

Biostimulants

Aad Termorshuizen

www.bodemplant.nl

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Who am I?

Aad Termorshuizen

- Specialist soil quality and plant pathogens
- 20 yrs at Wageningen University
- 10 yrs at BLGG/Eurofins/SoilCares Research
- Since 2017 independent consultant

Toolbox for farmers

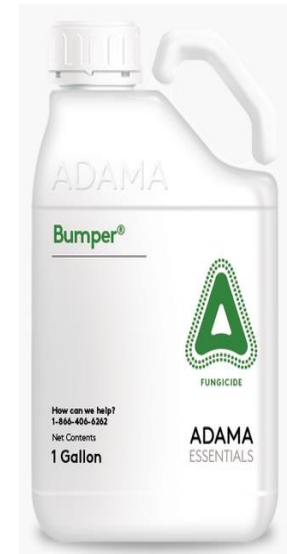
Fertilizers



Biostimulants



Pesticides



nieuw!!

Outline

- What are biostimulants?
- Regulations
- Science
- Comments
- Role of plant pathology

What is on the market?

- Extracts of algae and seaweed
- Humic acids, compost tea
- Biochar
- Biofertilizers, e.g. *Bacillus* spp., *Trichoderma* spp., *Pseudomonas* spp. etc. (not registered as pesticide), symbionts: mycorrhiza, N-binders (*Rhizobium*, *Azotobacter*, *Azospirillum*)
- Proteins and amino acids
- Compost (as soil improver)

+ combinations, e.g.

- *Bacillus* + *Trichoderma* + humic acids
- compost + *Trichoderma*
- humic acids + micronutrients + seaweed extract

- application usually both above- and belowground possible
- many products applicable on many or even all crops and soil types

Some of the claims made

- balanced nutrients
- increased soil organic matter content
- improved physiological reactions
- improved flowering
- increased yield
- improved root development
- improved tolerance against (a)biotic stress
- increase in populations of “good” micro-organisms
- improved soil structure
- applicable on many crops on on soil types

Usually a combination of claims

Some of the claims made

Organic plant growth biostimulant, wetting agent, and emulsifier. Improves plant water and nutrient intake, and the speed and success of germination of seeds. The active saponins then acts as metabolic stimulants to trigger other beneficial plant responses.

Increases gross margin
Improves Bio-diversity
Gives value to farm's natural fertiliser
Fewer losses through leaching
Improves the fertility of the soil
Better restitution to plants
Replaces any fertilisation input
Optimises nitrogen management
Increases carbon storage in the soil

- Increases yields of crops, vegetables & fruits
- Produces superior turf and deep roots
- Enhances uptake of fertilizers
- Replenishes depleted soils
- Promotes ecological balance

A liquid seaweed extract of *Ascophyllum nodosum* with added chelated amino acids, the building blocks of proteins and enzymes. The amino acids are provided in bioavailable form and designed for use in treating turf grass and sports amenities, providing the building blocks for healthy growth therein.

which together exert a positive effect on the whole growth cycle of arable and horticultural crops. It improves soil conditions and in particular promotes the activity of beneficial bacteria and fungi including mycorrhizae. This leads to an improved soil structure and encourages the symbiotic relationship between plants and their associated microbial species.

phytohormones, vitamins, minerals, pigments, polyunsaturated fatty acids and polysaccharides. This composition makes it an ideal product that will contribute in maximizing the yields of your crop, while also improving the quality of the fruits.

Biostimulants

- Until about 2020 free market
- From 2020, EU-regulated
- By definition, biostimulants are not pesticides and not fertilizers

Circular Economy Package

Proposal for a

REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

laying down rules on the making available on the market of CE marked fertilising products and amending Regulations (EC) No 1069/2009 and (EC) No 1107/2009

concept definitions according to the

Biostimulant

means a product stimulating plant nutrition processes independently of the product's nutrient content with the sole aim of improving one or more of the following characteristics of the plant:

- (a) nutrient use efficiency;
- (b) tolerance to abiotic stress;
- (c) quality traits.

Soil improver

A soil improver shall be a EU fertilising product the function of which is to maintain, improve or protect the physical or chemical properties, the structure or the biological activity of the soil to which it is added.

classification EU (concept)

Biostimulants

- microbial
 - non-microbial
- ...combinations?

Soil improvers

- organic
 - inorganic
- ...combinations?

