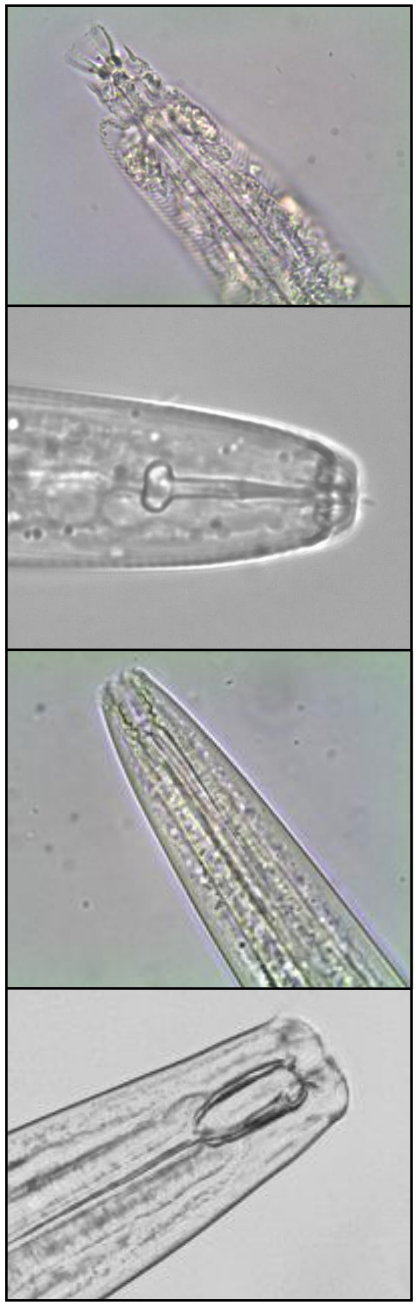


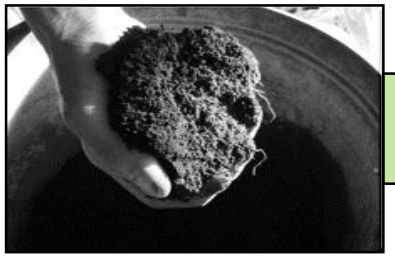
nemlab

Using nematodes as bio-indicators of soil health

Sheila Storey

2nd Annual Soil Health Day
Joostenbergvlakte
March 2018

soil health SUPPORT CENTRE
measuring the heartbeat of soil life



Contents

- What is soil health?
- How does soil biology work for you?
- How do you measure it?
- How do you achieve it?
- Why consider it?
- Root health

soil health
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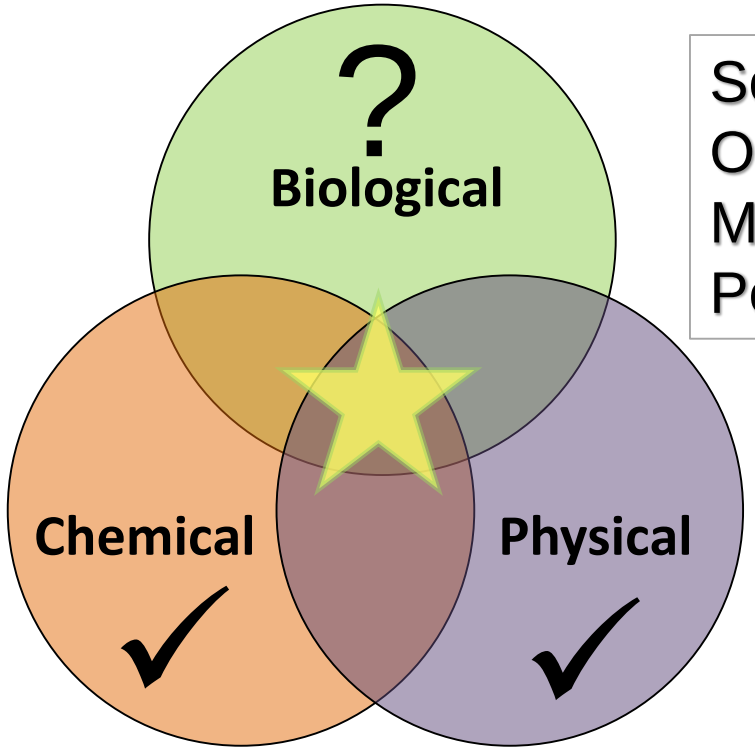
measuring the heartbeat of soil life

What is soil health?

Three components



Soil biodiversity
Organic carbon
Microbial biomass
Pests and diseases

Nutrients

Texture &
Pore size

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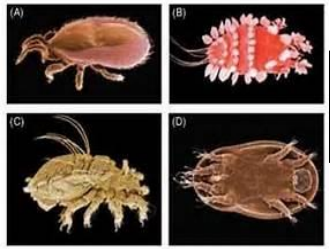
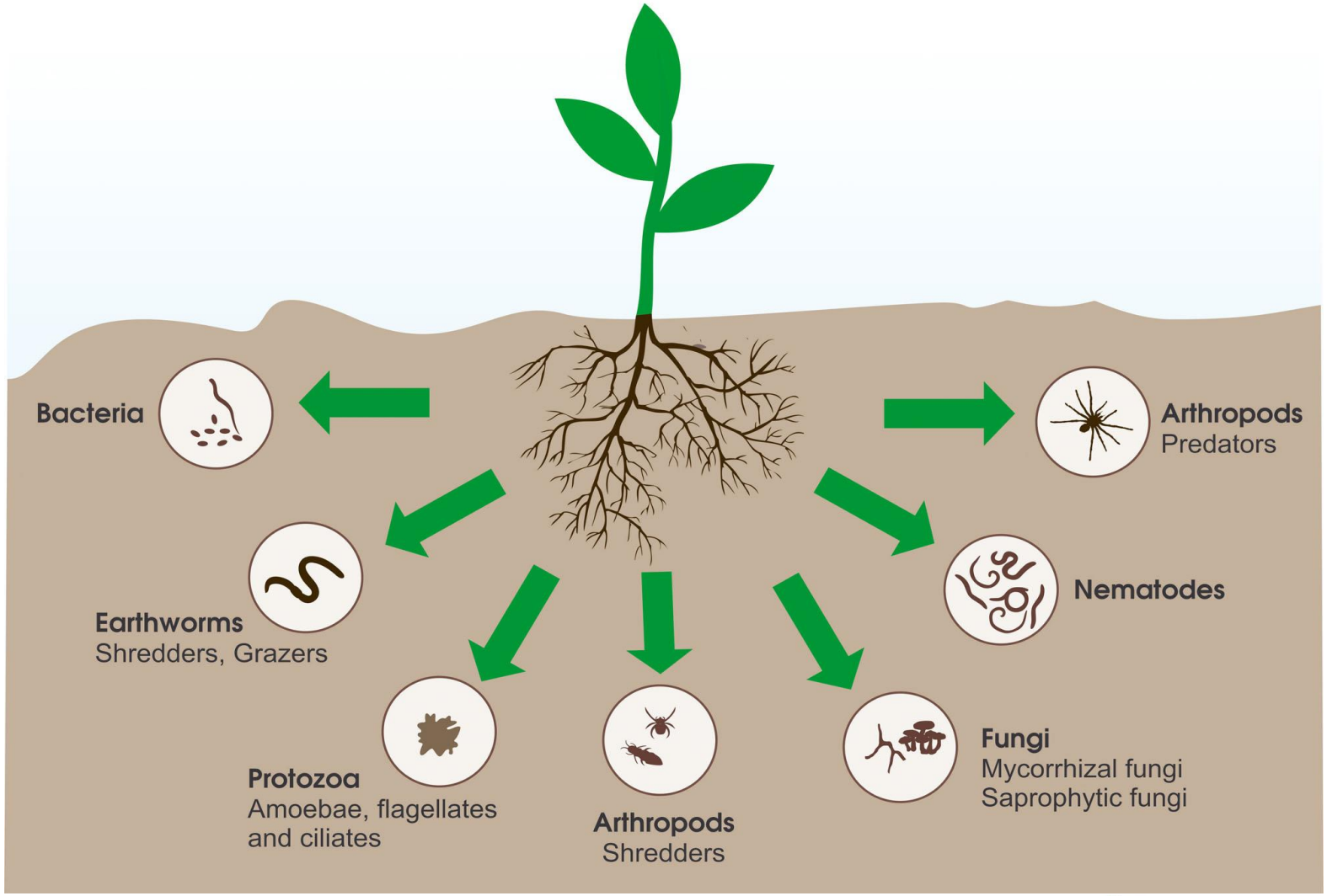


How does it work / function?



