

What about soil goes above ground

Hidden innovations and challenges in horticulture



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Stichting Control in Food & Flowers

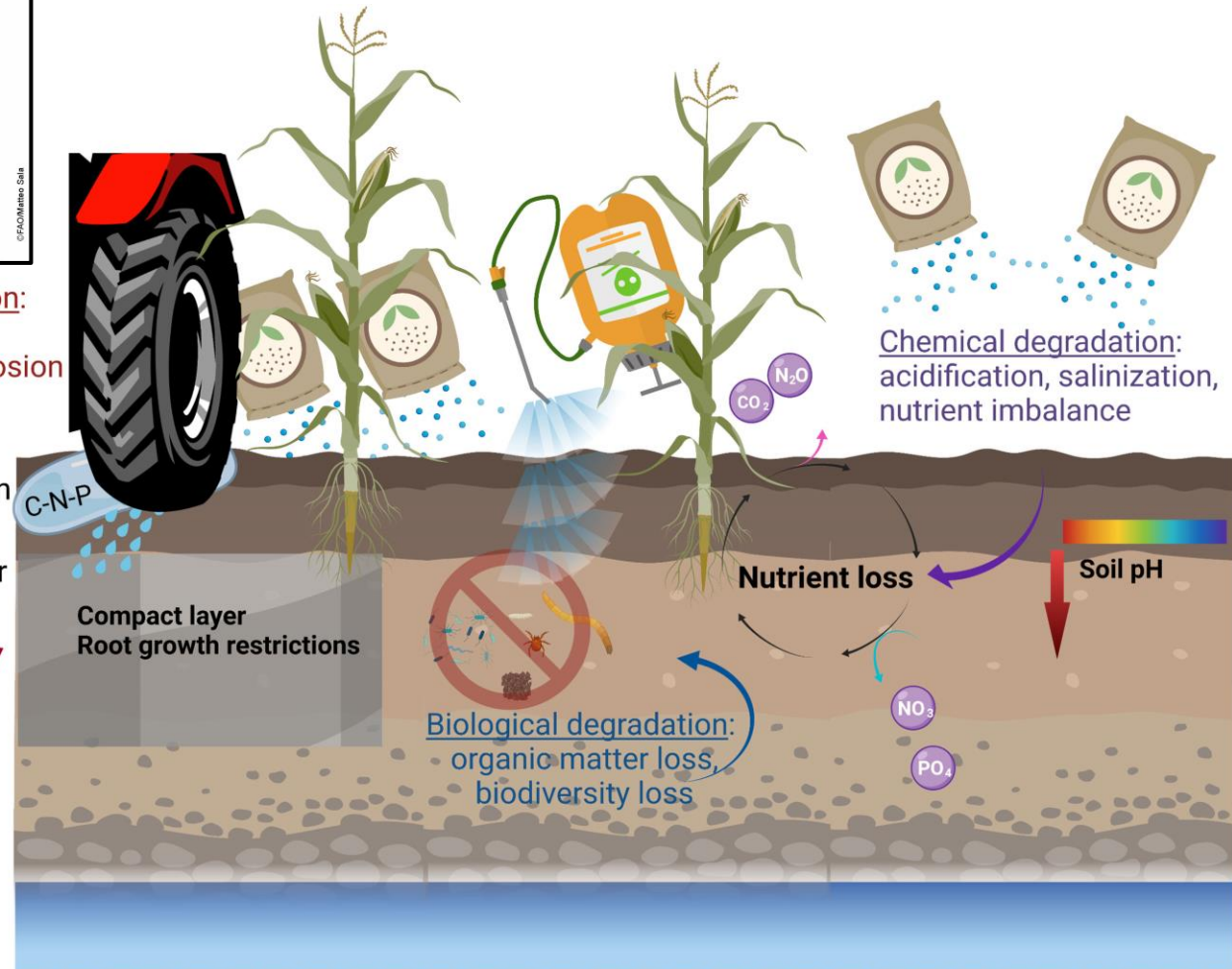
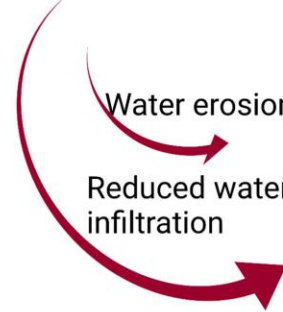
14 of March 2024

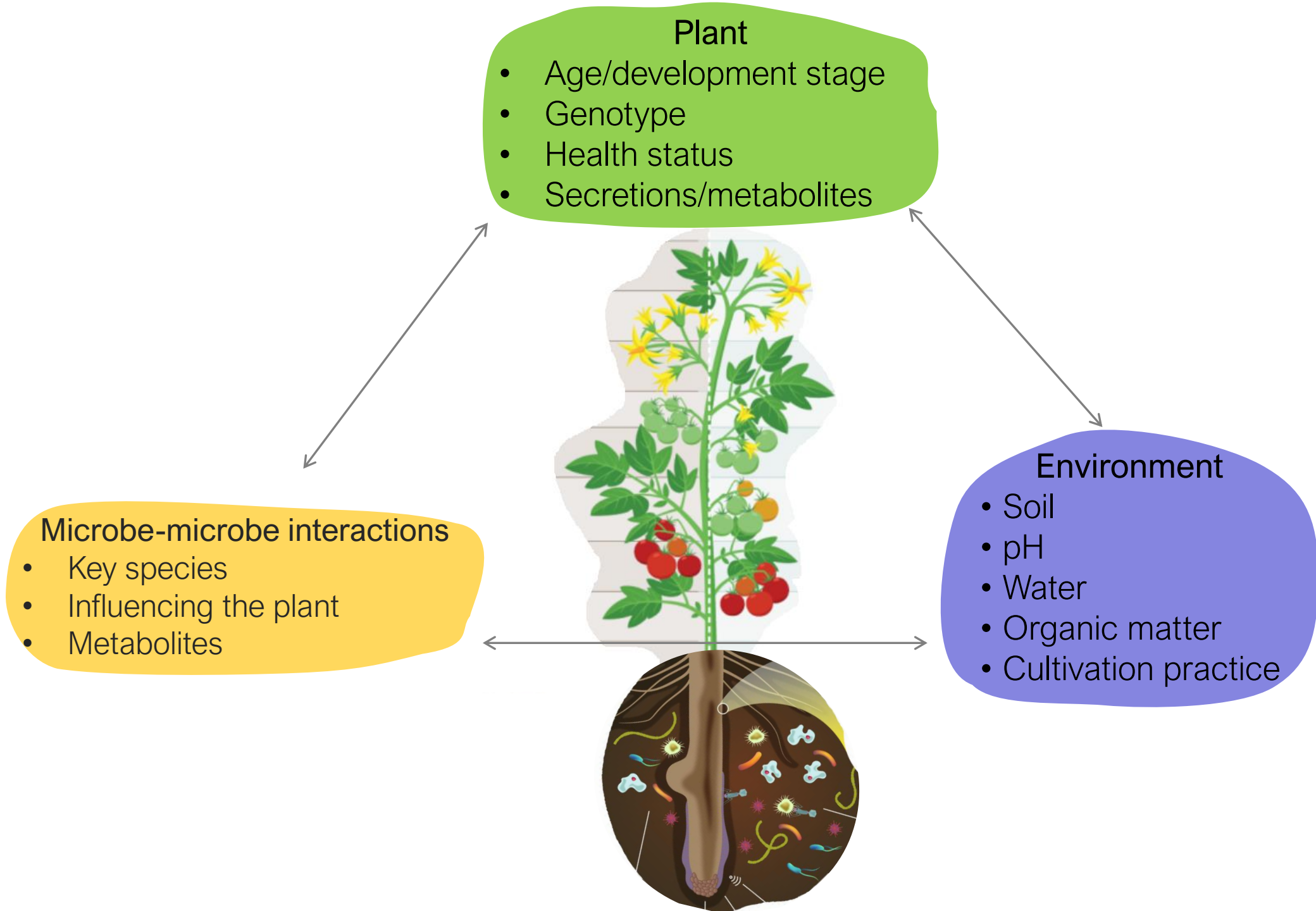
Functions of soil

- Soil structure
- Availability of nutrients
- Water regulation
- Organic matter: breakdown and built-up
- Plant defence
- Microbial diversity