Market of biostimulants

- 10⁹ € (Europe)
- especially a lot of activity in S-Europe
- world congress on biostimulants
- >100 producers, >1000 products



Miami, november 2017

Scientific research

- Many studies in S-Europe
- Little work in the Netherlands except on micro-organisms (PGPR and biocontrol)
- Not much done on mechanisms

Science: A small inventory

Ken Giller, Ep Heuvelink, Corné Pieterse, Jos Raaijmakers, Sander Schouten, Paul Struik

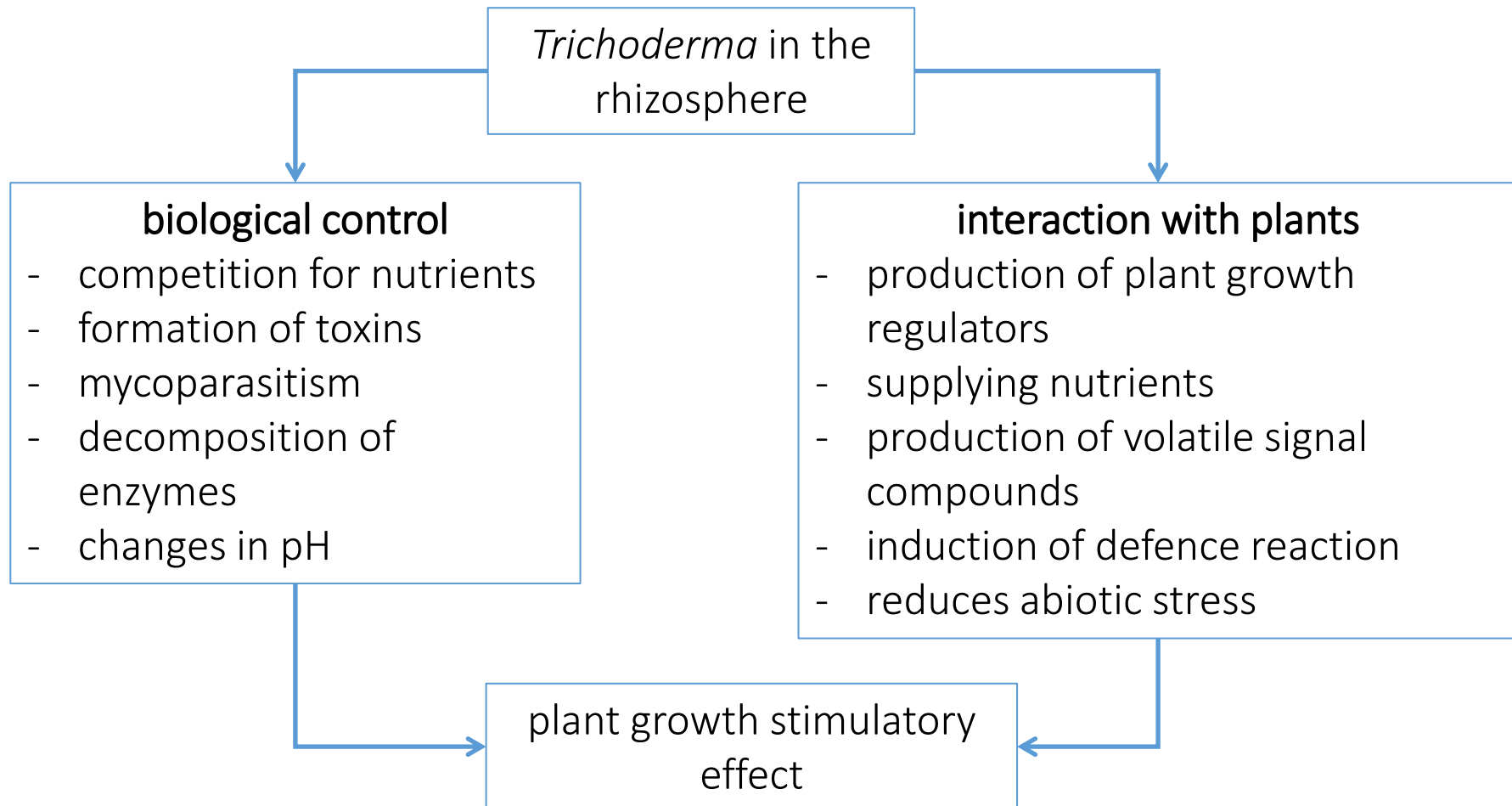
- Not able to judge because contents of biostimulant products is unclear
- Closer to nonsense than to sense – effects disappear outside the experimental conditions (except *Rhizobium*)
- Claims about biostimulants are too strong; however the same is sometimes true for pesticides
- Difference between biostimulant and biocontrol agent sometimes small
- More effective *Rhizobium*-strains through selection (2x)
- Development of specific microbial consortia (rhizobiome) (2x)
- Tailor-made bioconsortia are promising, incl. plant breeding
- Importance of microbe-produced volatile compounds
- We are just beginning to understand the interactions between micro-organisms and the plant

What's going on?

- Science identifies interesting results under artificial conditions (e.g. sterile soil, *Arabidopsis*)
- Practice scales this up to commercial products

Two examples

1. Success story: *Trichoderma*



1. *Trichoderma*

- After a lot of research a few strains are now registered as biocontrol agent, e.g. *Trichoderma harzianum* T22
- Now other *Trichoderma*'s are being sold as biostimulant
- What do we know about these *Trichoderma*'s?
 - if they also act like a biocontrol agent, then they are pesticides and not biostimulants
 - so if they are biostimulants, should producers then need to show that biocontrol properties are absent?

