Overview biostimulants

Aad Termorshuizen

9 januari 2020, Nijkerk, The Netherlands

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Who am I?

Aad Termorshuizen

- Specialist soil quality and soilborne plant pathogens
- 20 yr lecturer at Wageningen University
- 10 yr at BLGG/Eurofins and SoilCares Research as scientist
- From 2017 independent advisor (www.soilcrop.nl)

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Toolbox

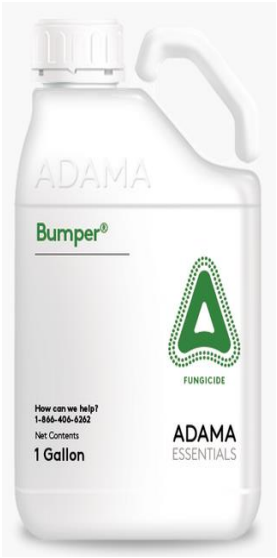
Fertilisers

Biostimulants

new!!

but not really new
- biofertilisers
- plant-growth promoting rhizobacteria
- mycorrhiza

Pesticides



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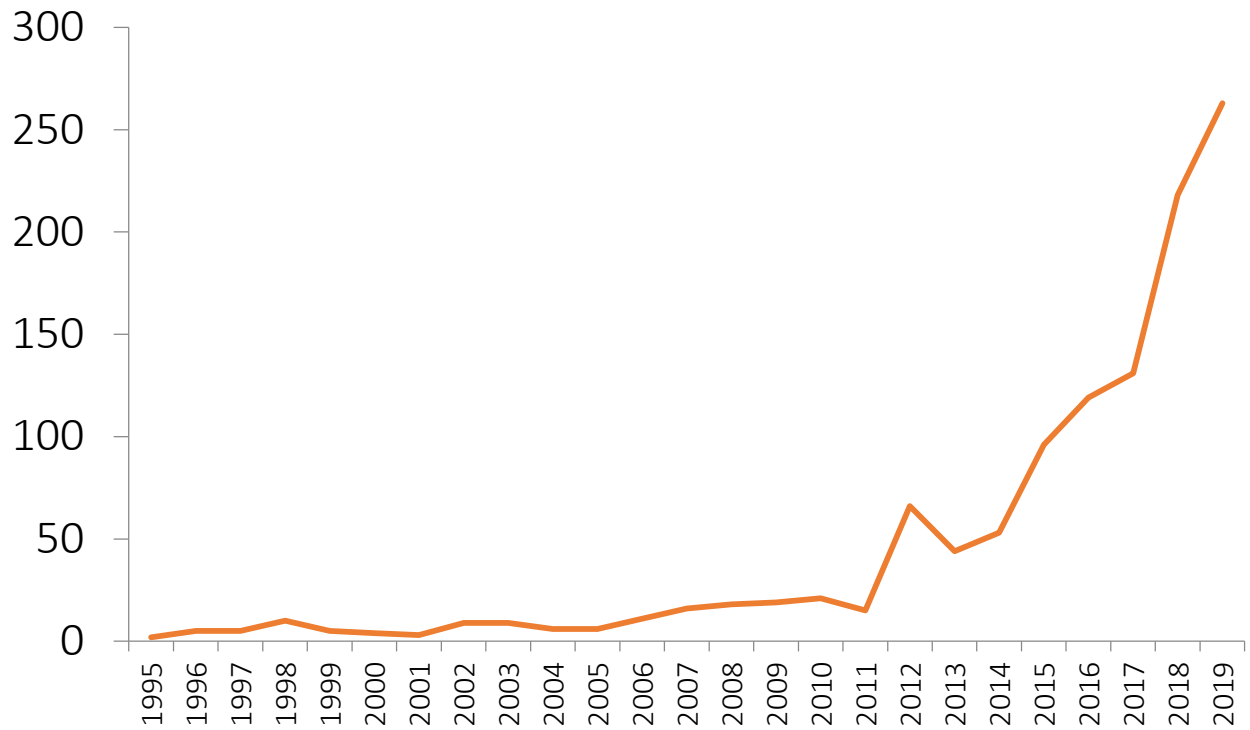
publications on biostimulants in Scopus



Contents of presentation

- Legislation see presentation by Harm Smit
- Types of biostimulants
- Highlights:
  - algae, seaweed
  - mycorrhiza
- Link with science
- Conclusions

significance for agriculture

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Types of biostimulants

- Plant extracts, e.g. algae and seaweed
- Humic acids, compost tea
- Proteins and amino acids
- Biopolymers, e.g. chitosan, chitine
- Anorganic compounds
- Biofertilisers, e.g. *Bacillus* spp., *Trichoderma* spp., *Pseudomonas* spp. etc. (if not registered as pesticide), symbionts: mycorrhiza, N-symbionts (*Rhizobium, Azotobacter, Azospirillum*)
- Compost (as soil conditioner)

+ combinations, bv.