Physical degradation:
structure loss,
compaction and erosion





Horticulture

- Plant**
- Age/development stage
 - Genotype
 - Health status
 - Secretions/metabolites

- Microbe-microbe interactions**
- Influencing the plant
 - Metabolites
 - Key species

- Environment**
- Soil
 - pH
 - Water
 - Organic matter
 - Cultivation practice

- Horticulture on soil**
- Heterogeneous growth medium
 - High microbial diversity

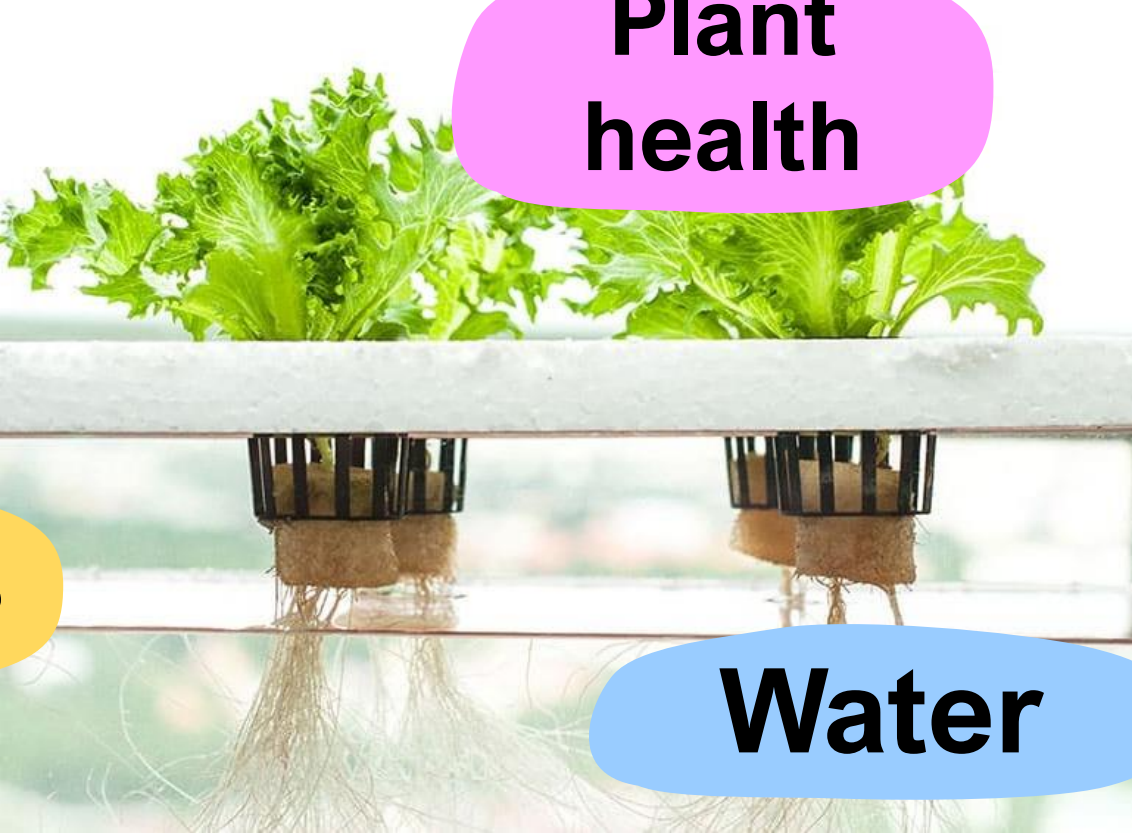
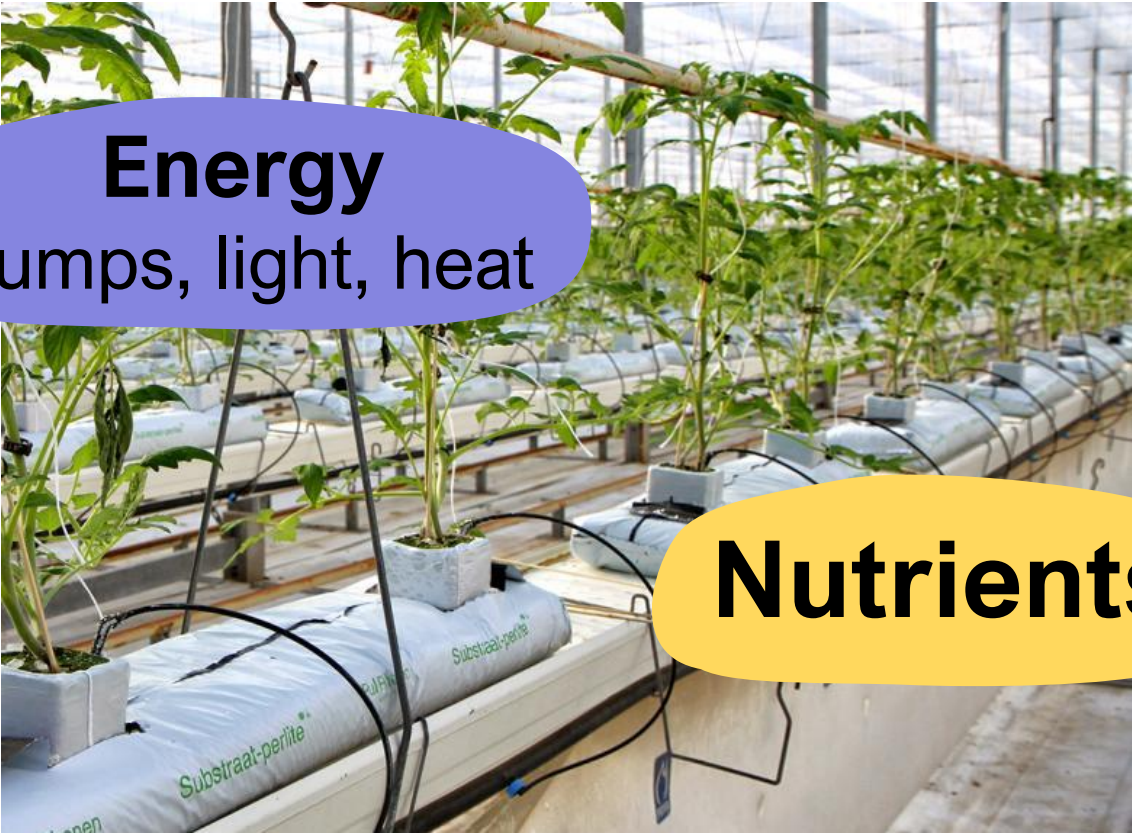


- Hydroponic horticulture on rockwool**
- Homogeneous growth medium
 - Favours growth of bacteria

Examples of horticultural practices

Rockwool (or cocos/bark/sawdust)

Hydroponics



Energy
pumps, light, heat

Plant health

Nutrients

Water

Challenges in horticulture → Research at



Nutrients

- optimal nutrient management
- Prevent diseases caused by deficiency
- new (bio-based) revenue models
- Fermentation: upgrading of residual materials
- reprocessing biological fertilizers
- new applications and cultivation of micro-organisms



Water & Energy

- sensing and precision horticulture and agriculture
- growth models for cost, cultivation, and energy optimization
- new crops, and cultivation practices
- resilient cultivation systems



Plant health

- hygiene protocols
- natural enemies
- optimization of the use of (microbial) antagonists
- new microbial crop protection products and methods
- protection against viruses
- guidance in the admission process for crop protection products
- contaminants in food
- healthy plant content substances



Research techniques

- Traditional microbiological techniques
 - Genomics: sequencing, metagenome, gene → functionalities
 - Targeted and non-targeted analysis (HPLC/GS-MS, QTOF)
- From lab to practice**
- optimization and cultivation of algae
 - entrance examination trial version with large and small greenhouses

Nutrient/substrate management

Circular economy within horticulture



Growth substrates, soil improvers and fertilizer



Watermanagement



Plant bioactive compounds



Biostimulants,
organic pesticides

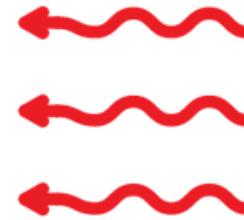


The need for circular economy...