2. Proven biostimulant: N-fixation with soybean

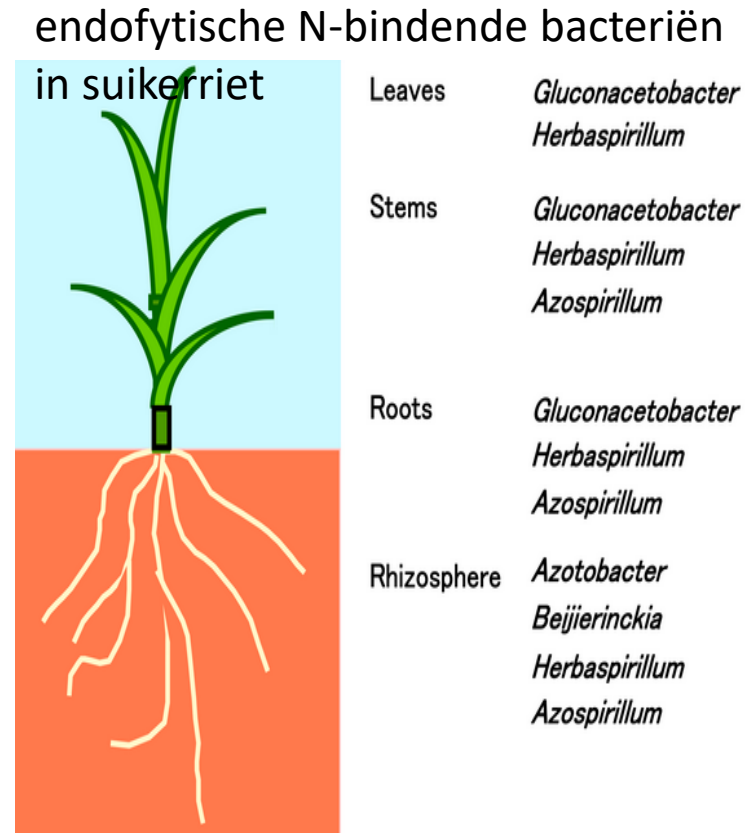
- *Bradyrhizobium japonicum* provided with soybean seed



<http://tonythegardener.blogspot.nl/p/nitrogen-fixing-in-leguminous-plants.html>

2. Extension: N-fixation

- Rhizobia are not needed to apply for many other legume species
- Non-symbiotic N-fixing micro-organisms
 - Free in soil (e.g. *Azotobacter*)
 - Endophytic (e.g. *Azospirillum*)
 - perhaps effective in sugarcane
 - research also on rice
 - ... and other grasses
 - dicot crops??

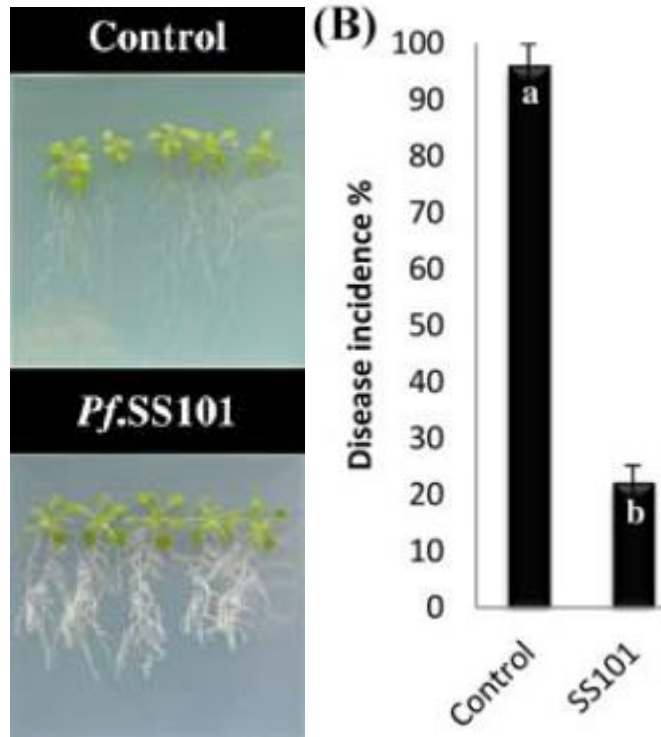


Ohyama et al., 2011

What has science to offer? – some examples

Multiple mechanisms effective at the same time

- *Arabidopsis thaliana*
- *Pseudomonas syringae* pv. *tomato*
- *Pseudomonas fluorescens* SS101

