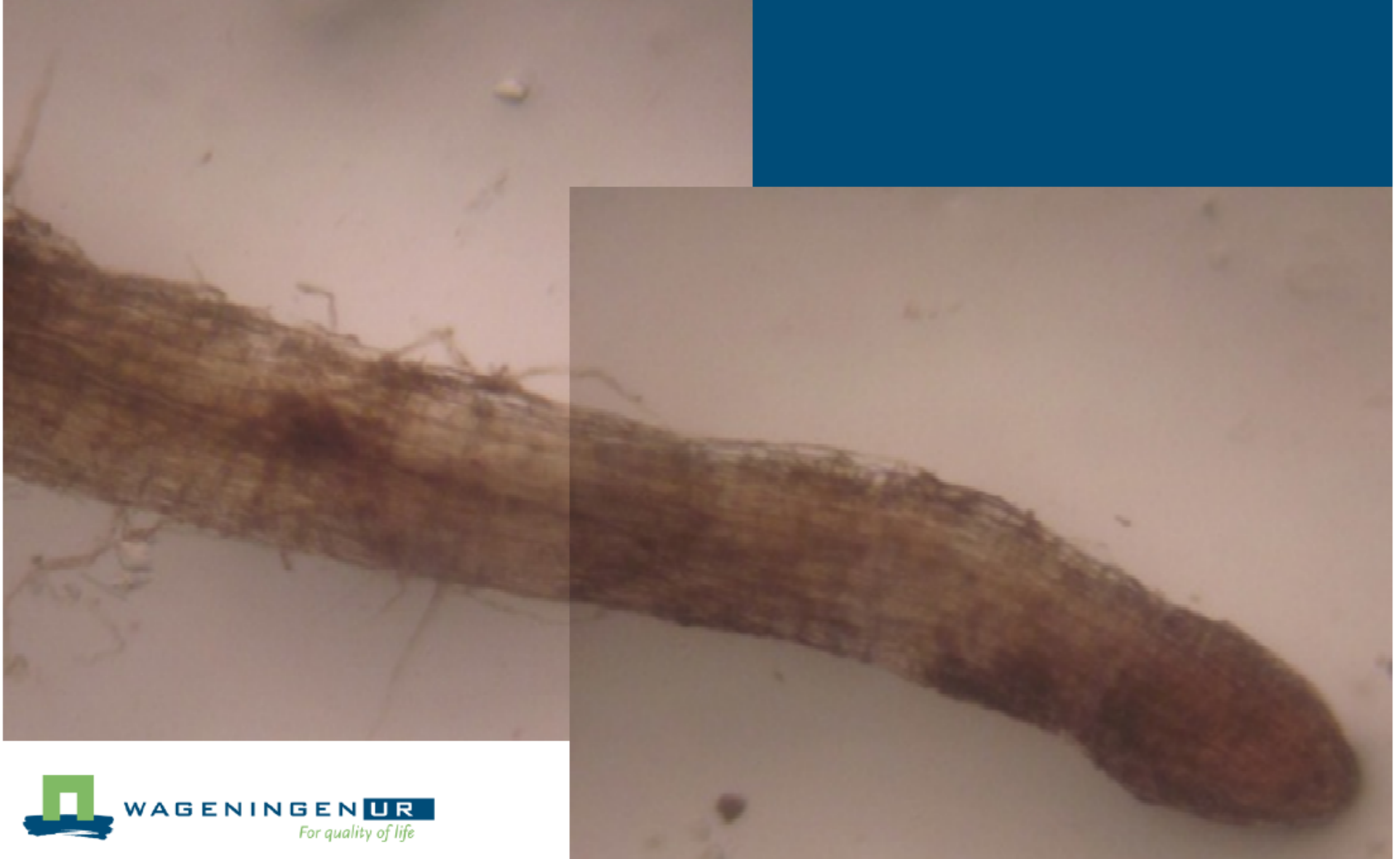


# Substrate 3. Micro Organisms

- Steam fungi
- Bacteria  $10^6 - 10^8$  CFU in mineral media
- Bacteria and Funghi  $10^8 - 10^{10}$  CFU in organic media
- Jump tails (fungi), worms (), nematodes (saprophytes)
- Poorly described/communicated succession
- Much easier controled than in soils
- Easier to learn to understand than in soils