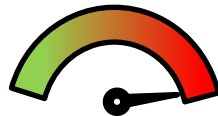


Challenges in horticulture

Energy

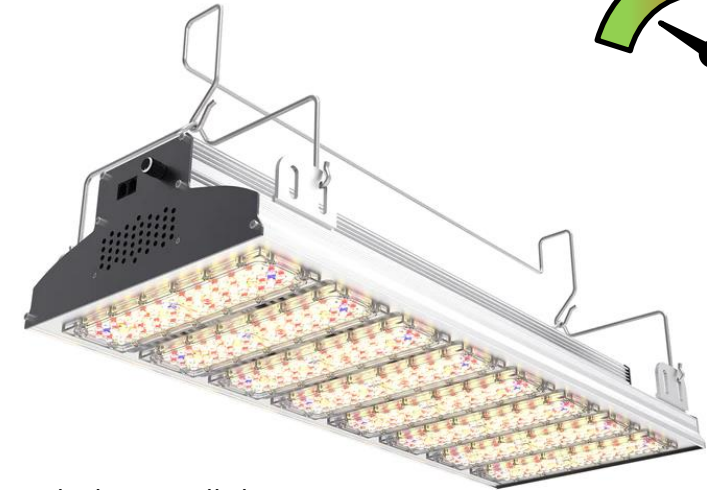
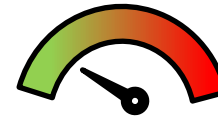


High-Intensity Discharge (HID)



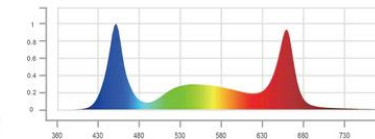
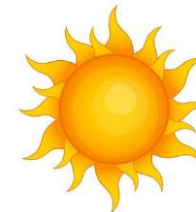
<https://www.percival-scientific.com/blog/lighting/high-intensity-discharge-lights-hid/>

LED lighting



<https://www.growpackage.com/products/eco-farm-n10-800w-commercial-led-grow-lights-for-greenhouse-replace-1000w-tps>

LED spectrum better mimics sunlight



SAMSUNG LEDS

Challenges in horticulture

Energy

LED



Smaller leaf surface area



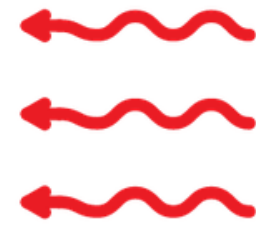
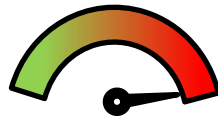
Less transpiration



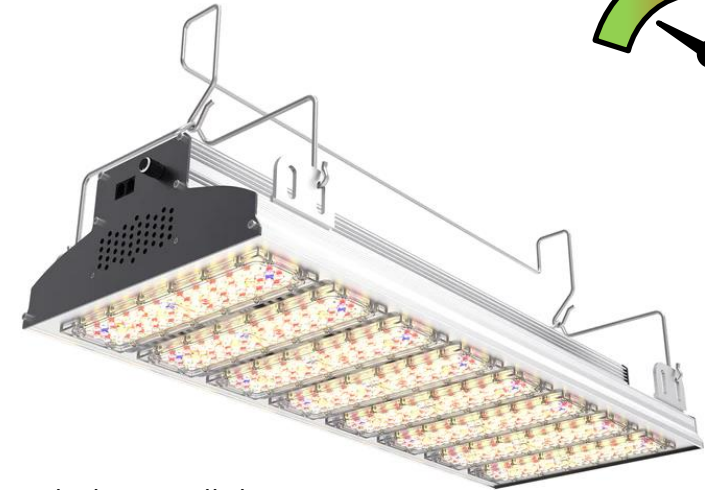
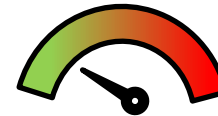
Changes nutrient uptake



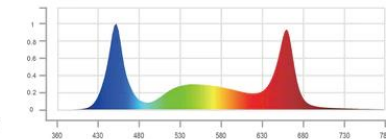
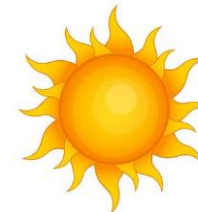
High-Intensity Discharge (HID)



LED lighting



LED spectrum better mimics sunlight

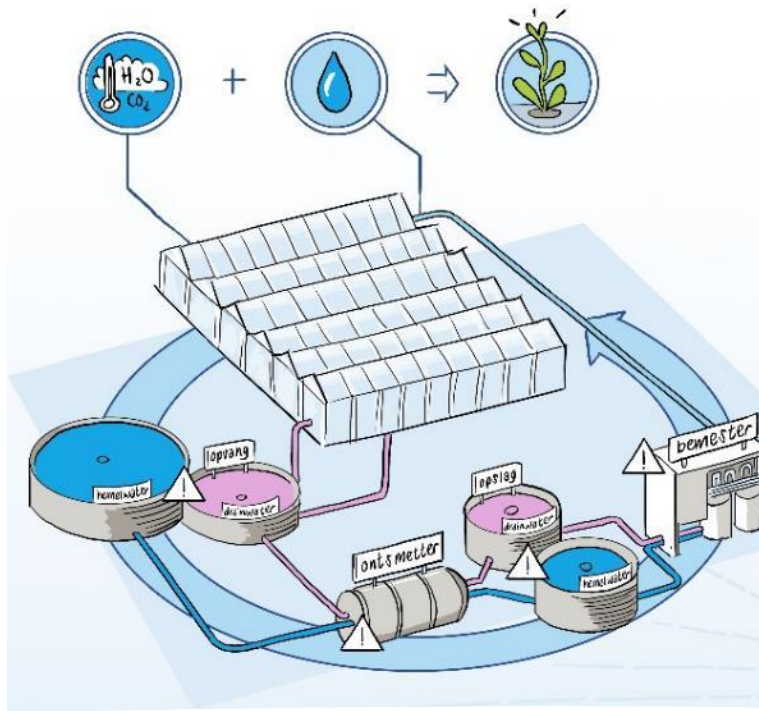


SAMSUNG LEDS

<https://www.growpackage.com/products/eco-farm-n10-800w-commercial-led-grow-lights-for-greenhouse-replace-1000w-hps>

Challenges in horticulture

Water



Sensors for growth optimization
e.g. project grenswaarden waterkwaliteit

Project OSIRES

Effect on plant when water is continuously recirculated?