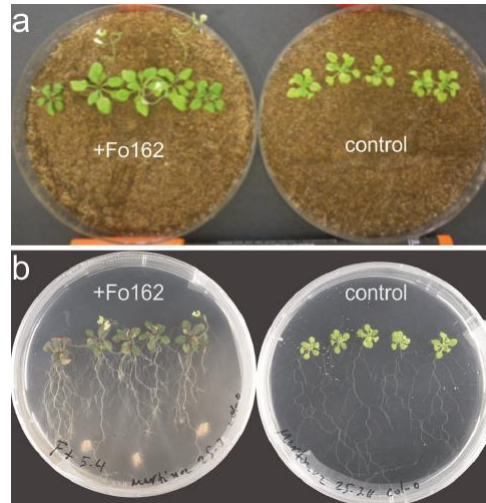


- Affecting formation & transport of auxin
- Biosynthesis of various steroids
- Affecting C-metabolism
- Stimulation of S-assimilation

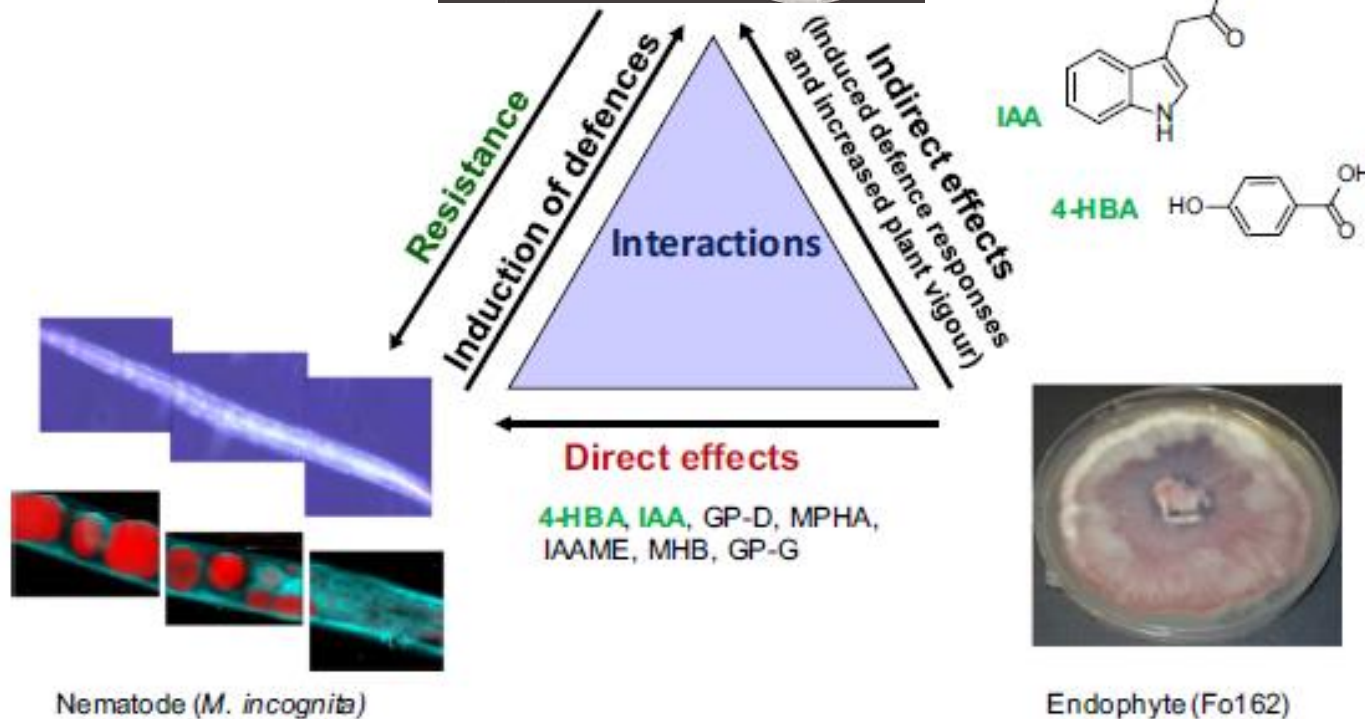
Direct and indirect effects

what has
science
to offer?