# Broadcasted Mycorrhiza on chrysanthemum





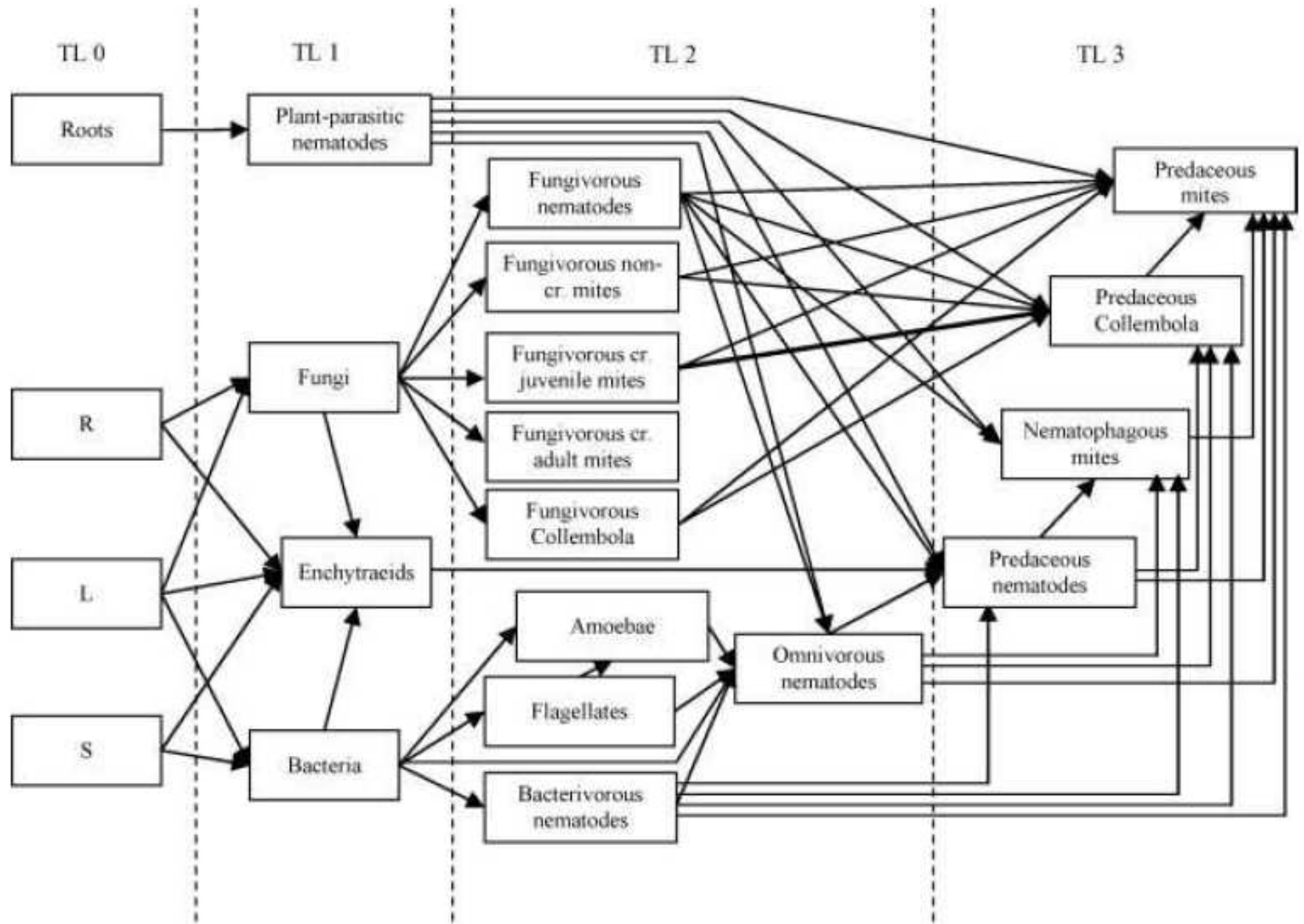


Fig. 1. Soil food web diagram. Arrows represent feeding links and points at the predator. TL = trophic level, R = recalcitrant organic matter, L = labile organic matter, S = water soluble sugars and cr = cryptostigmatic (From: Holterkamp et al.)