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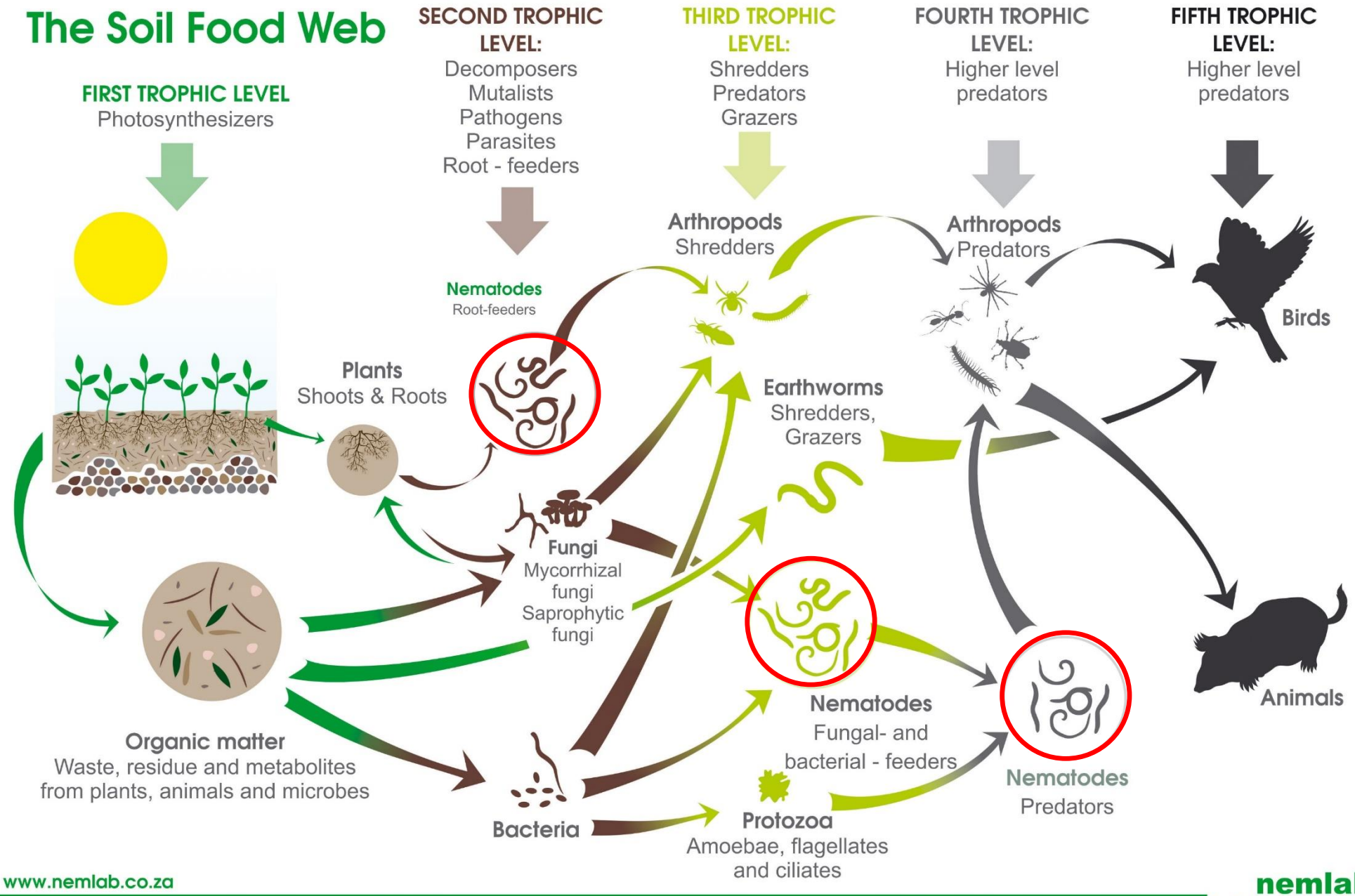
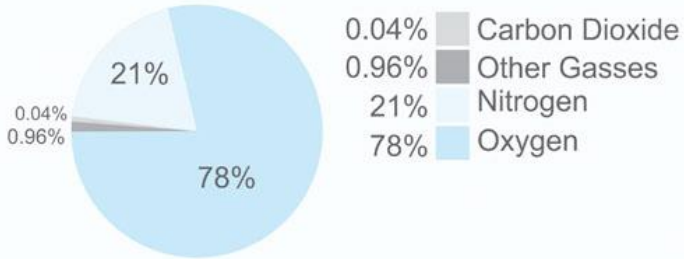
The Soil Food Web



Nutrient cycling



0.04% Carbon Dioxide
0.96% Other Gasses
21% Nitrogen
78% Oxygen

Sun energy

CO_2

N

Photosynthesis

CH_2O
(sugars, amino acids, organic acids)

Complex C:
(Cellulose, lignin, tannins)

Bacteria

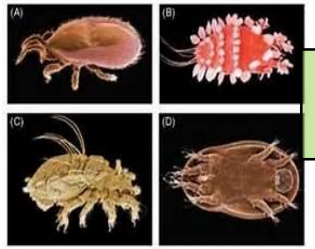
Fungi

Protozoa

Nematodes

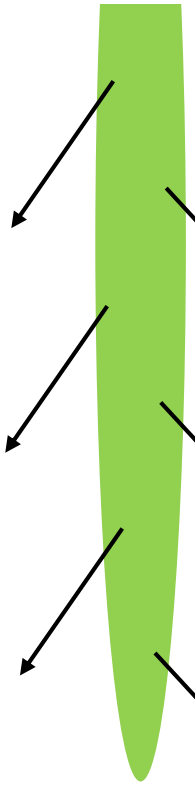
Excretions include water soluble and root diffusible nutrients

Excretions include 9 to 30% N



How does it work / function?