Bogner & al., 2016, Microb. Biotechnol.
Martinuz & al., 2015, Planta

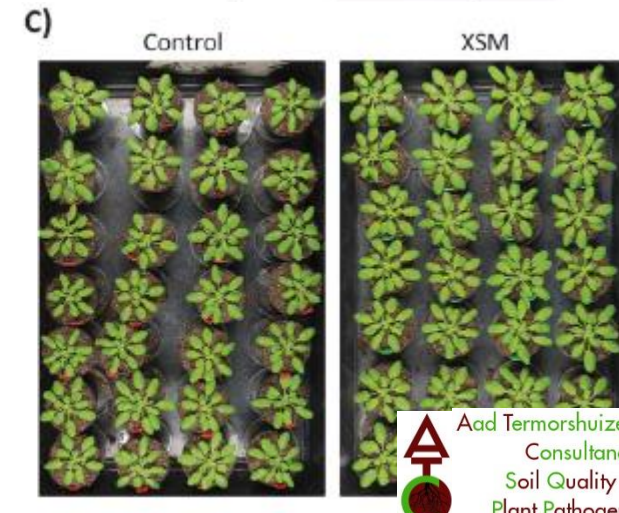
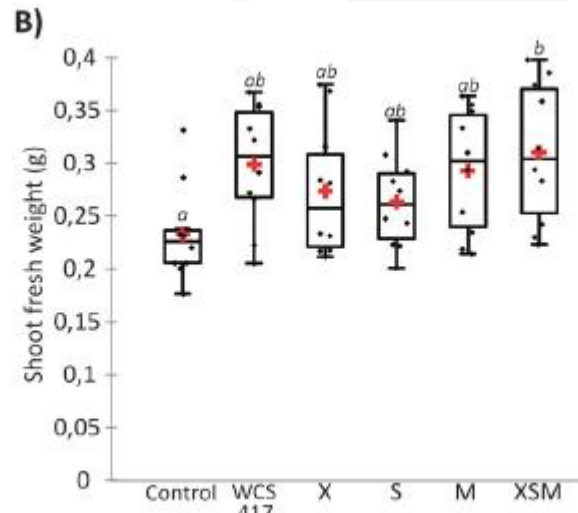
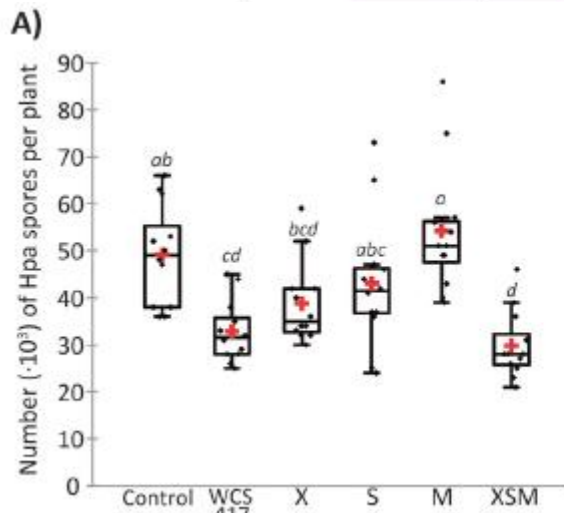
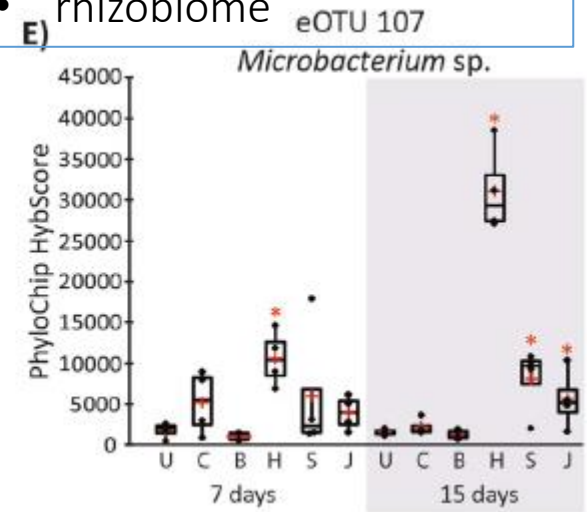
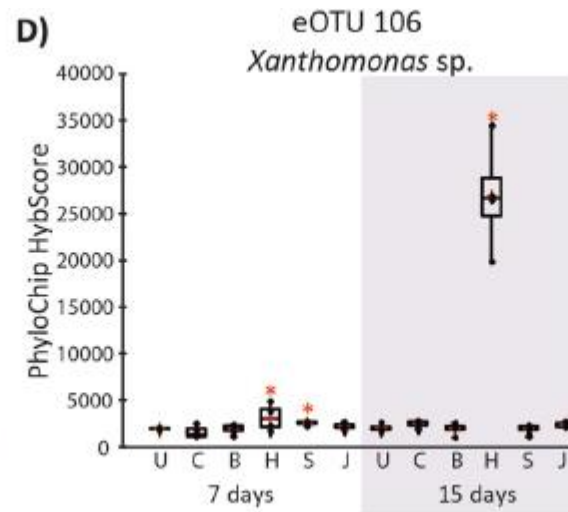
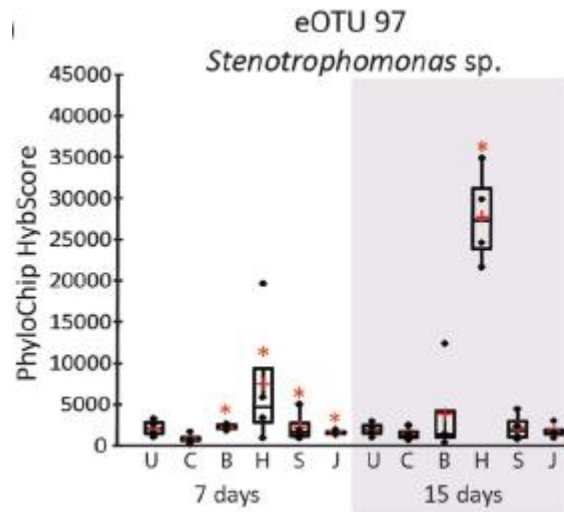