# Wet, bacterial mix added and dry rockwool

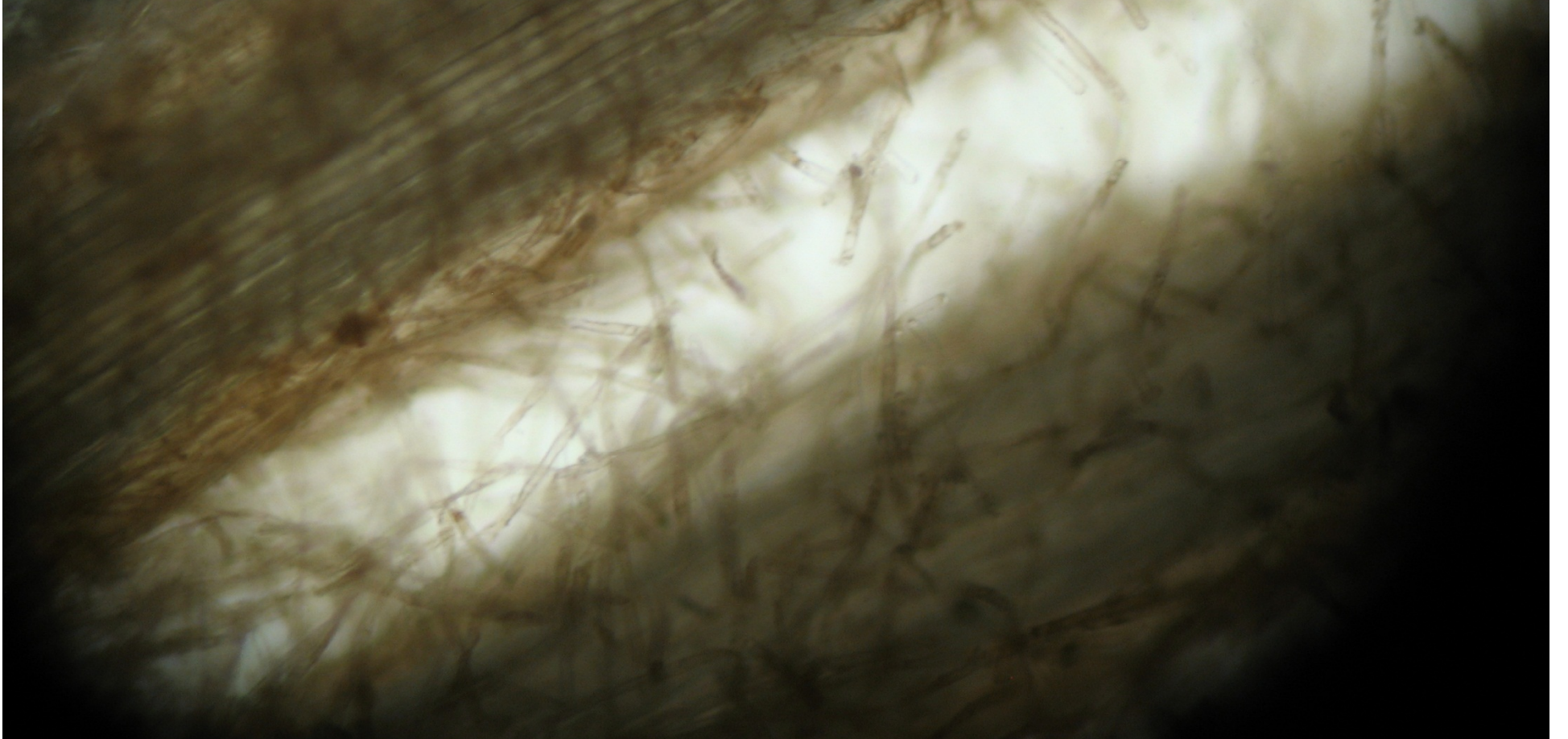
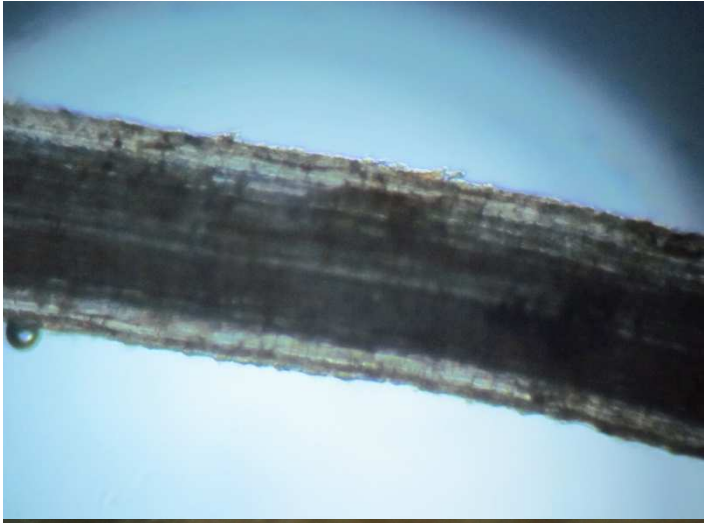
- Micro organisms improve rooting