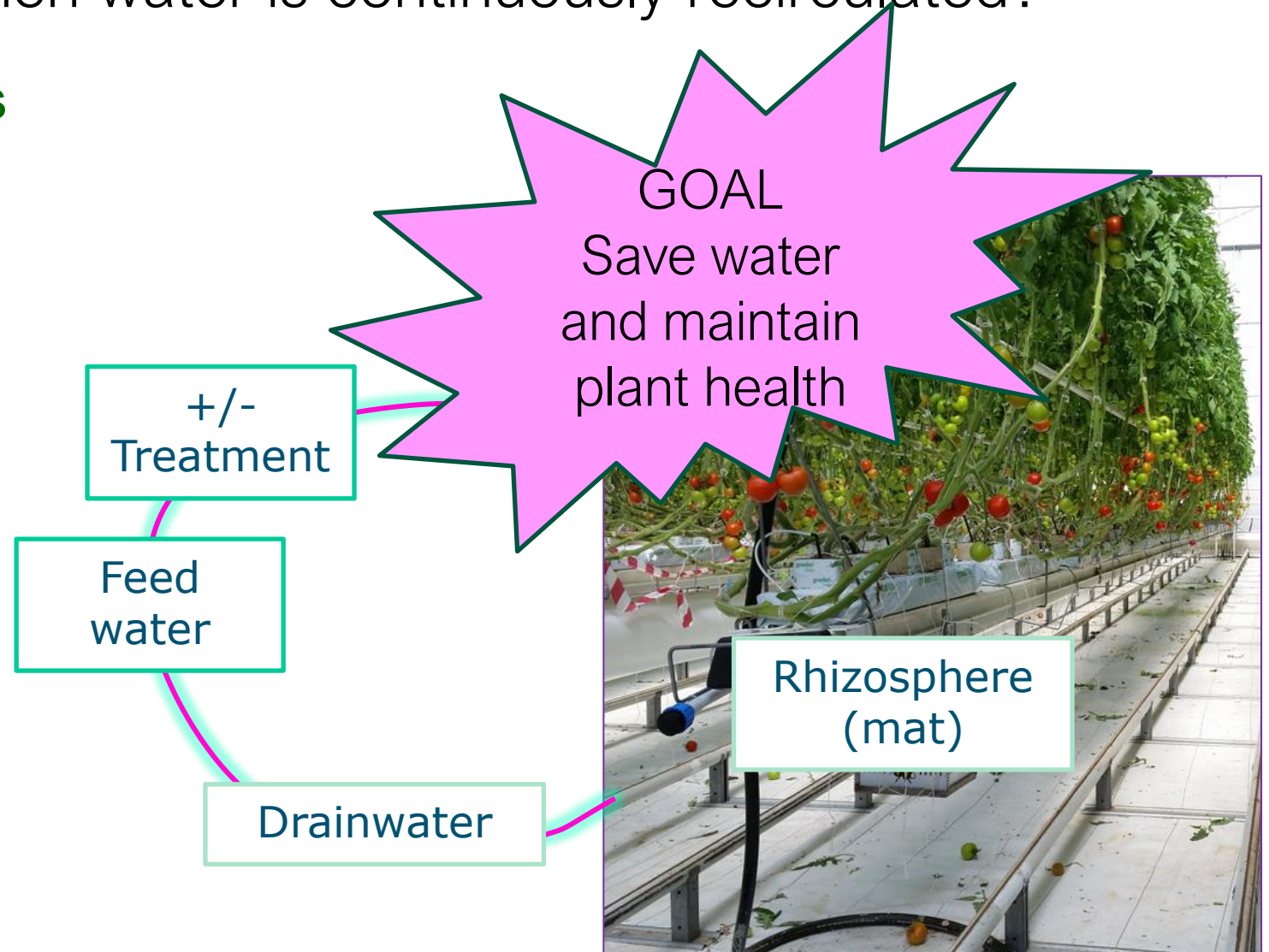
Water and rhizosphere analysis

Nutrients/org. compounds

- TOC
- Q-TOF analysis
- Shift over time

Microbiology

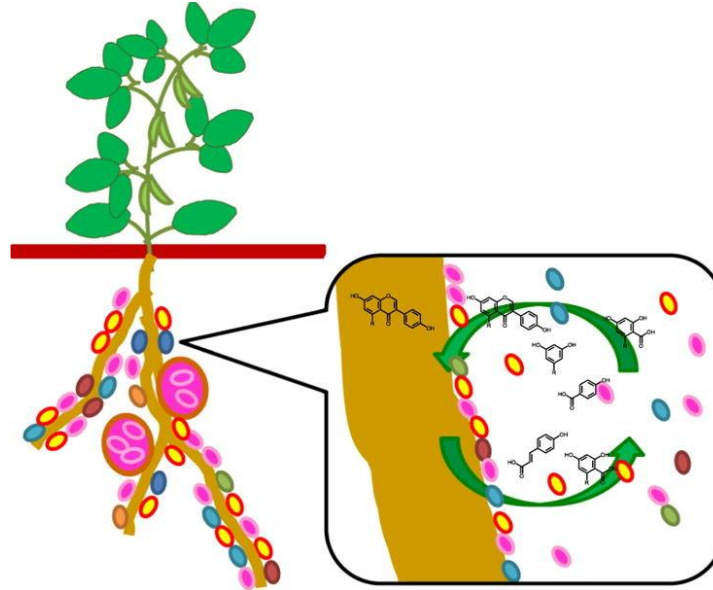
- 16S
 - Community shifts
 - Gene functionalities
- Nanopore sequencing
 - full genome



Which organic compounds are present in the interaction between plant and MOs?

Root exudates

- Extracellular enzymes
- Phenolic compounds
- Amino acids
- Organic acids
- Sugars
- ...

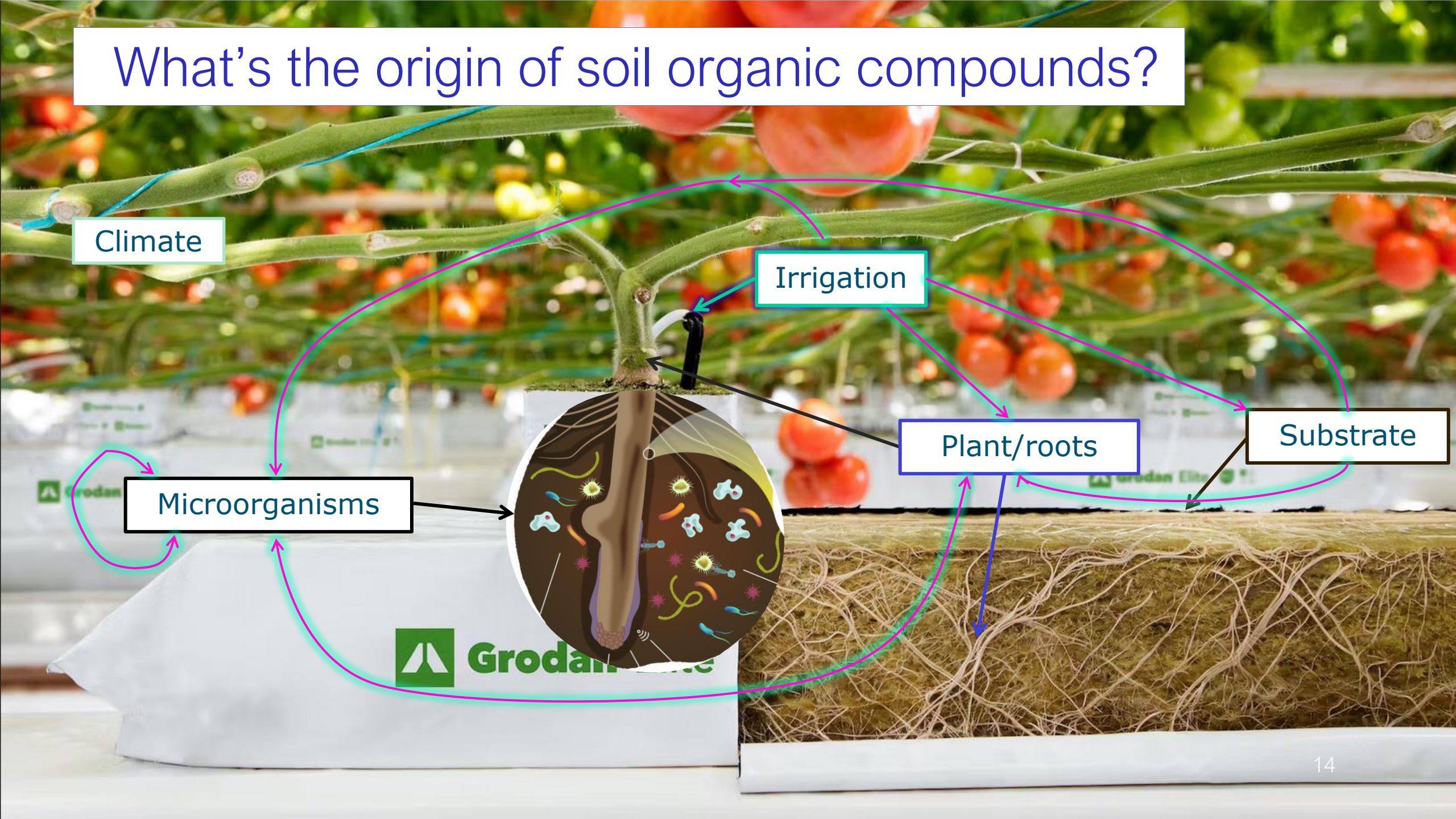


Microorganisms

- Exopolysaccharides
- Phytohormones
- Siderophores (↑ iron)
- Antibiotics and antifungals
- VOCs
- Enzymes
- ...