- *Arabidopsis thaliana*
- *Meloidogyne incognita*
- *Fusarium oxysporum* Fo162



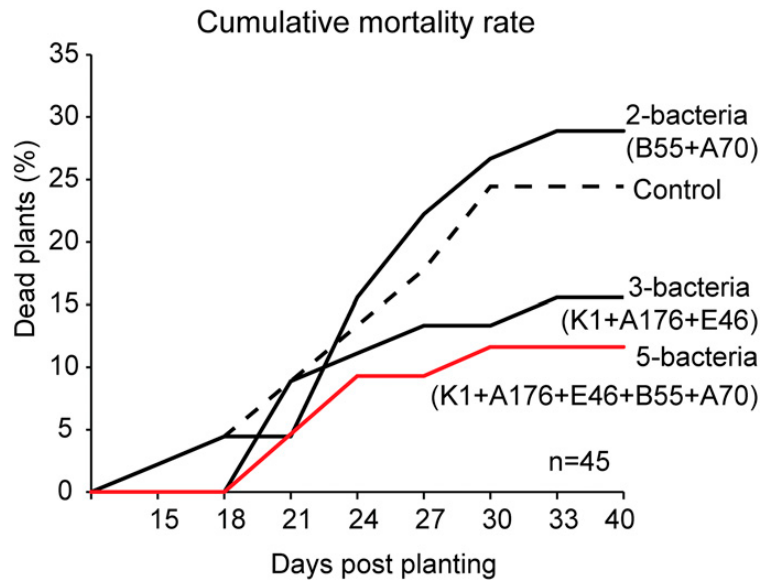
Downy mildew influences the rhizobiome

- *Arabidopsis thaliana*
- Downy mildew
(*Hyaloperonospora arabidopsidis*)
- rhizobiome



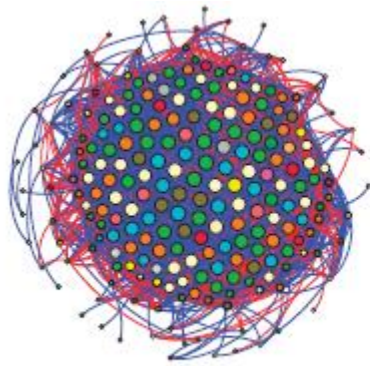
Consortia are more effective

- *Nicotiana attenuata*
- soilborne *Alternaria* & *Fusarium* spp. complex
- diverse soilborne bacteria

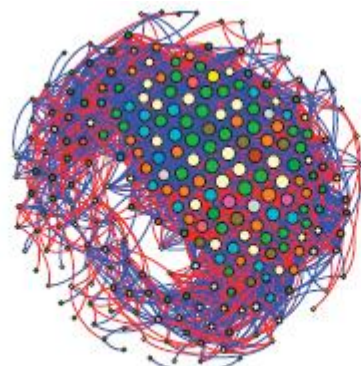


Rhizobiome is plant genotype dependent

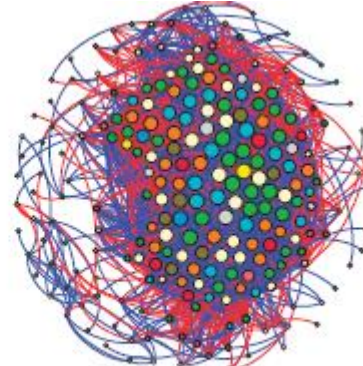
- cultivars of bean
- as function of resistance
against *Fusarium oxysporum*