Carbon released by the plant



6. C from dead plant cells

5. C to mutualistic fungi

4. Volatile organic C

3. Soluble root exudates

2. Insoluble glues

1. Root cap + epidermis cells

Plant Soil (2009) 321: 5 - 33

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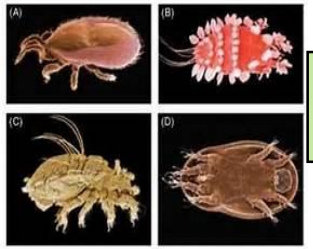
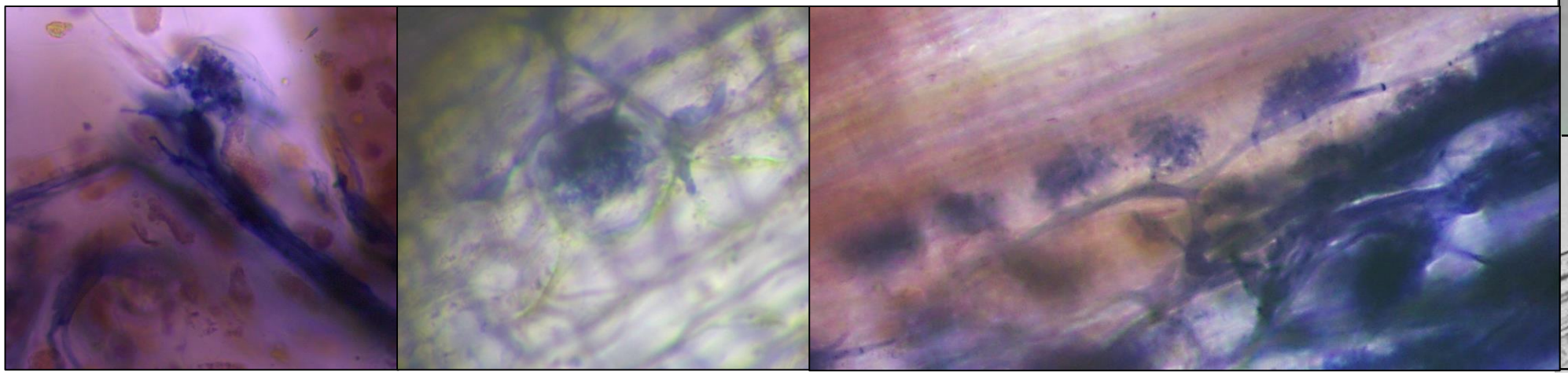
measuring the heartbeat of soil life

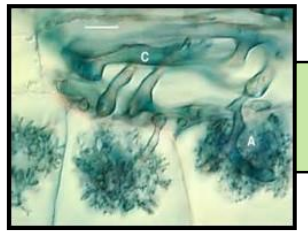


How does it work / function?

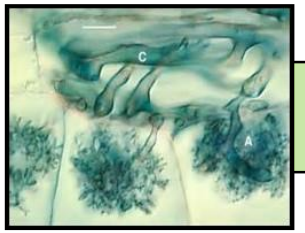
Two examples

- **Mycorrhizae**
- **Nematodes**



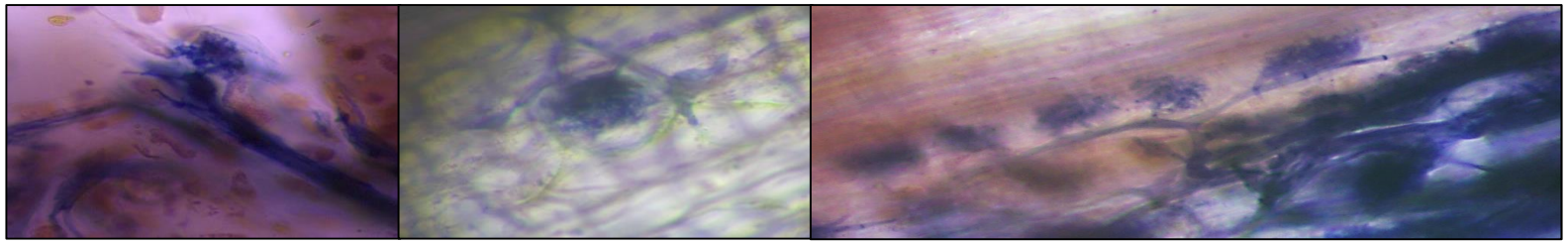


Mycorrhizae



Mycorrhizae

- Fungi that colonize plant roots
- Very common in soil
- Live together with most plant families – except Brassicas
- Form structures that take up nutrients more effectively – arbuscles, vesicles and hyphae
- Transfers phosphorous to plants - in return receive sugars from plant roots



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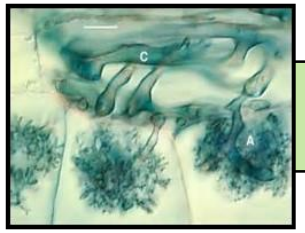


Mycorrhizae

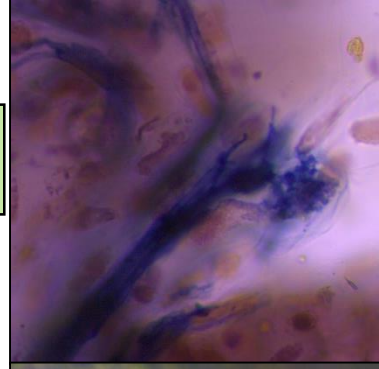
Many reasons why mycorrhizae are important (16)…

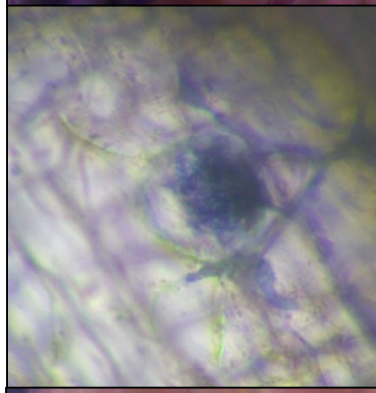
A. Increased yield

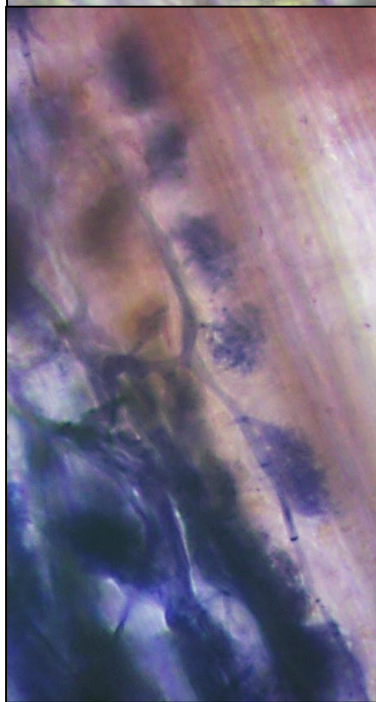
B. Free phosphorous

C. Drought tolerance

D. Biocontrol







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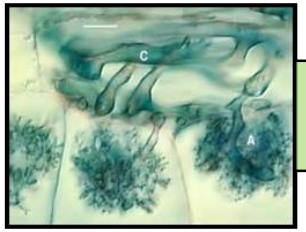

Mycorrhizae - yield

Lekberg and Koide (2005) examined 290 field and greenhouse experiments published between 1988 and 2003.

They found that…

In general, increased root colonization resulted in a yield increase of 23% across all management practices.