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

✓ application often possible above- and belowground
✓ many products applicable on many crops and soil types

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A selection of the claims

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

usually a combination of claims

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Concise overview biostimulants

1. humic acids
2. N-rich compounds, e.g. protein hydrolysates and amino acids
3. plant extracts, e.g. algae and seaweed
4. biopolymers
5. anorganic compounds
6. fungi, e.g. mycorrhiza and *Trichoderma*
7. bacteria

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Biostimulants: 1. humic acids

products

- ranging from compost tea to purified humic acids

effects

- increased soil CEC
- increase P-availability
- effects on plant hormones
- reduction of stress

remarks

- strongly situation-dependent
- effects mainly or only on soils very low in organic matter content
- compare with effects of e.g. compost, straw, etc.

Biostimulants: 2. N-rich compounds

products

- a.o. protein hydrolysates, amino acids, betaines, polyamines, incl. mixtures
- usually from agronomic residues

effects

- modulation of N-uptake
- regulation of TCA-related enzymes (TCA = citric acid cycle)
- reduction of stress from heavy metals (chelating effects)
- increase availability of micronutriënts
- antioxydant effects
- increase soil microbial activity
- increased soil CEC

remarks

- animal hydrolysates are not allowed in the EU
- compare with organic matter amendments, e.g. compost

Biostimulants: 3. Plant extracts

products

- mainly seaweed and algee, purified or not

effects

- increase micronutrient availability
- increased aeration of the soil
- immobilisation of heavy metals
- stimulation of PGPR and antagonists
- hormonal effects (germination of seed)
- antioxydant and antistress effects

remarks

- effects dependent on production method and species

Highlighted: algae and seaweed

a great amount of procucts, difficult to judge

Algal species involved

- *Ascophyllum nodosum*
- *Caulerpa scalpelliformis*
- *Chlorella ellipsoida*
- *Durvillea antarctica, D. potatorum*
- *Ecklonia maxima*
- *Enteromorpha flexuosa*
- *Fucus serratus, F. vesiculosus*
- *Gelidiella acerosa*
- *Gracilaria corticata, G. salicornia*
- *Himanthalia elongate*
- *Hypnea musciformis*
- *Kappaphycus alvarezii*
- *Laminaria digitata, L. hyperborean*
- *Macrocystis integrifolia, M. pyrifera*
- *Padina boergesenii, P. gymnospora, P. pavonica*
- *Sargassum muticum, S. tenerimum, S. wightii*
- *Spirulina maxima*
- *Ulva lactuca*

REVIEW
published: 26 January 2017
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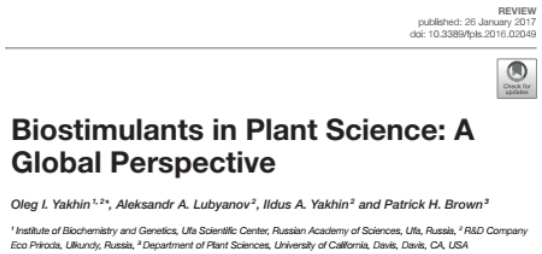
Biostimulants in Plant Science: A Global Perspective

Oleg I. Yakhin[1,2], Aleksandr A. Lubyanov[2], Ildus A. Yakhin[2] and Patrick H. Brown[3]*

[1] Institute of Biochemistry and Genetics, Ufa Scientific Center, Russian Academy of Sciences, Ufa, Russia, [2] R&D Company Eco Prirody, Ulkuncy, Russia, [3] Department of Plant Sciences, University of California, Davis, Davis, CA, USA