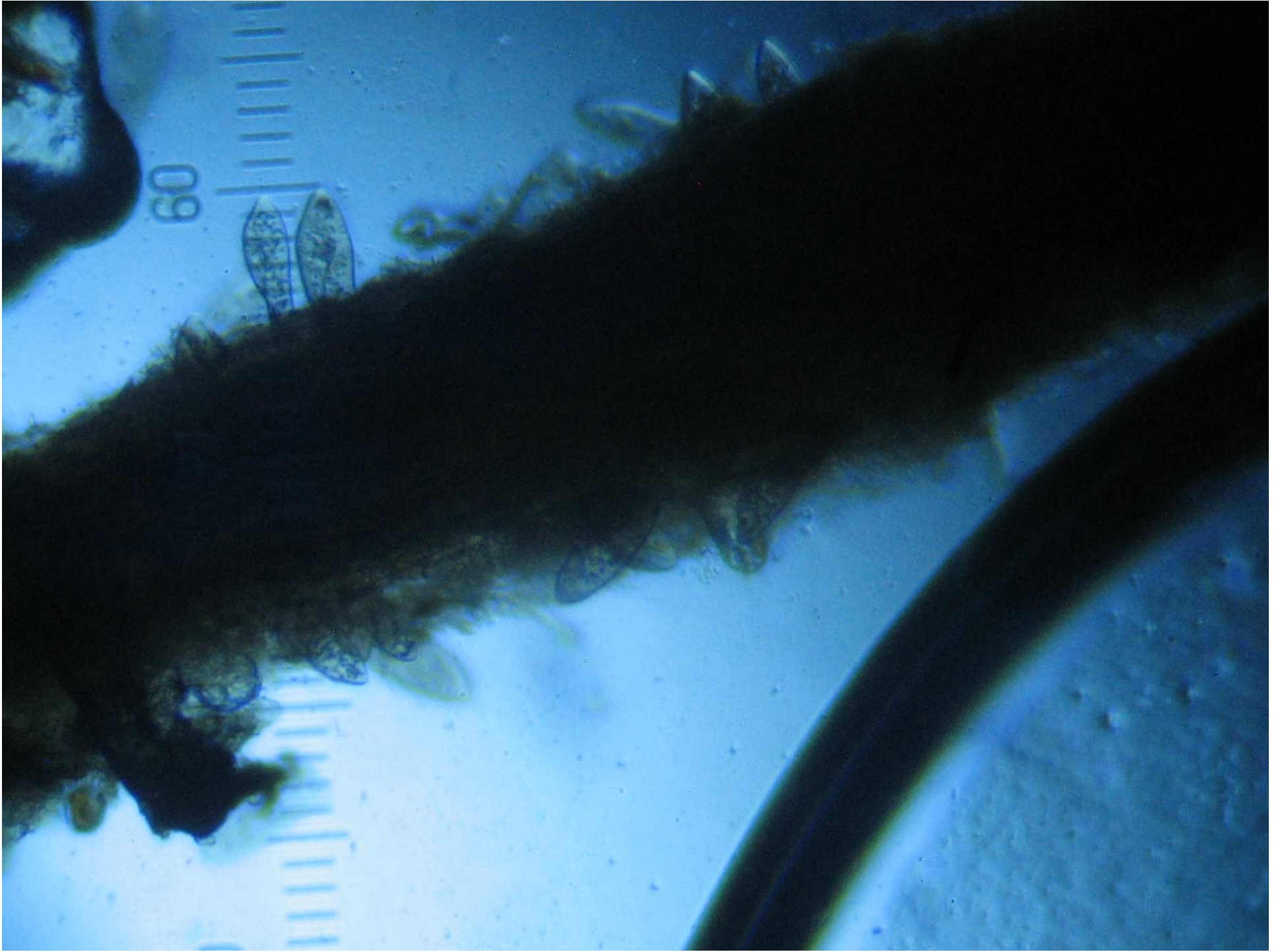


# Water 3. Micro Organisms

- Root hairs and cortex cells
- Bacteria, later Rotifera, single Nematodes