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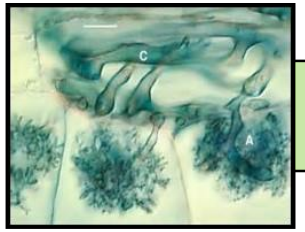
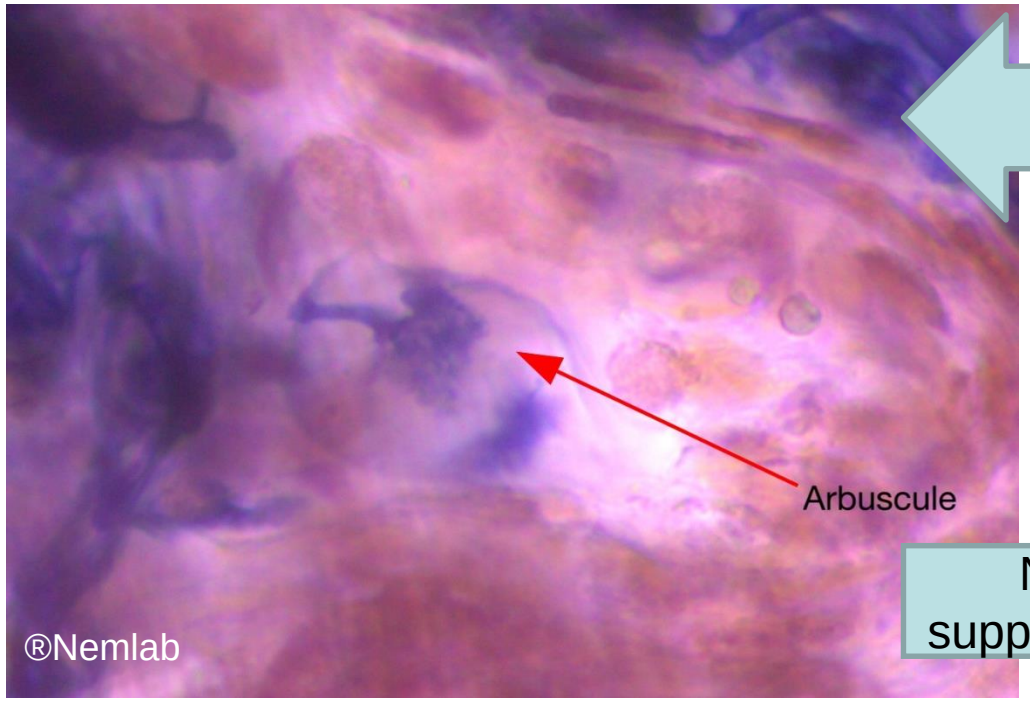


Mycorrhizae – free phosphorous

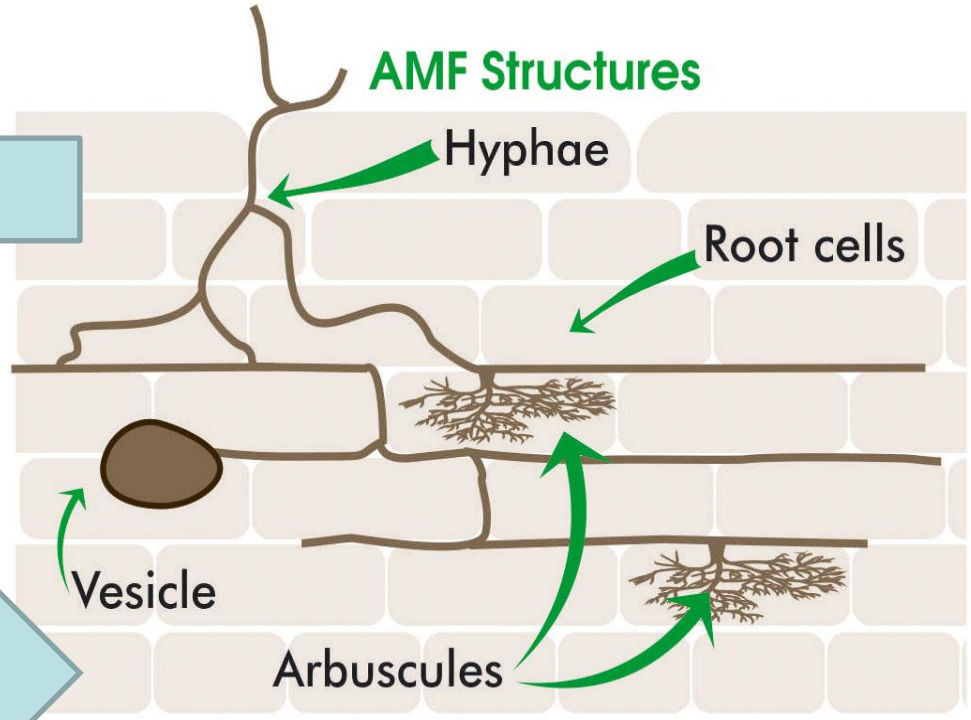


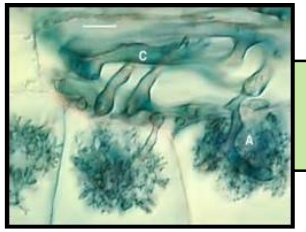
C

Assimilated carbon

Nutrient supplementation

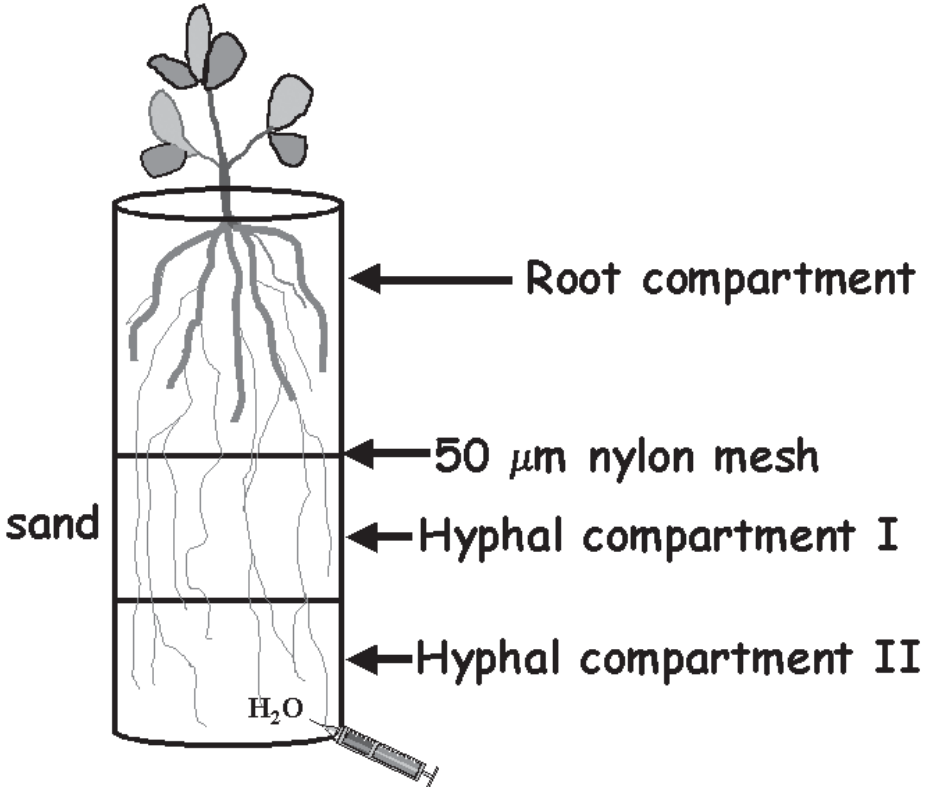
P





Mycorrhizae – drought tolerance

How much water can they really provide to a plant?