Algae: production methods

- acid processing / extraction
- alkaline extraction / hydrolysis / processing
- aqueous extraction
- cell burst
- cell rupture with high pressure treatment
- cold or frozen alkaline and water extractions
- cryoprocessing
- enzyme-assisted extraction (EAE)
- fermentation
- heated alkaline hydrolysis
- microwave-assisted extraction (MAE)
- neutral extraction
- pressurized liquid extraction (PLE)
- supercritical fluid extraction (SFE)
- ultrasound-assisted extraction (UAE)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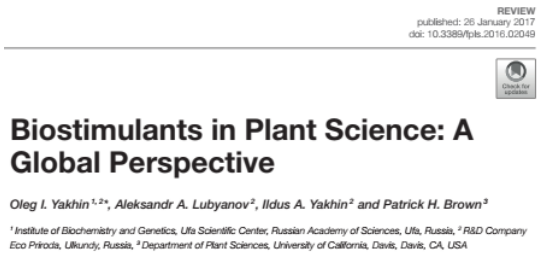
Algae: ingredients

- 1-Aminocyclopropane-l-carboxylic Acid (ACC)
- abscisic acid (ABA), alginic acid
- Auxins (IAA, IAAsp, IAAla, IAGly, IALeu, ICA, ILA, IPA, IPia, ICA, N,N-dimethyltryptamine, IAId, iso-indole, 1, 3-dione (N-hydroxy ethylphthalimide), auxin-like substances, phenyl-3-acetic acid (PAA) and hydroxyphenyl acetic acid (OH-PAA))
- Betaines (Glycinebetaine, γ-aminobutyric acid betaine, δ-aminovaleric acid betaine, glycinebetaine, laminine, lysinebetaine, ascophylline)
- Carbohydrates: 1-(2-furanyl) ethanone (mannitol), 5-methyl-2-furcarboxaldehyde (fucoidan), 2-hydroxy-3-methyl-2-cyclopenten-1-one (laminarin), diannhydromannitol (mannitol), 1,6-anhydromannopyranose and 1,6-anhydromannofuranose (mannitol)
- Cytokinins: zeatin (Z), dihydrozeatin (DHZ), trans-zeatin (tZR), cis-zeatin (cZR), dihydrozeatin riboside (DHZR), isopentenyladenine (iP), isopentenyladenosine (iPR), benzyladenine riboside (BAR), meta-topolin (mT), meta-topolin riboside (mTR), ortho topolin (oT), and ortho-topolin riboside (oTR), cytokinin glucosides, etc.
  Gibberellic acid (GA3), carrageenans
- lipids
- melatonin
- minerals (Na, Ca, Cu, Fe, I, K, Mg, Na, P, S, B, Mn, Zn, Co, potassium oxide
- phosphorus oxide, N, S, Cl, HCO- 3 , etc.)
- oligosaccharides
- pepsin
- phenolic compounds: eckol, phloroglucinol, etc.
- polysaccharides
- protein sterols: 22-Dehydrocholesterol, 24-Methylenecholesterol, 24-Methylenecycloartanol, 24-Methylenophenol, 28-Isofucosterol, 5-Dihydroergosterol, Brassicasterol, Campesterol, Cholesterol, Chondrillasterol; Clerosterol, Clionasterol, Codisterol, Cycloartenol, Decortinol, Decortinone, Desmosterol, Ergosterol, Fucosterol, Isodecortinol, Obusifoliol, Ostreasterol, Poriferastenol, Sitosterol; ß-Stitosterol, Stigmasterol, Zymosterol, 14,5-Ketosteroids, 15-Ergostenol; 17-Ergostenol, etc.



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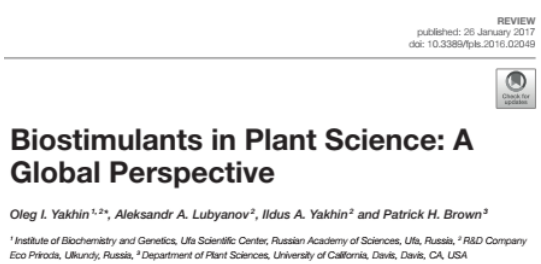
Algae: mechanisms and effects (1)