- Paramecium, later Dinellas, Vorticera

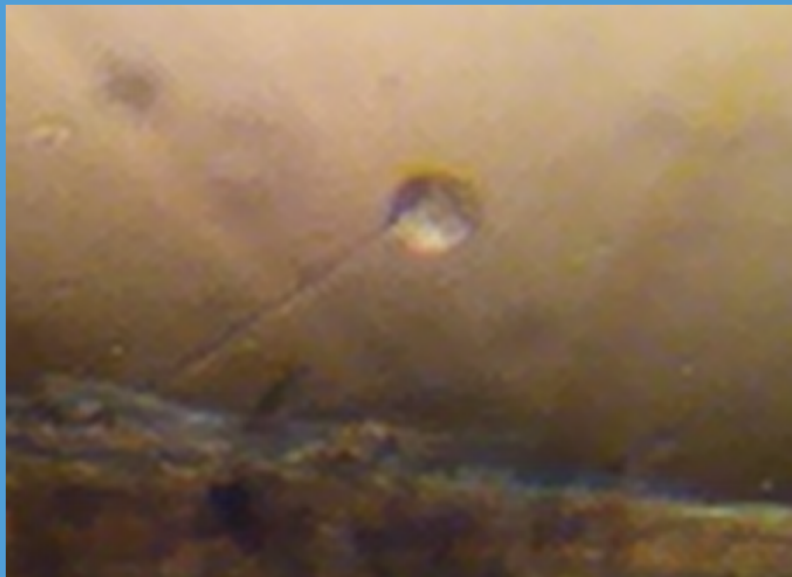
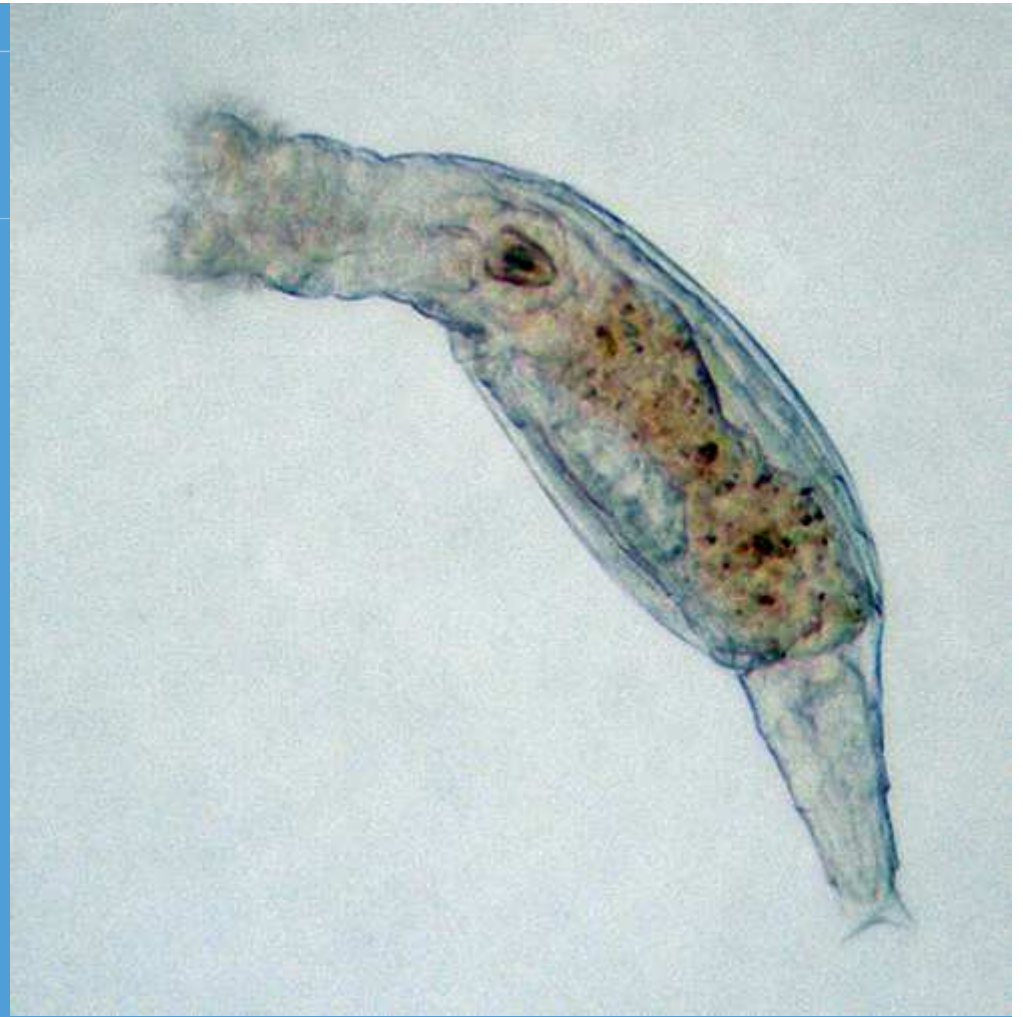