Ruiz-Lozano & Azcon, 1995

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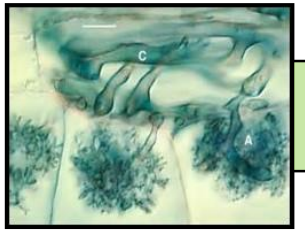
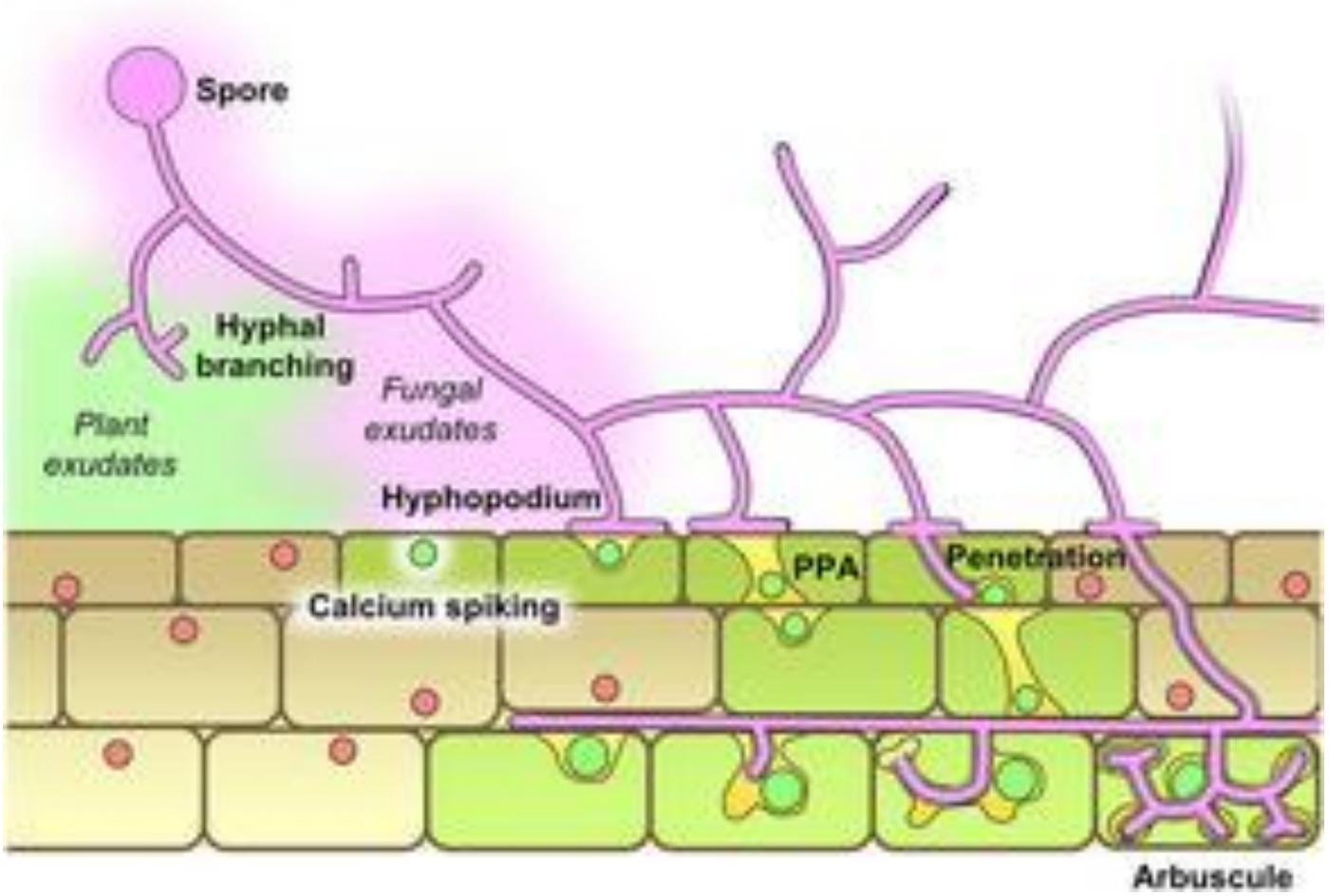
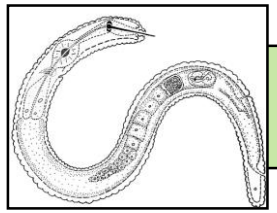


Mycorrhizae - biocontrol

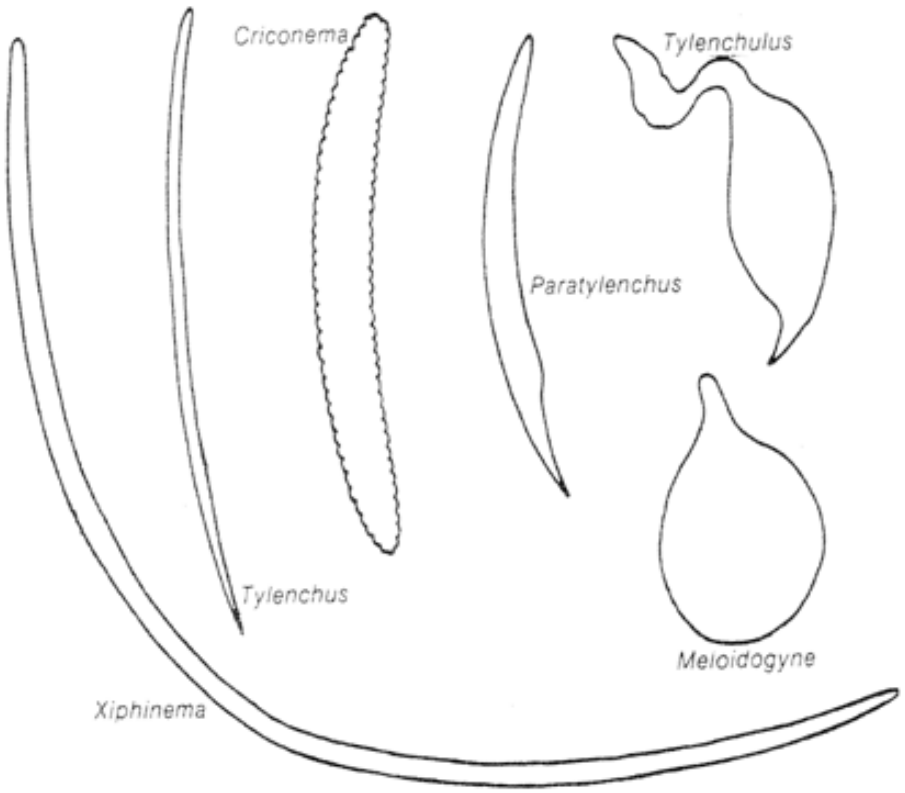
Expansive AMF network signals the whole fungal network that it is being attacked. In turn a signal is switched on which allows the plants to turn on their defence mechanism

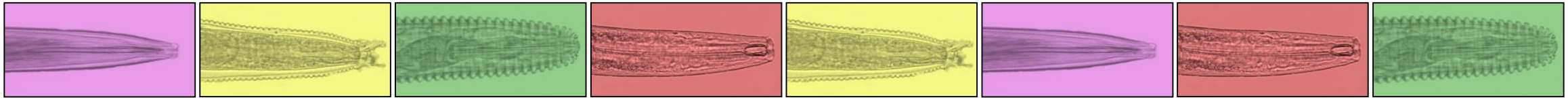


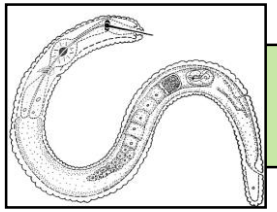


What is a nematode?