- increase nutrient absorption and fertilizer efficiency
- nutrient uptake
- uptake of Cu, Ca, K and Mg
- macro- and microelements content
- assimilation of N, C, and S
- could reduce the fertilizers
- efficient water uptake
- auxin-, cytokinin-, gibberellin-like activity
- modulation of phytohormones
- regulation of gene expression
- increase photosynthetic efficiency
- photosynthetic pigments (chlorophyll, carotenoids)
- total protein concentrations, amino acid, betaines, carbohydrate content, ascorbic acid
- nutrient concentrations
- increase metabolites including phenolic compounds
- up-regulation of bio-synthetic enzymes
- enhance antioxidant activity.
- enhance biosynthesis of non-enzymatic compounds
- delay senescence
- reduce transpiration
- enhance stomatal conductance
- change of metabolism
- alter of root architecture
- modulation of root exudates
- activate the mechanisms of strengthening cell walls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Algae: mechanisms and effects (2)

- decrease rate of transpiration
- sensitivity of the plants to water deficiency
- resistance to frost, insect and pathogen attack, disease and pests
- enhance locally plant immunity against viruses
- reduced virus infection
- reduction in root-knot nematode infestation
- against salinity stress, water stress
- induce improvement of plant growth under sea water stress
- tolerant to iron deficiency
- increase #of fruits per plant and size of fruit
- improdved fruit and, crop yield, fruit quality
- development of a vigorous root system and improved growth
- increase in fresh weight, grain weight and yield components
- root formation
- improved growth characters (length, fresh, dry weight) of shoots and roots, quality of the plants
- stimulate plant growth
- induce rooting

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Methods of analysis for the in vitro and in vivo determination of the fungicidal activity of seaweeds: a mini review (Review)

O' Keeffe, E., Hughes, H., McLoughlin, P., Tan, S.P., McCarthy, N.

Department of Science, Eco-Innovation Research Centre, Waterford Institute of Technology, Waterford, Ireland

Research seaweed extracts

TABLE 1 | List of extracts manufactured from *A. nodosum* biomass that were reported to improve plant growth.