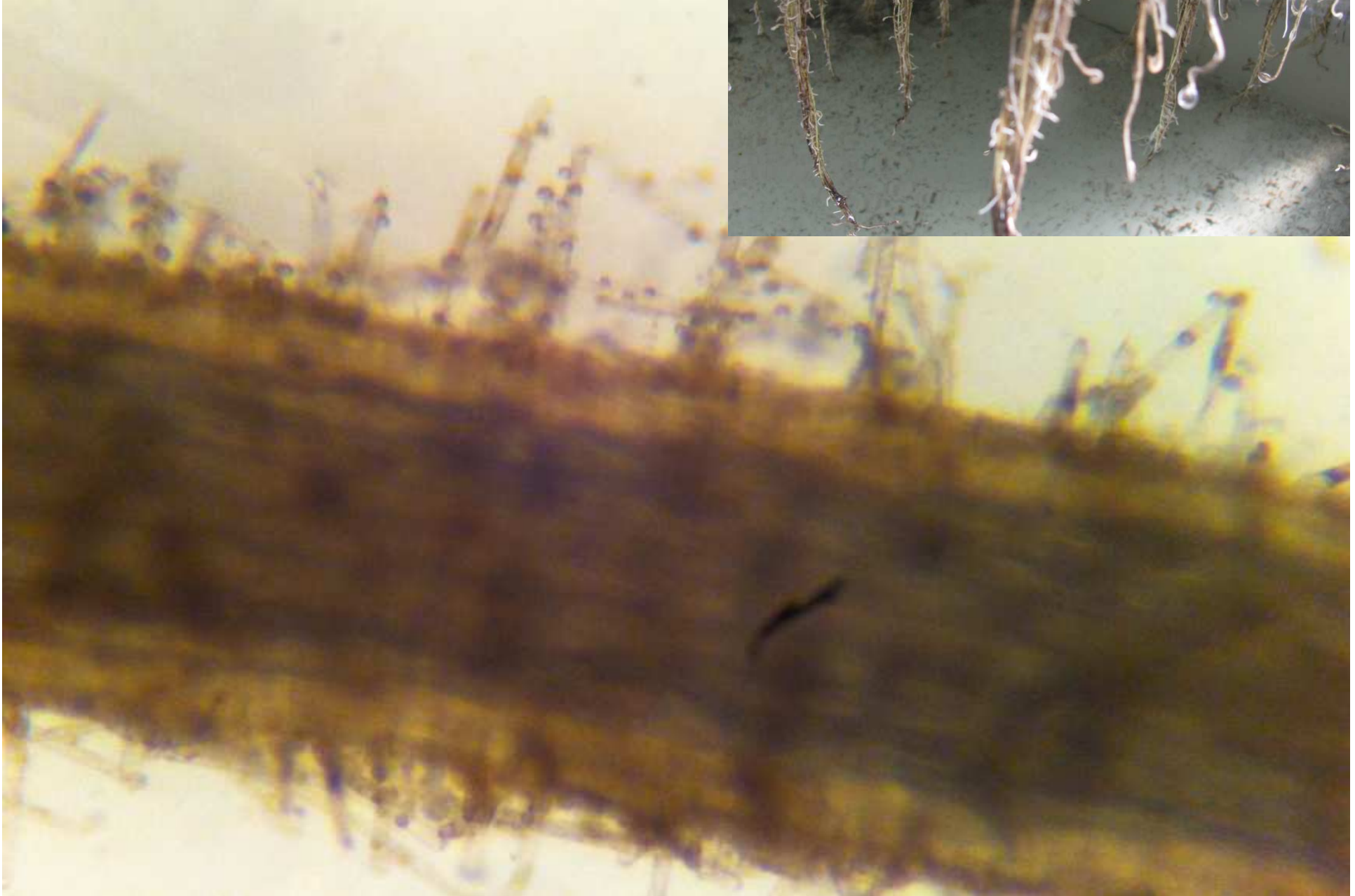




# Bacteria predators and super predators







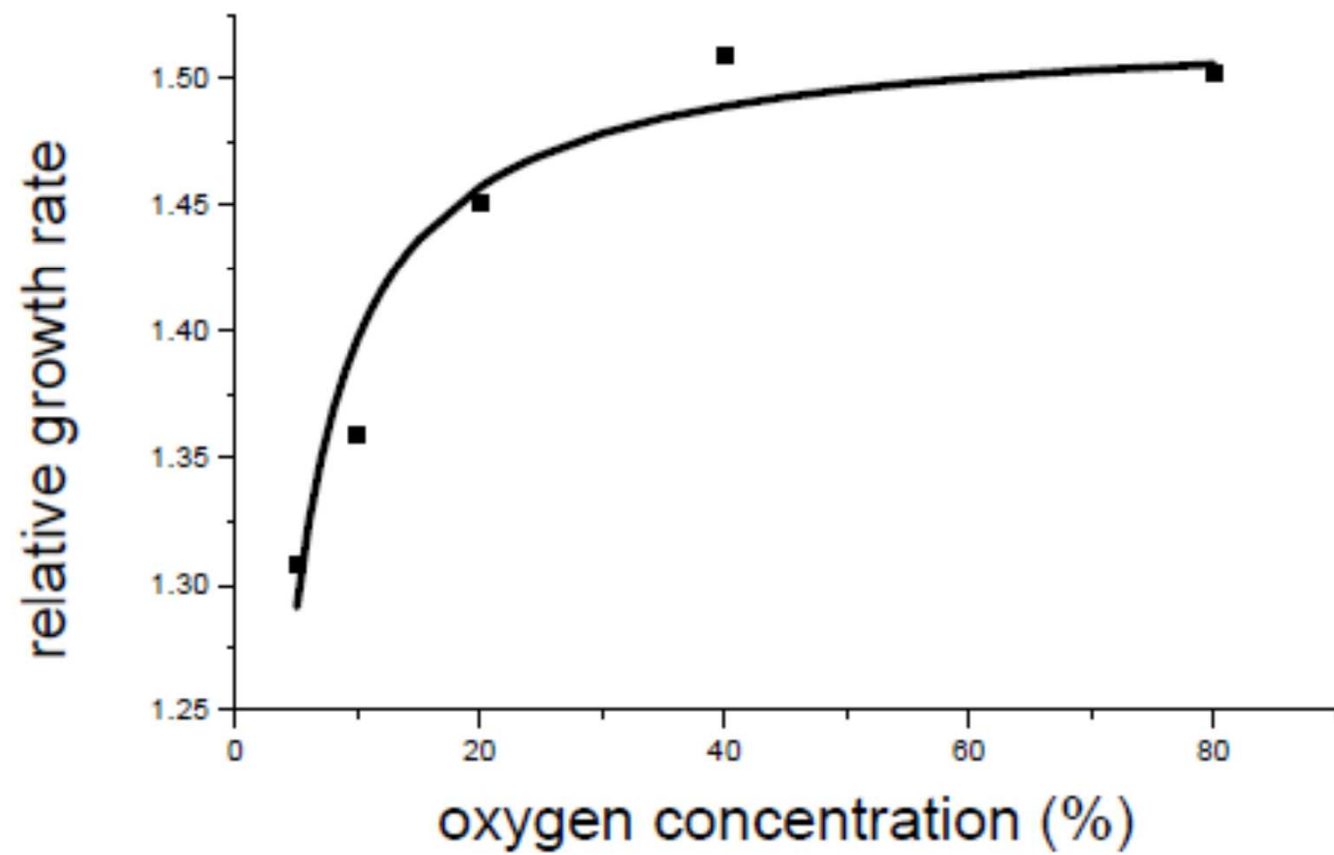


# Substrate 4. Oxygen supply

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- Root length growth stops
- Nutrient uptake and water uptake stop
- Roots die of, starting with root hairs and cortex
- Pythium arrives, 3-7 days AFTER root die
- Speedy aeration: required 2mg/h/ gr FW root mass or
- Mass flow in water and air with discontinuous supply
- A saturated layer is inevitable, its thickness is a choice





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- Supply must be symmetrical for each plant