Nutrient breakdown
Signaling substances
Increase plant resilience
- pathogen defense
- stress tolerance

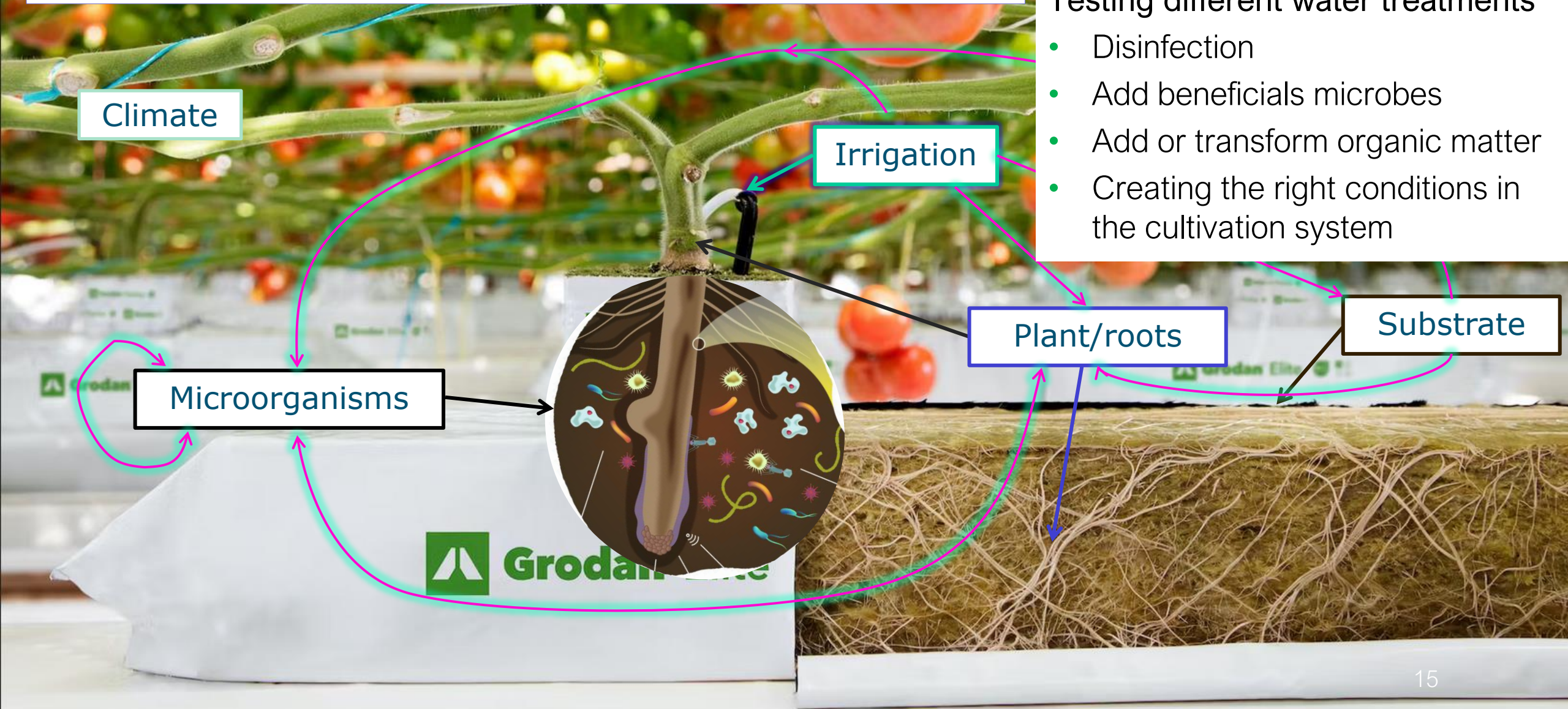
What's the origin of soil organic compounds?



Steering organic compounds by water treatment → Steering plant-microbe -interactions

Testing different water treatments

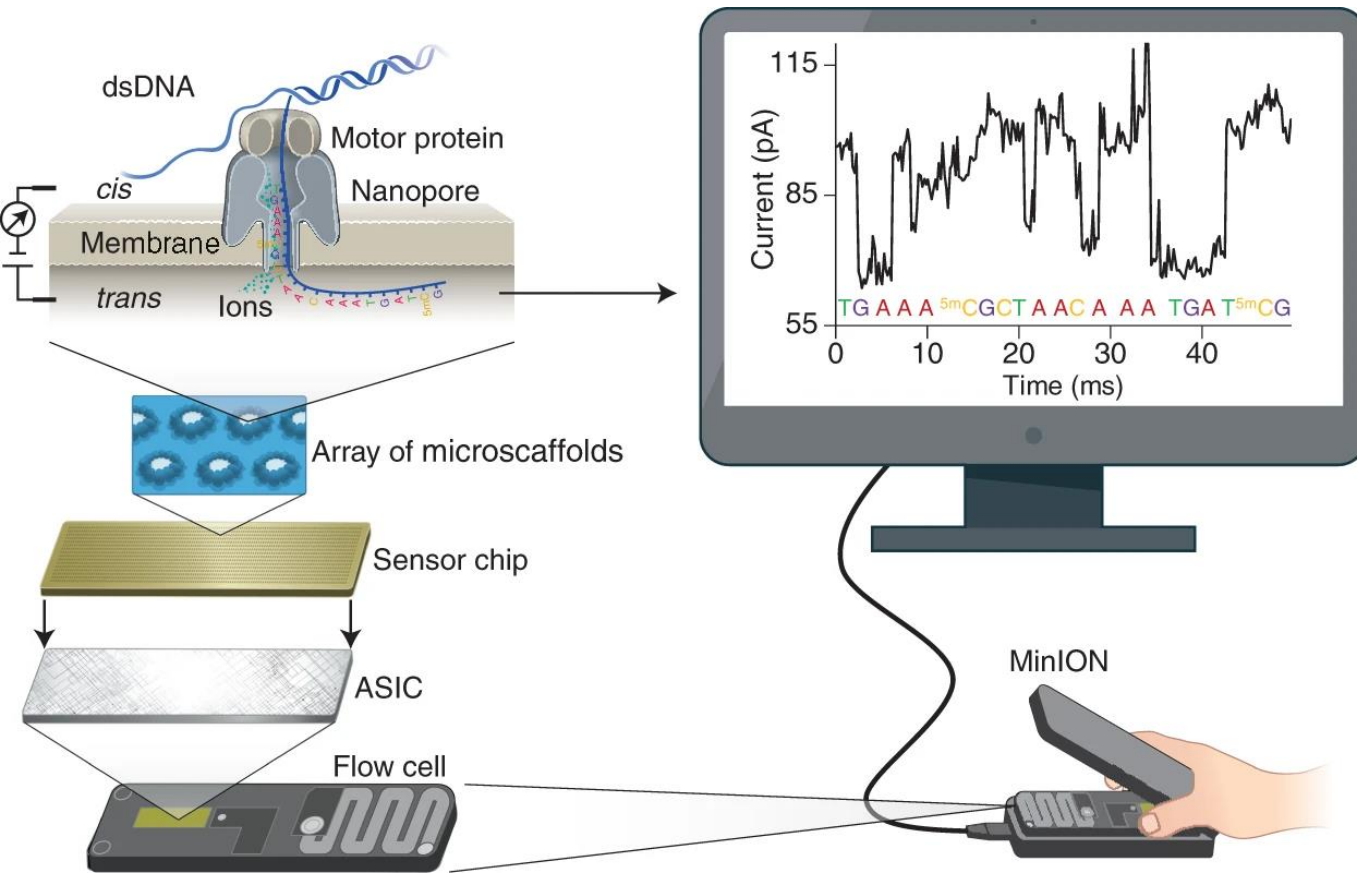
- Disinfection
- Add beneficial microbes
- Add or transform organic matter
- Creating the right conditions in the cultivation system



Who is there?