S. No.	Extract	Crop	Function	References
1	GA14® (Goemar, France)	*Spinacia oleracea*	Foliar spray improved total fresh biomass	Cassan et al., 1992
2	Maxicrop® Original	Tomato	Higher chlorophyll content in sprayed plants	Whapham et al., 1993
3	Maxicrop®	*Capsicum annuum*	Improved yield and quality	Eris et al., 1995
4	Goemar®	*Citrus unshiu*	Early maturation of fruit	Fornes et al., 1995
5	*A. nodosum* extract	Kiwi fruit	Improved fruit growth, weight, and maturation	Chouliaras et al., 1997
	A. nodosum extract	Tomato, dwarf French bean, wheat, barley, maize	Enhanced leaf chlorophyll level	
6	Acadian® (Acadian Seaplants)	*Vitis vinifera*	Improved yield and fruit quality	Norrie et al., 2002
7	Acadian® (Acadian Seaplants)	*Poa pratensis*	Improved shelf life and transplant rooting	Zhang et al., 2003
8	Maxicrop®, Proton®, Algipower®	*Vitis vinifera*	Improved copper uptake of grapevine	Turan and Köse, 2004
9	Goemar®	Clementine Mandarin and Navelina Orange	Increased productivity and yield	Fornes et al., 2002
10	*A. nodosum* extract	*Arabidopsis thaliana*	Improved plant growth by modulation of concentration and localization of auxin	Rayorath et al., 2008
11	*A. nodosum* extract	*Hordeum vulgare*	Induced gibberellic-acid-independent amylase activity in barley and promoted seed germination	Rayorath et al., 2008
12	Goëmar BM 86®	Apple	Improved the fruit quality of apple and have high nitrogen content	Basak, 2008
13	Acadian® Marine Plant Extract Powder (AMPEP)	*Kappaphycus striatum*	AMPEP improves micro-propogation	Hurtado et al., 2009
14	*A. nodosum* extract	*Olea europaea*	Showed increased tree productivity and improved their nutrition status and oil quality parameters	Chouliaras et al., 2009
15	Alge®	*Citrullus lanatus*	Application of extract showed increased growth parameters and yield responses	Abdel-Mawgoud et al., 2010
16	Actiwave®	Strawberry	Increases fruit yield and quality and acts as iron chelator	Spinelli et al., 2010
17	Acadian® (Acadian Seaplants)	*Spinacia oleracea*	Enhances phenolic antioxidant content of Spinach	Fan et al., 2011
18	AMPEP	*Ulva lactuca*	Reduces ionic liquid induced oxidative stress in *Ulva lactuca*	Kumar et al., 2013
19	*A. nodosum extract*	*Medicago sativa*	Improves root colonization of rhizobial symbionts	Khan et al., 2012
20	*A. nodosum* extract	Strawberry	Improved plant growth, fruit quality and microbial growth	Alam et al., 2013
21	Super Fifty®, Ecoelicitor®	Lettuce; Oilseed rape	Enhanced plant growth and tolerance to biotic and biotic stresses	Guinan et al., 2012
22	Acadian® (Acadian Seaplants)	*Spinacia oleracea*	Improved yield and nutritional quality	Fan et al., 2013
23	Acadian® (Acadian Seaplants)	*Spinacia oleracea*	Improves phenolics and antioxidant content of spinach	Fan et al., 2013
24	Alga Special (AS)	*Vitis vinifera*	Improved vegetative growth	Popescu and Popescu, 2014
25	AZAL5	*Brassica napus*	Promotes plant growth and nutrient uptake	Jannin et al., 2013
26	AlgaeGreen®	*Brassica oleracea*	Enhanced biosynthesis of secondary metabolites	Lola-Luz et al., 2013
27	Acadian® (Acadian Seaplants)	*Spinacia oleracea*	Preharvest ANE application enhanced post-harvest storage quality of spinach	Fan et al., 2014
28	Acadian® (Acadian Seaplants)	Carrot	Promote plant growth and root yield in carrot associated with increased root-zone soil microbial activity	Alam et al., 2014
29	Stella Maris™	*Calibrachoa hybrida*	Increased biosynthesis of secondary metabolites and enhanced antibacterial and antifungal properties of *C. hybrida* extract	Elansary et al., 2016a
	A. nodosum extract	*Vitis vinifera*	Improved growth, yield, berry quality attributes, and leaf nutrient content of grapevines	Sabir et al., 2014
30	Premium liquid seaweed	*Allium cepa*	Improved vegetative growth and yield of onion	Hidangmayum and Sharma, 2017
31	Seaweed extract	*Zea mays*	Promotes root morphology and plant nutrition	Ertani et al., 2018
32	Acadian® (Acadian Seaplants)	*Vitis vinifera*	Foliar spray has a positive effect on ripening dynamics and fruit quality	Frioni et al., 2018
33	Rygex®, Super fifty®	*Solanum lycopersicum*	Increased plant growth and fruit quality and mitigates salinity stress in tomato plants	Di Stasio et al., 2018
34	Seaweed extract	*Spinacia oleracea*	Improved growth, quality, and nutritional value of spinach grown under drought conditions	Xu and Leskovar, 2015
35	Seasol®	*Fragaria ananassa*	Increased growth response of strawberry root	Mattner et al., 2018

Application	# publications
fruit	10
spinach	6
tomato, sweet pepper	3
strawberry	3
corn, rape seed	2
onion, been, carrot, cabbage, clover, grass	1

***Ascophyllum nodosum*-Based Biostimulants: Sustainable Applications in Agriculture for the Stimulation of Plant Growth, Stress Tolerance, and Disease Management**

Pushp Sheel Shukla[1], Emily Grace Mantin[1], Mohd Adil[1], Sruti Bajpai[1], Alan T. Critchley[2] and Balakrishnan Prithiviraj[1]

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Article

Biostimulants and Microorganisms Boost the Nutritional Composition of Buckwheat (*Fagopyrum esculentum* Moench) Sprouts

- 14-day-old plants
- cultivated in soilless environment

A Commercial Extract of Brown Macroalga (*Ascophyllum nodosum*) Affects Yield and the Nutritional Quality of Spinach *In Vitro*

Di Fan , D. Mark Hodges , Alan T. Critchley & Balakrishnan Prithiviraj

- in vitro
- experiment duration 21 d

Biostimulants: 4. Biopolymers

products

- chitin from shrimp and insect industry
- chitosan is deacetylated chitin

effects

- increase plant resistance/immunity (chitosan)
- effects on soil antagonists (chitins)

remarks

- effects vary
- costly

Biostimulants: 5. Anorganic compounds

products

- with Al, Co, Na, Se en/of Si

effects

- variable, often stress-lowering and/or stimulating plant growth
- effects of Se on nutritional value of grass is well-known