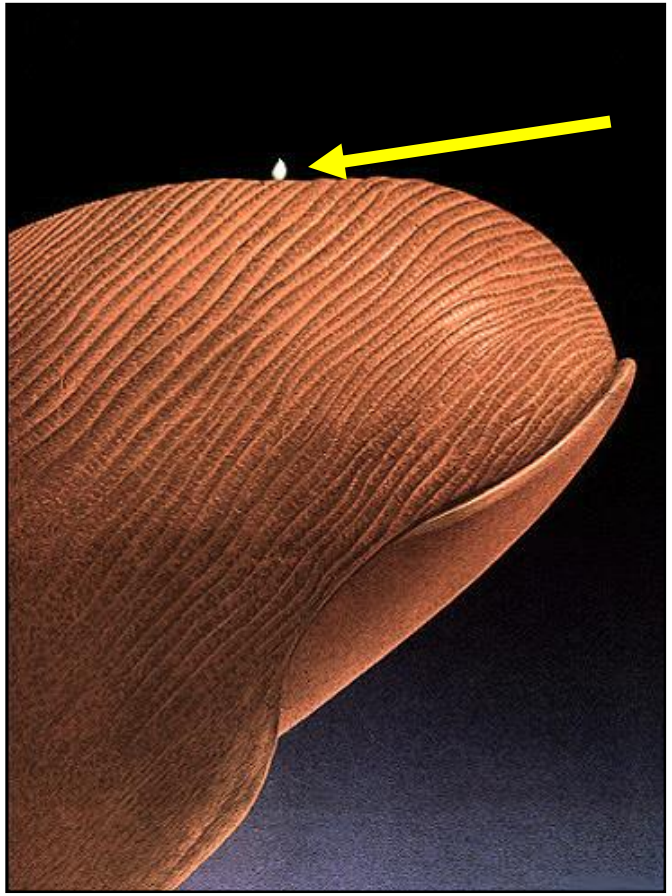
- Microscopically small
- Unsegmented organisms
- Length between 0,1-1mm
- Vary in shape
- Occur in groundwater in the soil
- Feed on various organisms in the soil

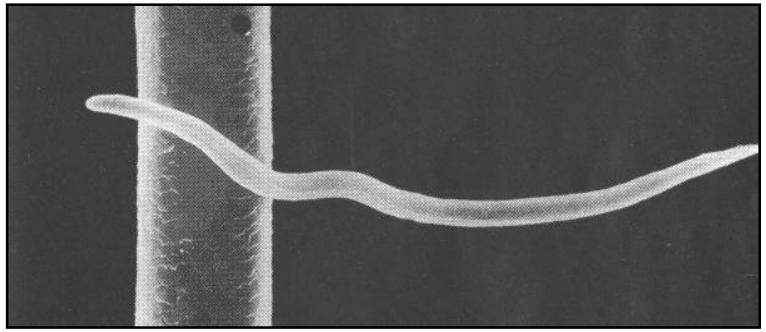




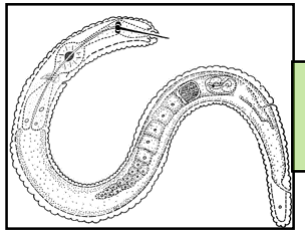


What is a nematode?

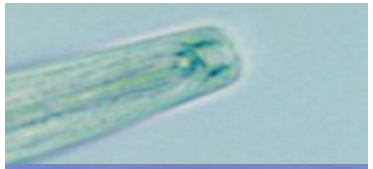


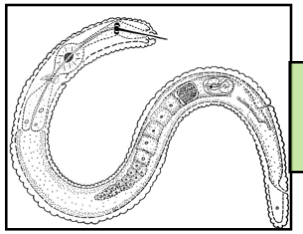


nemlab



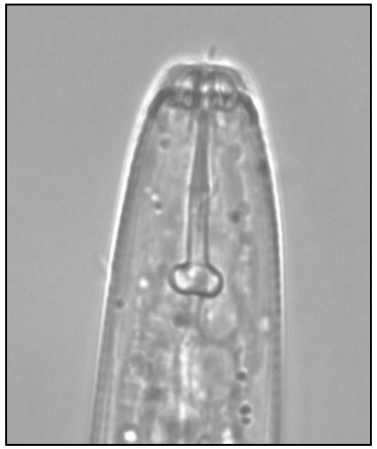
The different nematode feeding groups

Unicellular feeders	Unicellular **eucaryote** feeding: yeast, algae, lichen	
Bacterivores	Feed on **bacteria**: use hollow tube	
Fungivores	Feed on **fungi**: stylet punctures hyphae	
Herbivores	Feed on/in **plant roots**: use stylets	
Omnivores	Feed on more than one type of food source: **org. material** etc	
Predators	Feed on **other nematodes**: puncture with tooth	
EPNs	Feed on **insects** (and bacteria) no stylet	



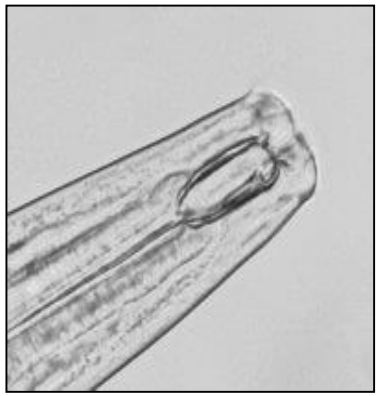
The different nematode feeding groups - 7

- Feed on bacteria
- Extensions make wave-like movements

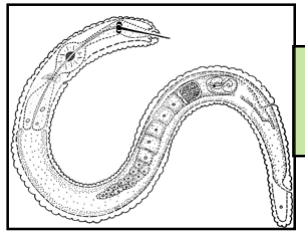


- Feed on plant roots
- Has a stylet

- Feed on fungi
- Stylet pierces hyphae



- Feed on other nematodes
- Tooth-like structure tears apart nematode



Nematode functions in the soil

Ecosystem service providers
– what can they do for you?

- Break down organic material
- Redistribute minerals and nutrients - can contribute between 9 to 30% of total mineralizable N to the soil
- Sequester carbon
- Improve soil structure
- Can regulate other diseases
- Can cause economic crop losses

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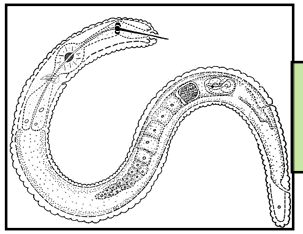
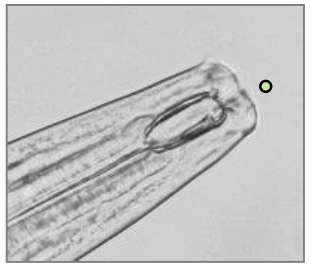
measuring the heartbeat of soil life



Nematodes as bio-indicators of soil health

- simple / easy to sample and analyse
- relatively easy to measure
- have a best time to sample
- present in poor and healthy soils
- reliably assess impacts of practices
- provide useful information
- cost-effective test

Pick me!