DNA sequencing technologies

OXFORD NANOPORE TECHNOLOGIES

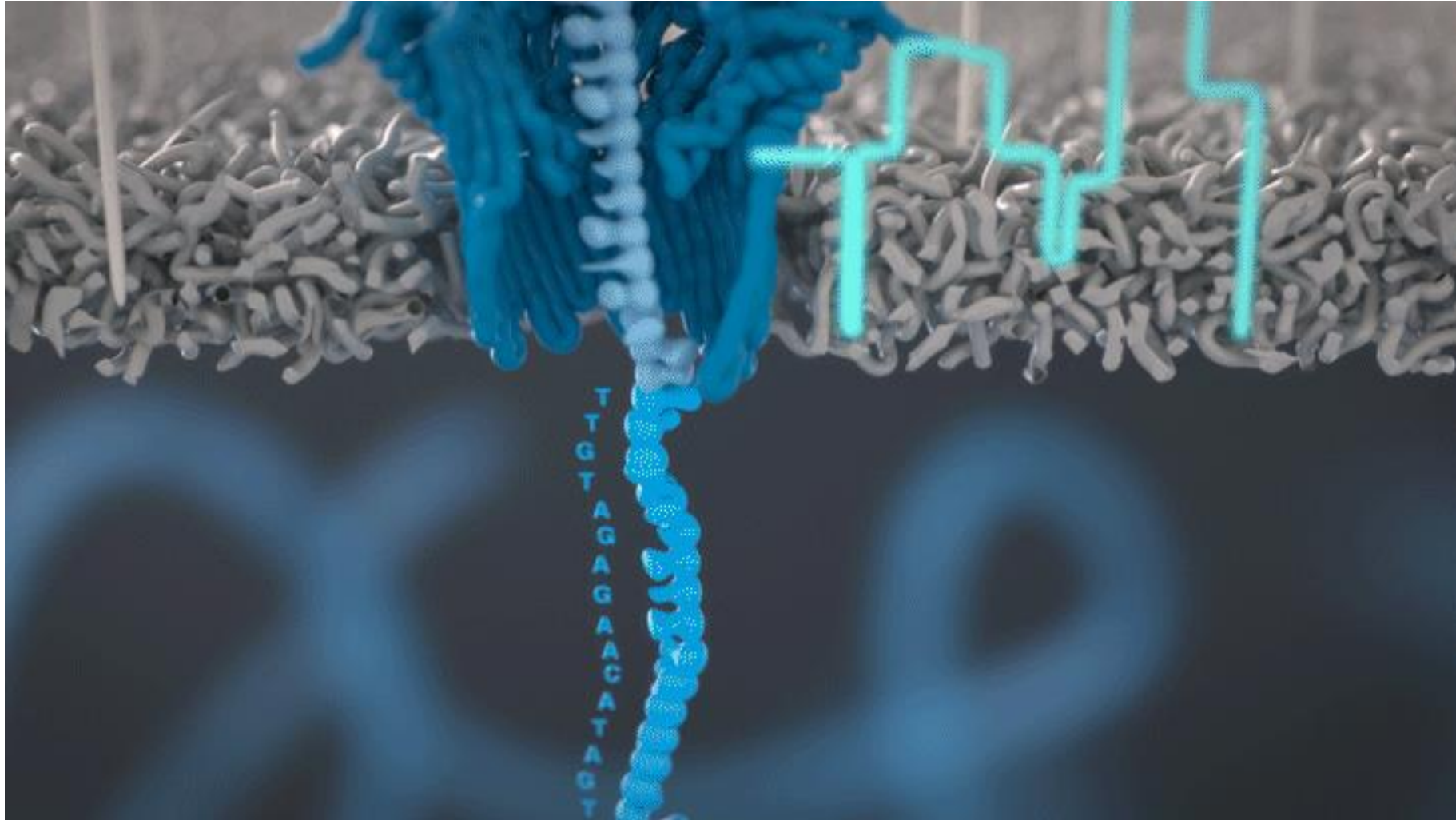


Long READS – ONT

- “Less” accurate but can detect structural changes
- Small machine
- Big development efforts
- Sequencing on-site



Nanopore sequencing in action



What is there?

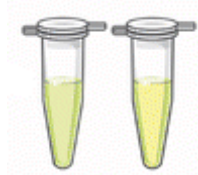
UPLC-QTOF analysis



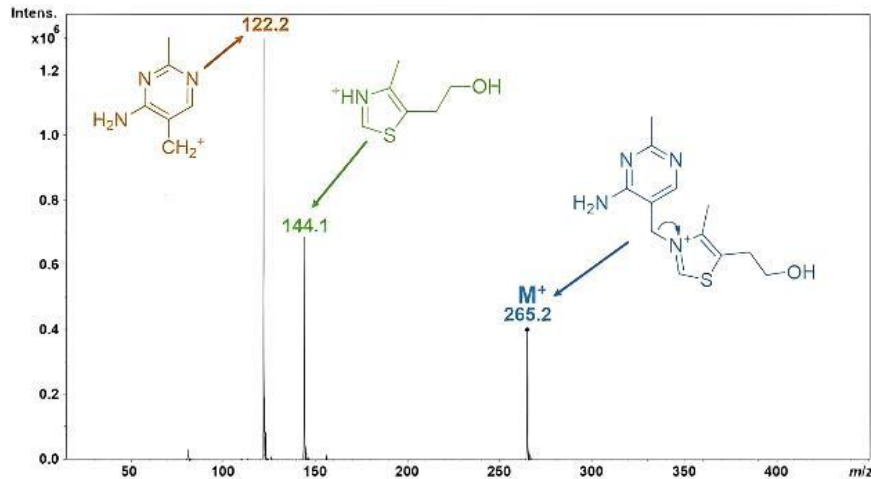
Chemical composition of complex samples

Identify unknown compounds, without prior knowledge about the chemical content of the sample.