Biostimulants: 6. Fungi

products

- a.o. mycorrhiza, *Trichoderma*

effects

- mycorrhiza: effect on P-availability, disease suppressive, plant growth stimulating, improved drought tolerance
- *Trichoderma*: stimulating plant growth, but also antagonist

Highlighted: mycorrhiza in agriculture

Two methods to manage mycorrhiza

- inoculation with mycorrhiza product

or

- cultural measures:

measure	practice	feasibility
reduced soil tillage	current trend	++
refrain from growing non-mycorrhiza crops	don't crop cabbage (incl. crucifer-manure crops), sugar beet	– –
continuous cultivation with mycorrhiza crops	mixture (grass/clover), cereals/clover followed by grass	+/–
aim at reduced soil-P	P-AL<20, P_{CaCl2}<1, P-Olsen<50	– –

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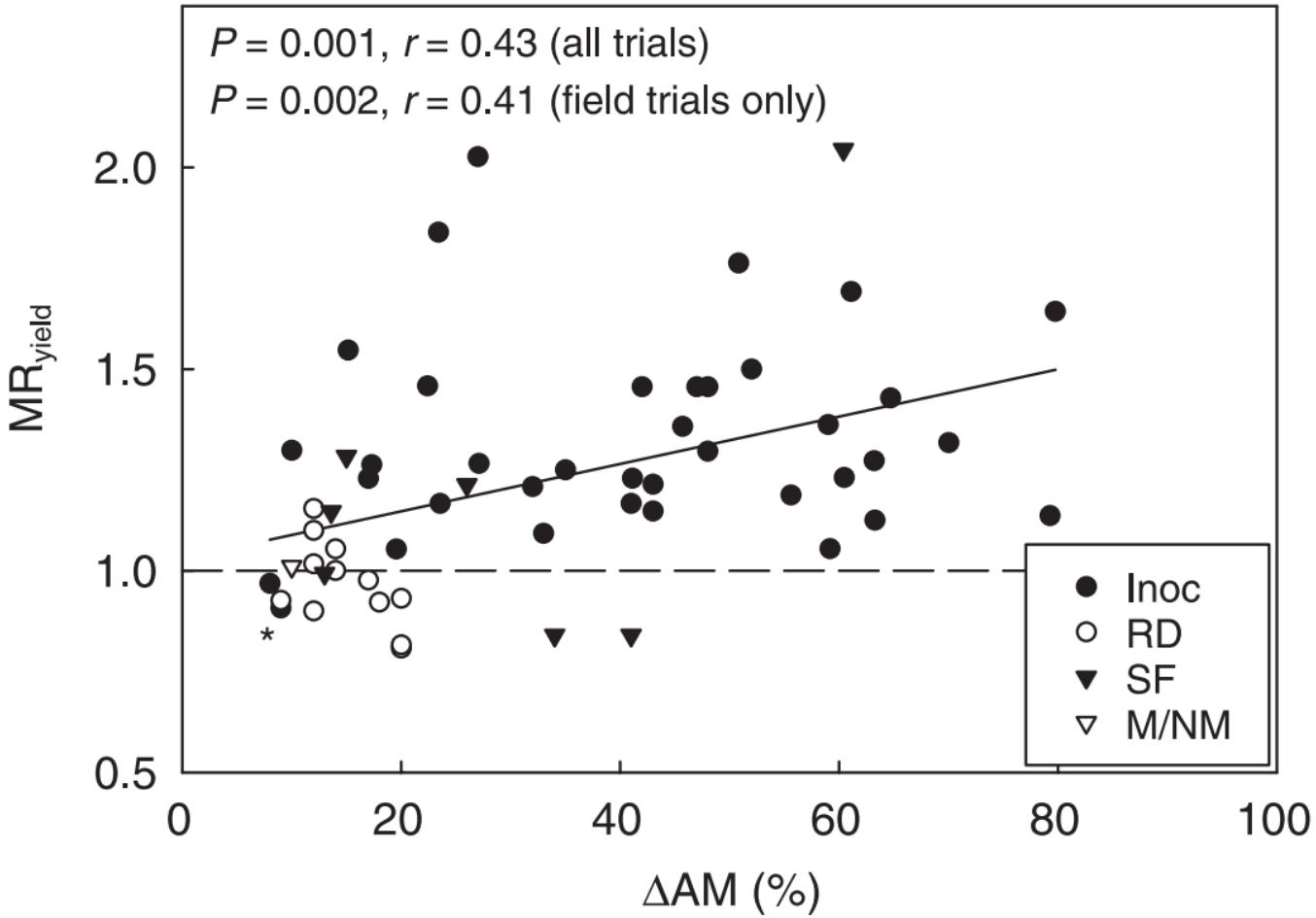
Stimulation of crop yield by mycorrhiza