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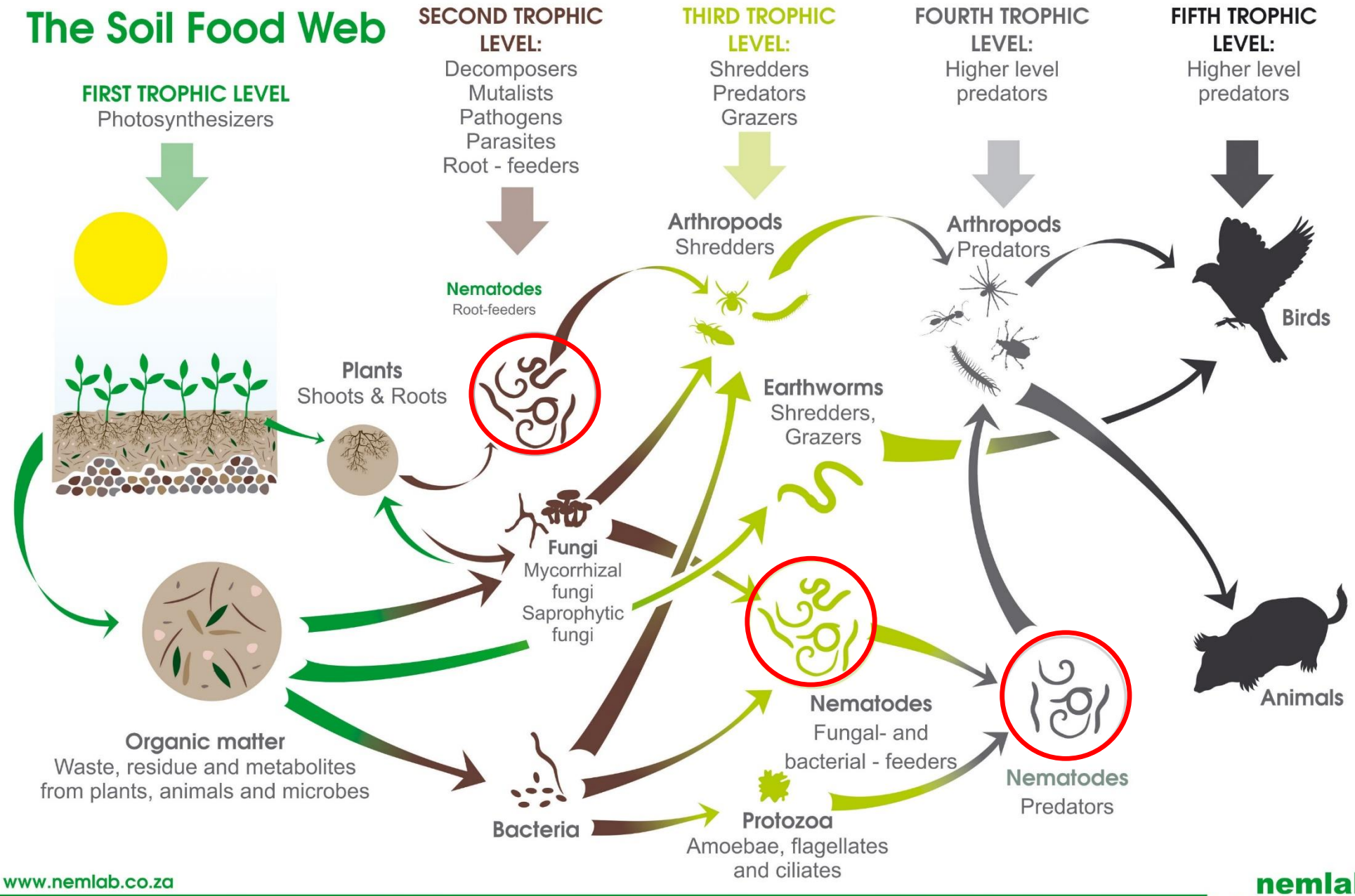
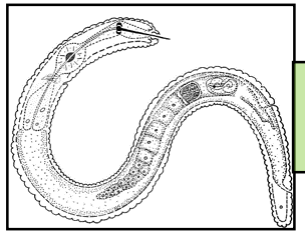
The Soil Food Web





Nematode faunal profile

The nematode faunal profile to measure soil health has a number of steps

1. Identify nematodes to family level
2. Classify into feeding groups

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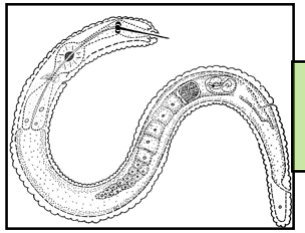

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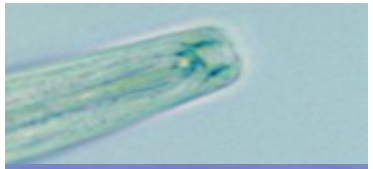
Unicellular feeders	Unicellular **eucaryote** feeding: yeast, algae, lichen	
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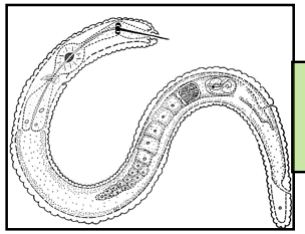

Nematode faunal profile

The nematode faunal profile to measure soil health has a number of steps

1. Identify nematodes to family level
2. Classify into feeding groups
3. Allocate cp-values to each family

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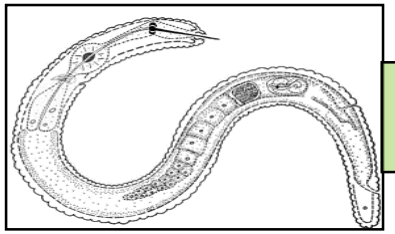

Colonizer-Persister Scale

cp value (1-5)

Colonizer - cp1	Persister - cp5
• short life cycle • small body size • highly prolific • mainly bacterivores • feed continuously	• longer life cycle • larger body size • less prolific • mostly carnivores & omnivores • very sensitive to disturbances

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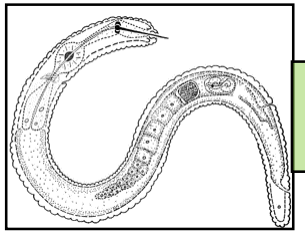

Nematode faunal profile

The nematode faunal profile to measure soil health has a number of steps

1. Identify nematodes to family level
2. Classify into feeding groups
3. Allocate cp-values to each family
4. Calculate various indices using equations and the above
5. Draw up a nematode faunal profile model
6. Interpret the results

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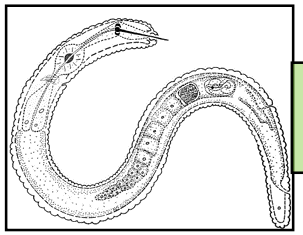

A. Nemlab soil health result

Ecological Indices

Index	Value %	Explanation
SI = Structure Index (soil food web)	36.36	Soil food web structure increasing
EI = Enrichment Index	85.11	Enrichment highly N enriched but not decomposed
CI = Channel Index	0.0	Decomposition channel is bacterial
BI = Basal Index	13.73	Bacterial dominated system with abundant resources and fast nutrient turnover
FBI = Fungivore-Bacterivore Index	0.0	System busy recovering from stress