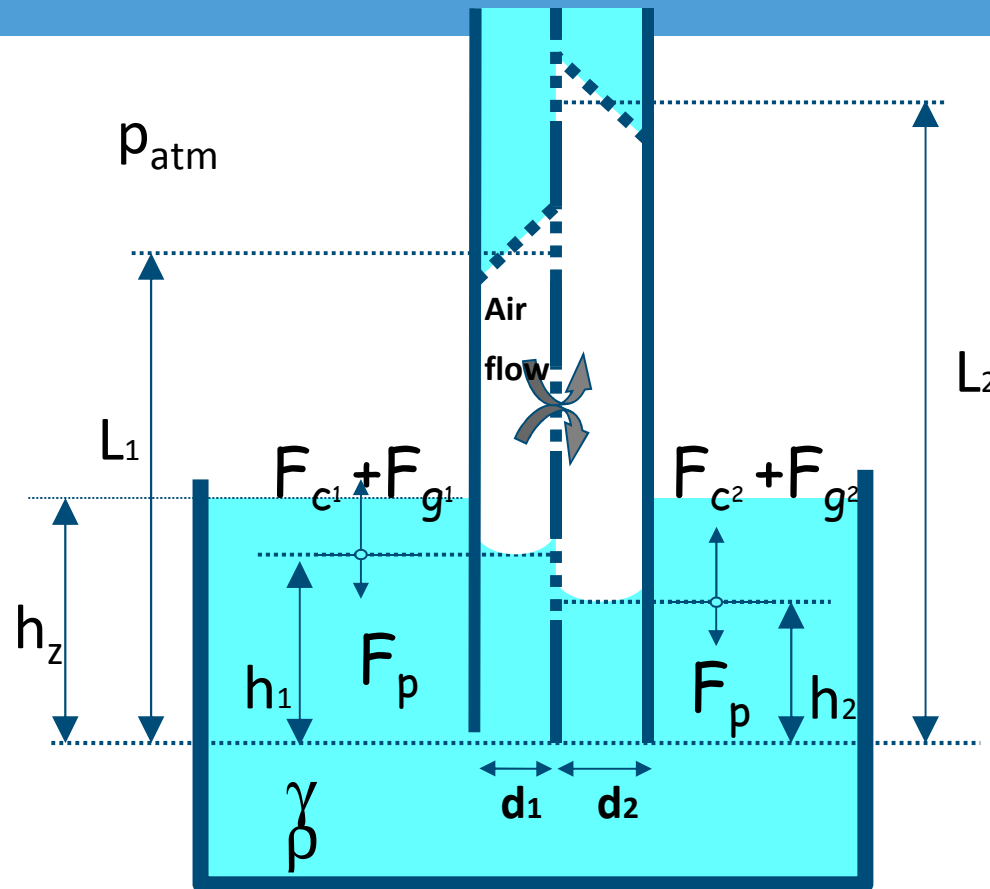


# Substrate 5. Plant Hydraulic Conductivity

- Steam fungi
- Bacteria  $10^6$  –  $10^8$  CFU in mineral media
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# Disappearance of Emboli → physical process



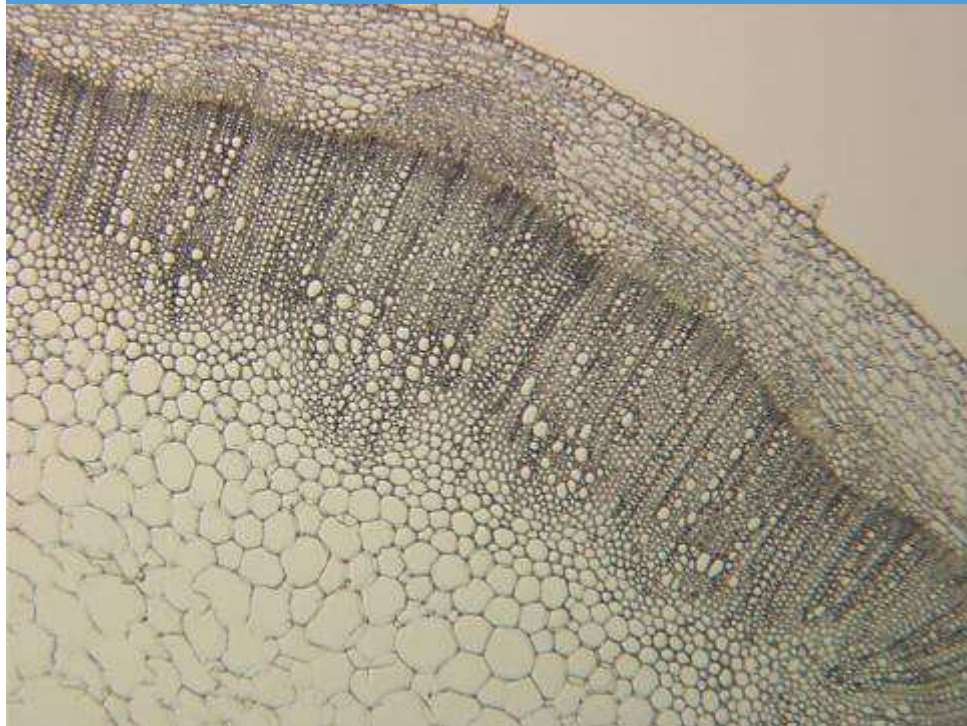
$$F_c = 2 \cdot \pi \cdot r \cdot \gamma \cdot \cos \theta$$

$$F_g = \pi \cdot r^2 \cdot (h - h_z) \cdot \rho \cdot g$$

$$F_p = \left( \frac{L}{L - h} - 1 \right) \cdot p_{\text{atm}} \cdot \pi \cdot r^2$$