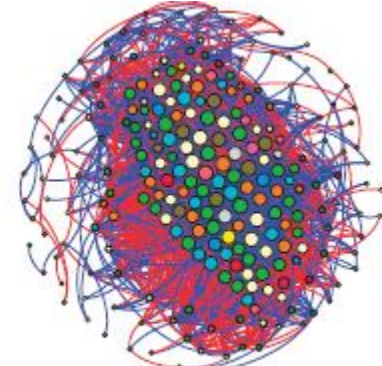
Resistant
IAC Milenio



Moderately Resistant
IAC Imperador



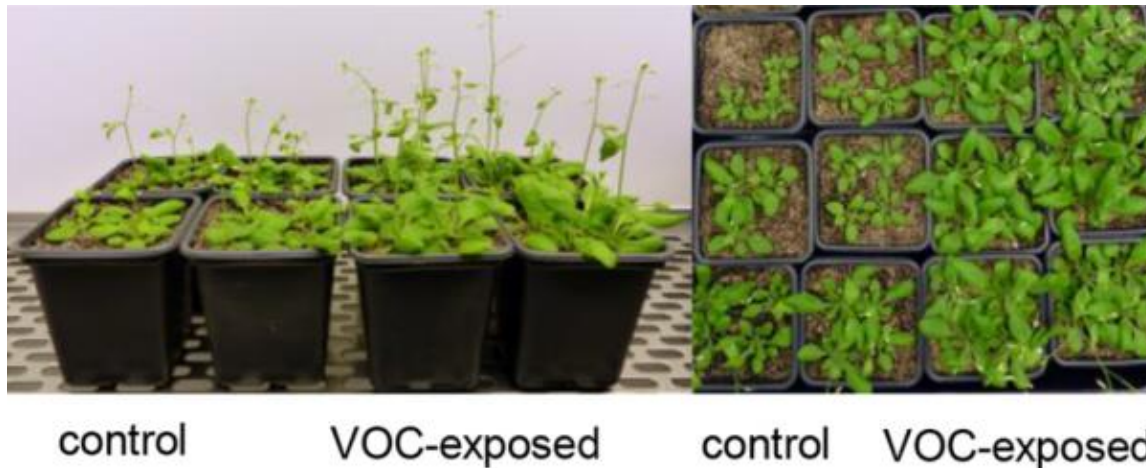
Moderately Resistant
BRS Estilo



Susceptible
IAC Alvorada

Effects of a plant pathogen

- *Arabidopsis thaliana*
- *Rhizoctonia solani*
- Volatile compounds produced by *R. solani*



- Volatile compounds produced by *Rhizoctonia* stimulate plant growth
- Resistance against *Rhizoctonia* unchanged
- Resistance against *Mamestra brassicae* decreased
- Auxin \uparrow , ethylene \downarrow , jasmonic acid \downarrow

REVIEW

View Article Online
View Journal



Microbial small molecules – weapons of plant subversion

Cite this: DOI: 10.1039/c7np00062f

Ioannis A. Stringlis, ^a Hao Zhang, ^a Corné M. J. Pieterse, ^a Melvin D. Bolton ^{bc}
and Ronnie de Jonge *^{ade}

4. Concluding remarks

In this review of recent literature on the biological role of microbe-derived natural products on microbial associations with plants we observe interesting parallels between microbes that are detrimental and those that are beneficial for the plant. Both groups of microbes use analogous strategies to colonize their host, and thus this division, to some extent, is context-dependent. Even more so, certain pathogenic microbes might cause severe disease on one plant, but are endophytic on others.