- High resolution
- High sensitivity
- Fast measurements
- Combines the flexibility of multiple fragmentation options



Sample preparation



Data processing



UPLC-QTOF analysis

Project: control of plant parasitic nematodes in chrysanthemum

**Plant
health**



Meloidogyne incognita

Alternatives for current practices

Soil steaming to kill parasitic nematodes



Energy

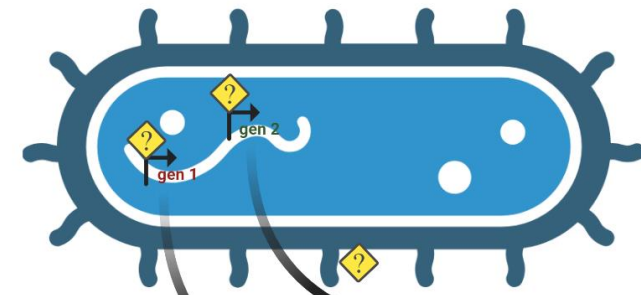
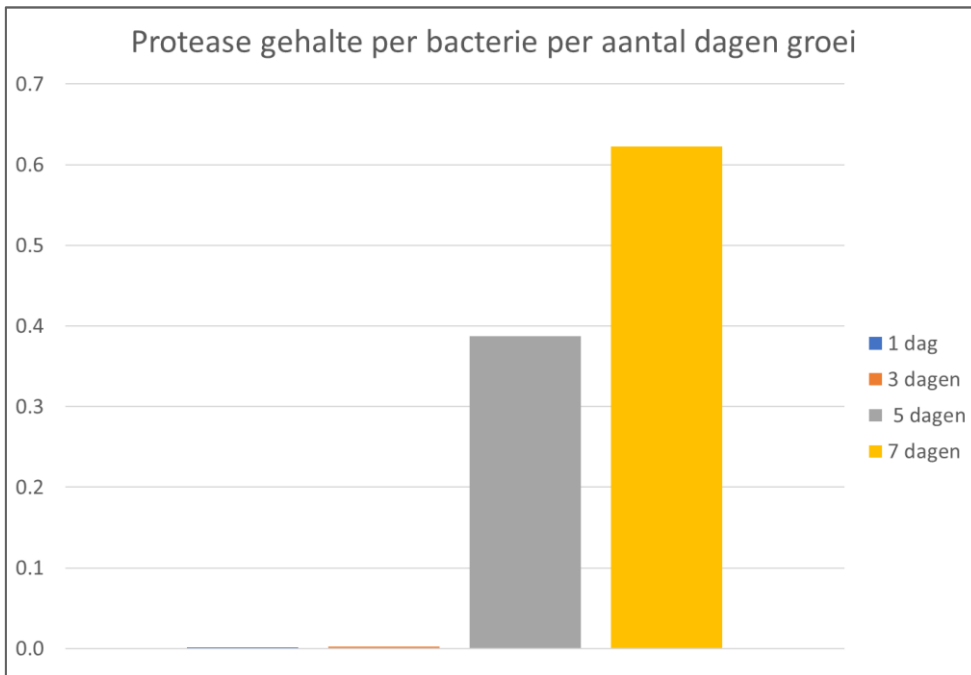
Transition from
chemical pesticides to
organic biocontrol

Bacteria as biocontrol against root-knot-nematodes

Example: bacteria as biocontrol

1. Markers: Connection between amount of bacterial enzymes and killing of nematodes?

Substraat 1	Substraat 2	Substraat 3	Afdoding <i>in-vitro</i>
exochitinase (chitobiosidase)	exochitinase (β -N-acetylglucosaminidase)	endochitinase	Bacterien suspensie + nematoden
Low	Low	Low	Middel-low



Welke wapens?

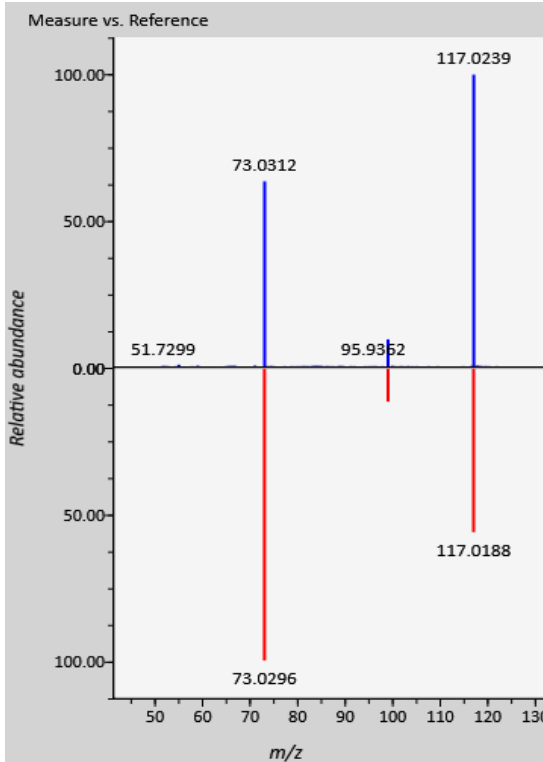
◆ Hoe worden ze aangezet?



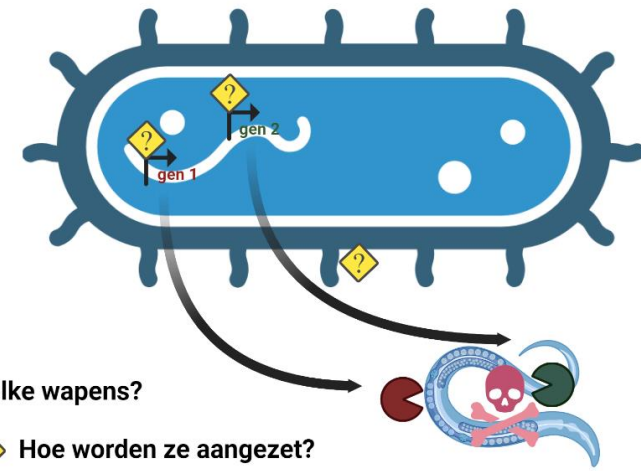
Bacteria as biocontrol against root-knot-nematodes

Example: bacteria as biocontrol

1. Markers: Connection between amount of bacterial enzymes and killing of nematodes?
2. Overview of secondary metabolites excreted by soil bacterium and QTOF analysis