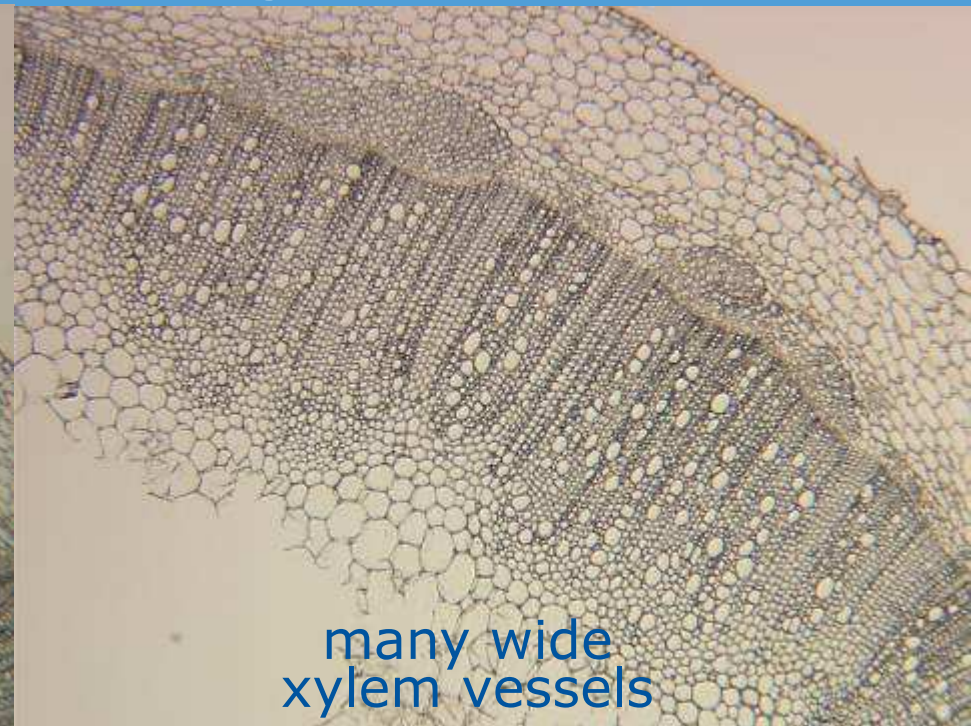
# Root substrate water content

Low water content



Good recovery of air emboli

High water content



Bad recovery of air emboli



# Water 5. Plant Hydraulic Conductivity

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- Possible wider vessels so vase life might differ.



- Carbon Dioxide dosing is essential (or production becomes -30%).
- In instable substrates: CO<sub>2</sub> dosing is substantial and related to temperature (and moisture and N-supply)
- Peroxides clean. Batch dosing is required.
- Supply water must be clean
- T influences root formation
- T influences max oxygen content in the water



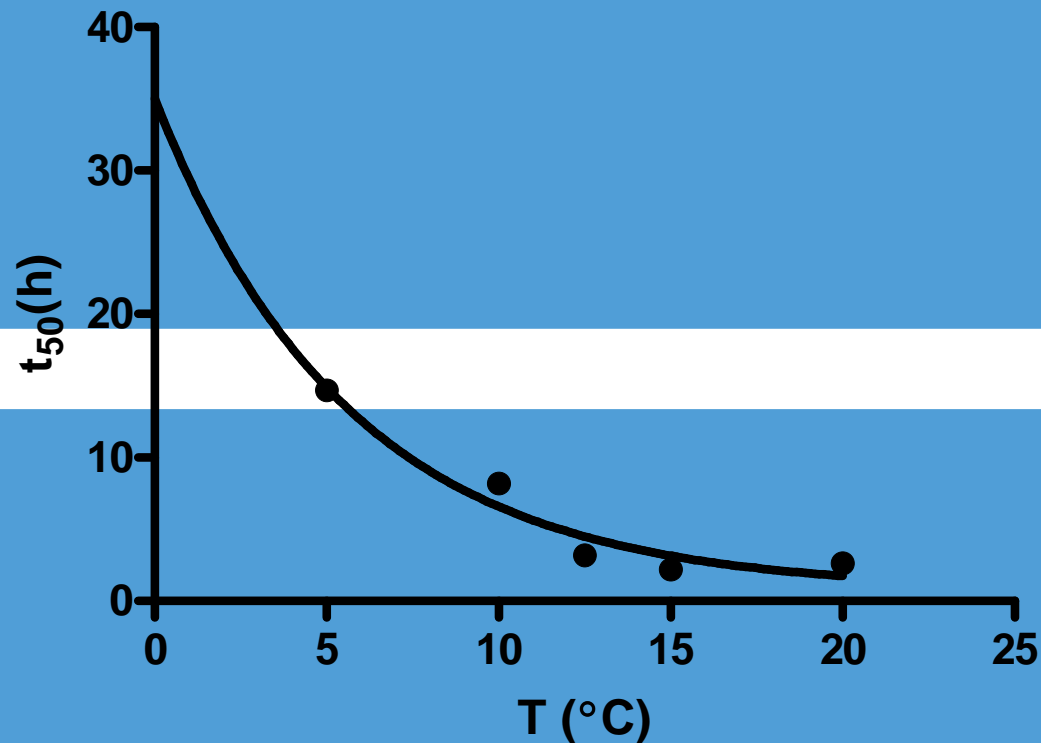


# Temperature

- 25 degrees C versus 20 degrees C.



# Conidia germination



At temperatures  $< 5^{\circ}\text{C}$  condensed water has to be present at  $> 10$  hrs



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# Wageningen UR Greenhouse Horticulture

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Innovations for the  
horticultural sector



WAGENINGEN **UR**  
*For quality of life*