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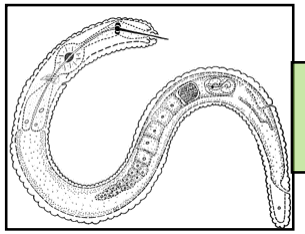
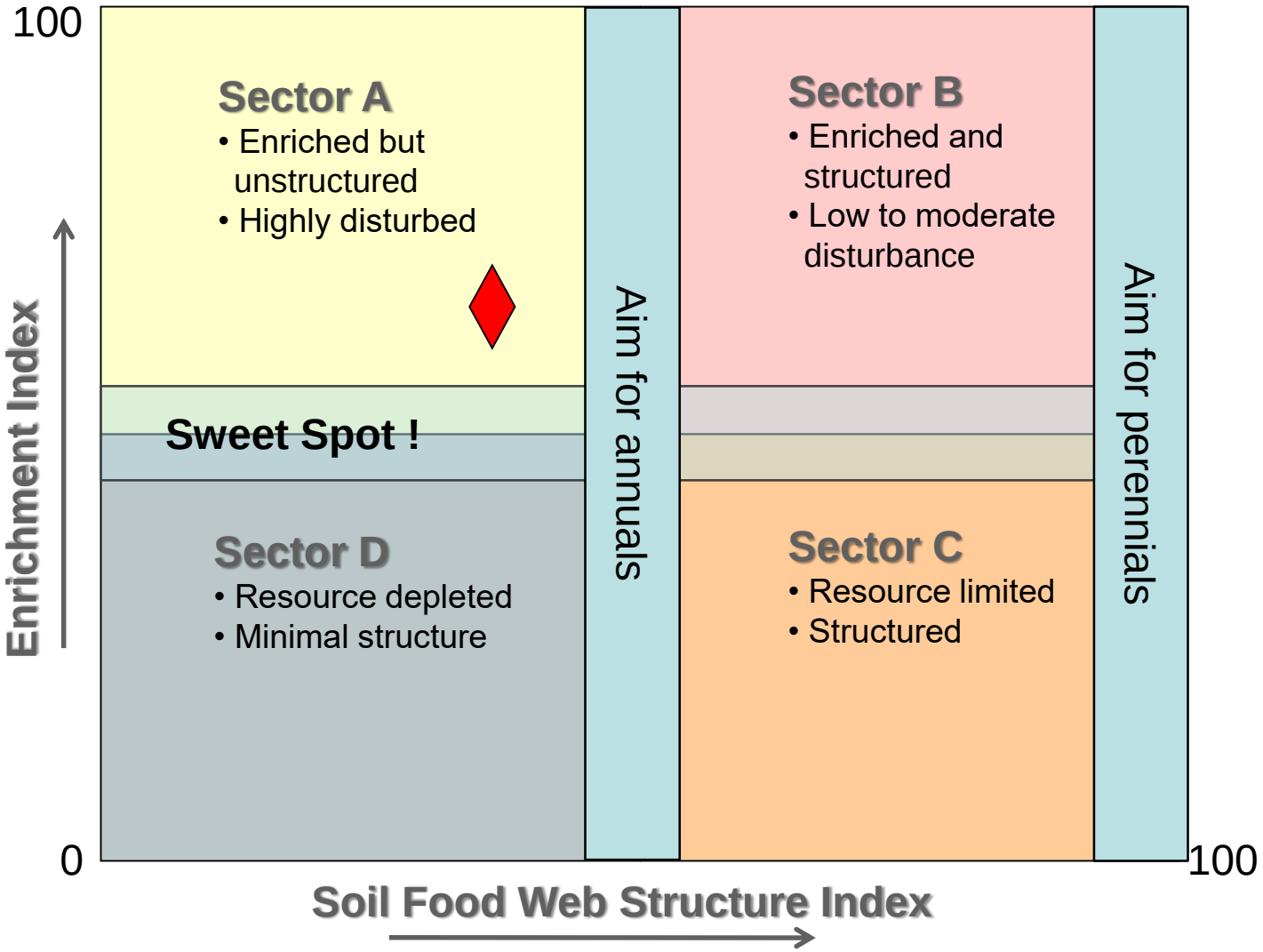


C. Nematode Faunal Profile Result



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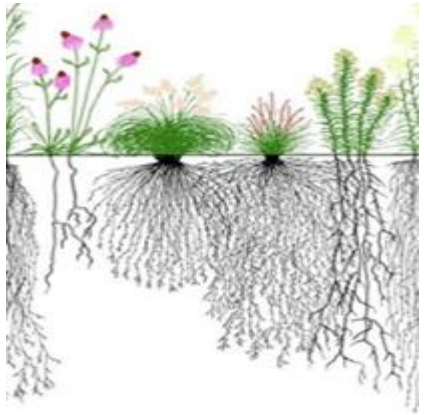
TESTS
Solvita 24 hour CO_2-C Burst test
Aggregate stability test
Haney Soil Health fertility analyses
Solvita SLAN Test
Standard chemical analyses using Mehlich 3 as extractant
Mycorrhizae colonization percentage
Nematode Soil Health Analyses

How do we achieve it?

Cover!

Diversity



Living roots

Reduced tillage

How do we achieve it?

- Compost – serves as an inoculant
- Cover ….. eg straw, wood chips, cuttings etc
- Cover crops
- Weeds
- Compost tea
- Vermicast
- Manure

Cover crop choices…

- Preferably a mix
- Include a grass, a brassica, a legume, a broadleaf (and a radish) …
- Issues addressed when selecting a choice:
  - reduce compaction
  - increase organic material (biomass)
  - stimulate soil biology
  - reduce erosion
  - add nitrogen

Root health

- ‘Plant Growth Promoting Rhizobacteria’ (PGPR’s) bv *Bacillus*
- Mycorrhizae
- Endophytes eg *Trichoderma* spp
- Root stimulants containing auxins & cytokinins

= biological supplements or amendments

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Why consider soil health?

Soil is a non-renewable resource

Organic material content = humus = sponge

Increased water holding capacity

Excellent habitat for rich soil microbe diversity

Improved aggregate stability / soil structure

Together, the hyphae and glomalin form a sticky net that traps particles of sand, silt, clay and organic matter and holds them together to form lumps or aggregates of soil

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Why consider soil health?

- Increased water infiltration – no crusting
- Decreased run-off and evaporation
- Improved nutrient cycling
- Carbon sequestration = helps climate change
- Low weed and pathogen pressure
- Resilience = ability to recover
- Healthy soils are the foundation for everything

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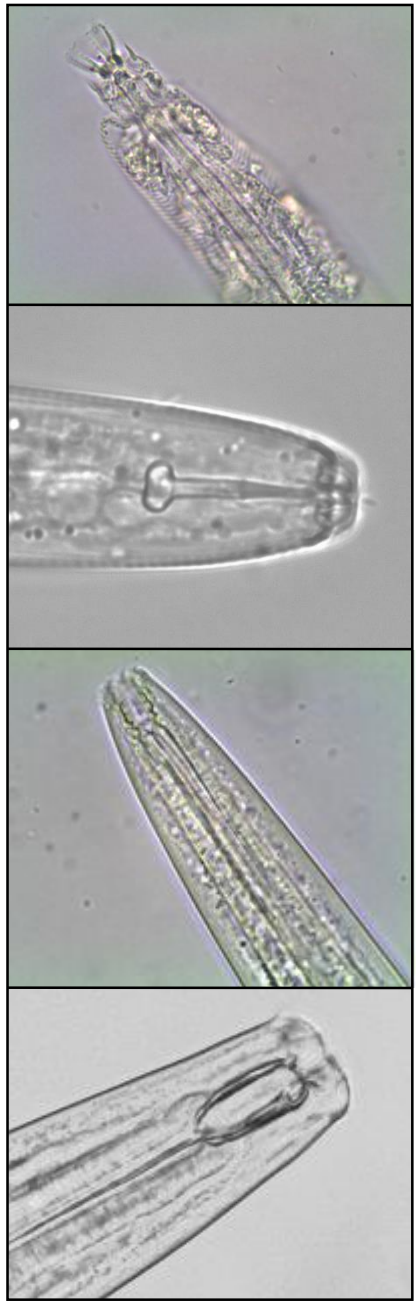

USDA Natural Resources Conservation Service

Unlocking the soil health in South Africa!

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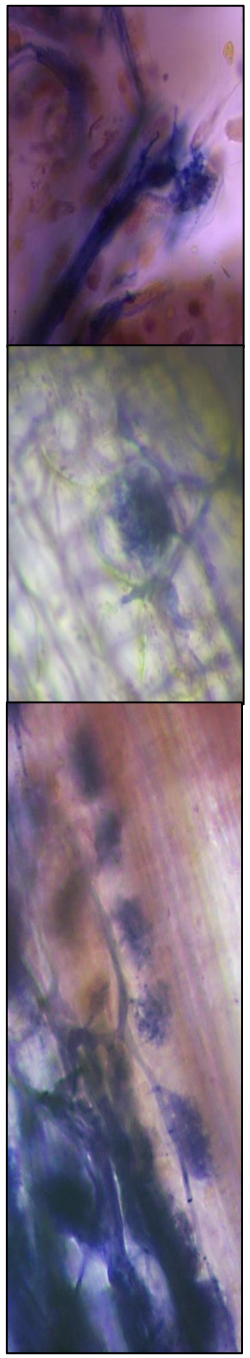

Acknowledgements

Landbouweekblad
Caro Kapp - photos

Contact details

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