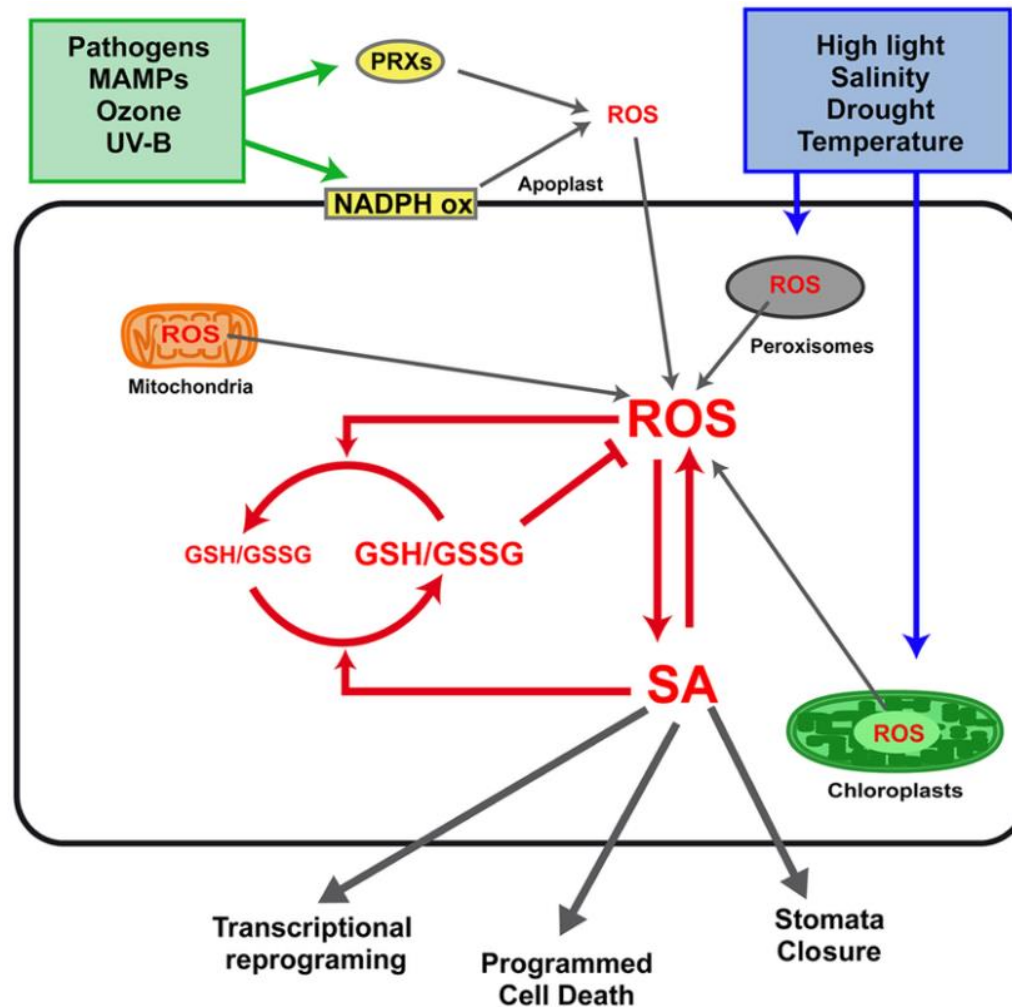
Perspectives from science

- PGPR: can have multiple effects (Fe, S, biocontrol,, hormones, secondary metabolites)
- Consortia of micro-organisms can act synergistically
- Plant pathogens can influence PGPRs
- Rhizobiome plant-, genotype- and environment-dependent
- Also plant pathogens participate in chemical warfare


Biostimulant vs. (biological) control

- Difference?
- Which indirect effects should we take into account?
- Specify micro-organisms in biostimulants to the level of isolate?
- For biostimulants, is there need to show absence of a biocontrol effect?
- Mechanisms of biocontrol:
 - hyperparasitism
 - amensalism
 - competition
 - ISR

Stress partially evolves along the same pathways



Biostimulants, development

- European Biostimulants Industry Council 
European Biostimulants Industry Council
- EU: registration as fertilizer or as pesticide
- Not clear what will happen with product combinations
- Registration will include a statement on effectiveness
- How effectiveness should be tested is currently an open question (role of NEN)
- Initiative to merge biostimulants and soil improvers

Quality of label often insufficient

proprietary blend of six bacterial cultures and eighteen species of endo- and ecto-mycorrhiza

Composition	
Rhizosphere Bacteria	0,01%
Trichoderma atroviride	2×10^8 UFC/g
Glomus spp.	10 spores /gr

**CONTAINS NON-PLANT FOOD INGREDIENTS:
95.0% Plant Extracts (Microbe Food)**

For organisms definition to level of isolate is needed

Science vs. practice?

Science

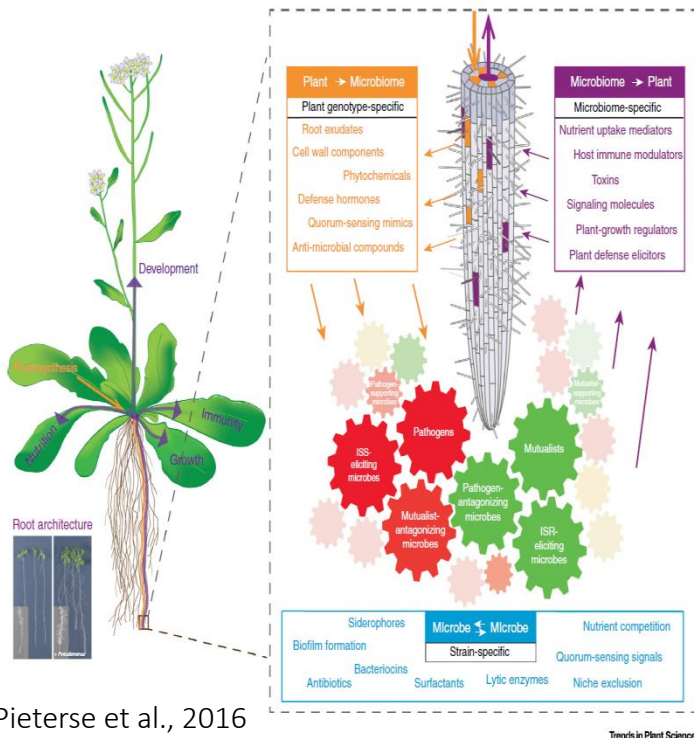
Testing of principles:

- often on model plants
- often on unnatural substrates
- at overdosis
- short-duration experiments

Practive

Products should be effective:

- on crops
- on field soil
- at economically affordable dosages
- leading to a positive result experienced by the farmer



Conclusions

- There are many biostimulants on the market
- Claims are often too large; scientific literature insufficiently backs the claims made; labels often unclear
- Claims should be verifiable
- Is the study of biostimulants in the Netherlands lagging behind?
- A honest playing field for biostimulants and biocontrol agents should be created
- Can the difference between biostimulants and biocontrol agents be maintained?
- Considerable distance between practice and science
- What should be the role of the Royal Dutch Plant Pathological Society?

Thank you for your attention!

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Acknowledgements: Ken Giller, Ep Heuvelink, Corné Pieterse, Jos Raaijmakers, Sander Schouten and Paul Struik