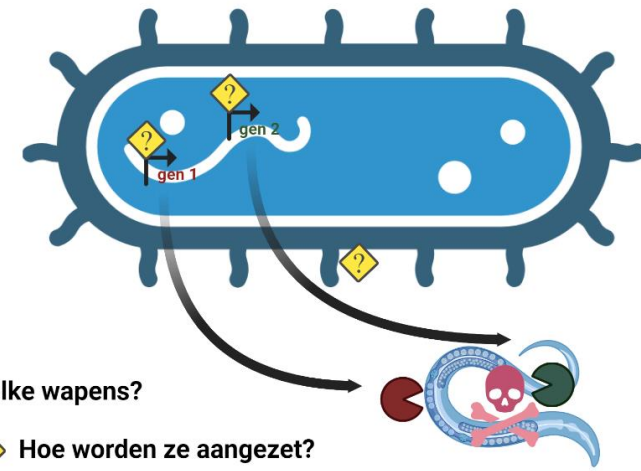
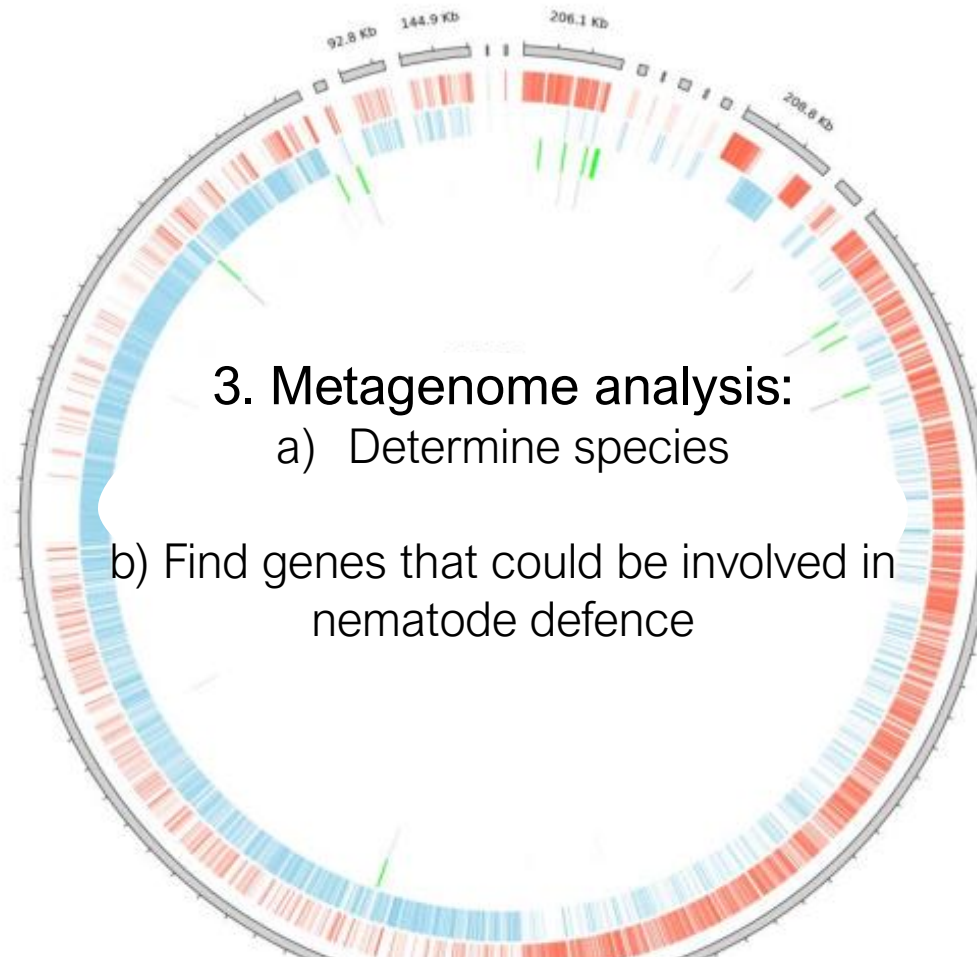
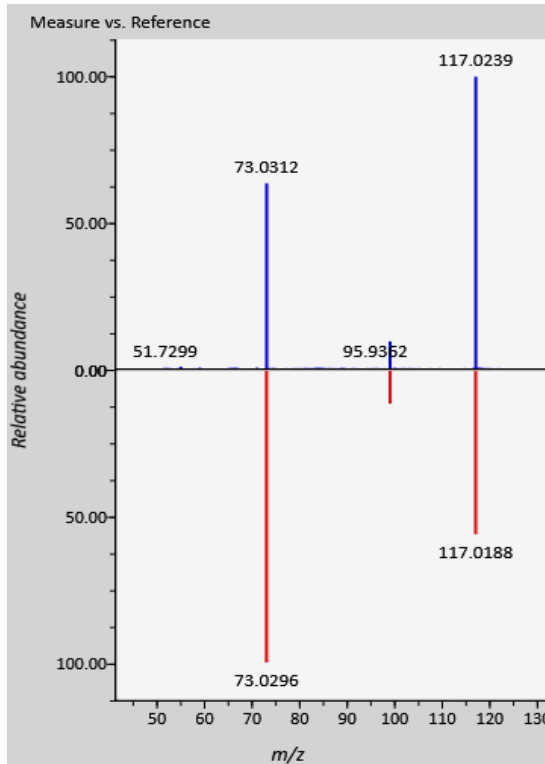
e.g. Siderophore production



Bacteria as biocontrol against root-knot-nematodes

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Virussensor: early detection of plant viruses in water

Challenges

1. Detection of low concentrations

(Virus concentration is 100.000x to 1.000.000x lower than in plant material)

2. Differentiate between active/inactive virus

3. Specificity: unspecific signals from other substances present in water



Plantago asiatica virus (PIAMV)
In lilly



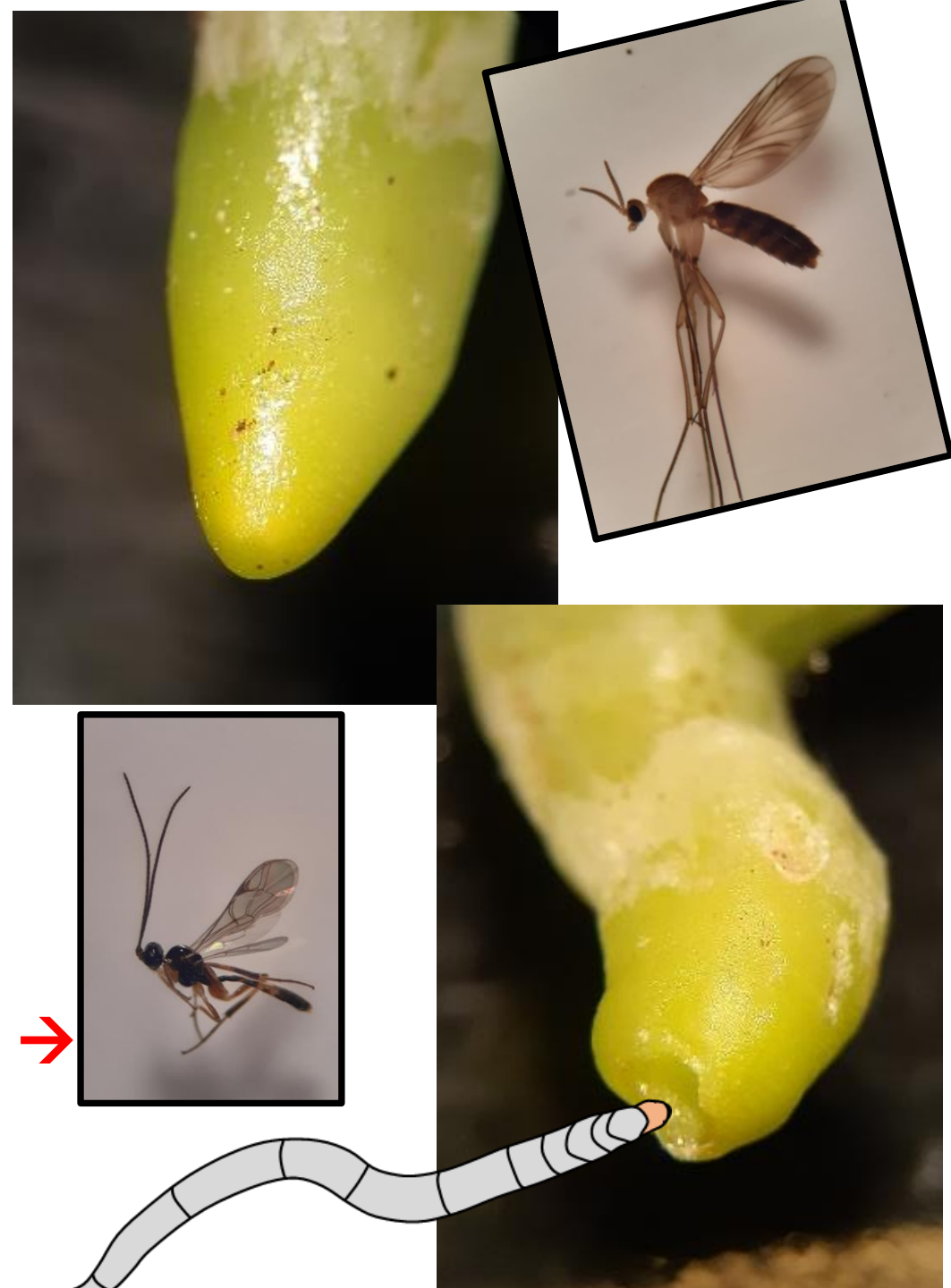
Cucumber green mottle mosaic virus (CGMMV) in cucumber

Lyprauta (potworm) problem

- Big problem in Phalaenopsis
- Also present in other cultivations
- *Lyprauta cambria* meest schadelijk
 - New in science
 - A lot to discover (ecology)

- parasitoid wasps (sluipwesp) discovered!
 - *Megastylus woelkei*
 - New in science
 - A lot to discover (ecology)

Greenhouse introduces its own biocontrol! →



Conclusions – future challenges

- Individual organisms in soil are well described
- Substrates and nutrients can be analysed
- But the ecological context is often missing
- Translation to practice: Biocontrol, one bacterium works against pathogen, but once in the environment loses functionality (→ how to make it work?)
- Ecology in soil → big data and state of the art technology needed to unravel existing complexity