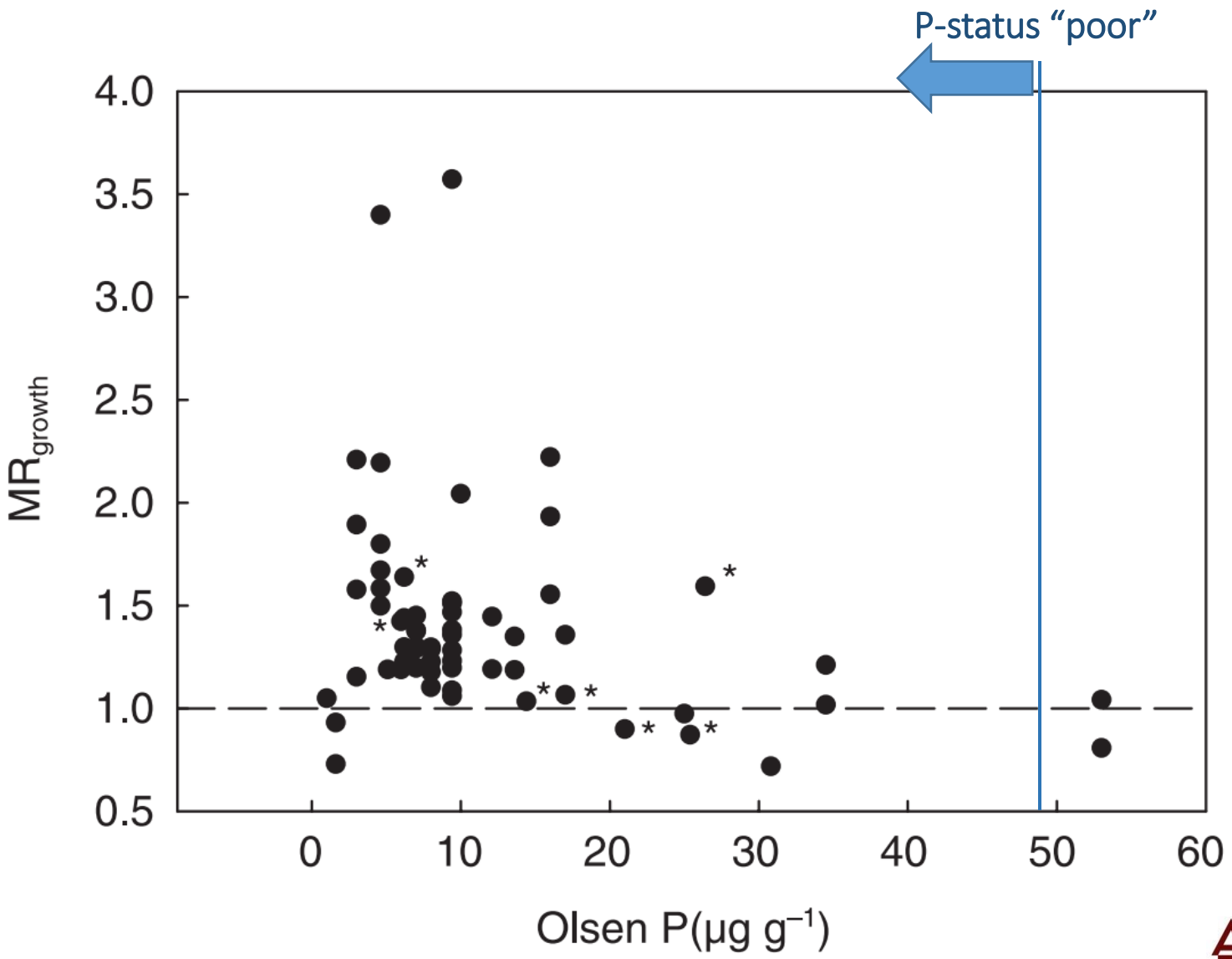


New Phytologist
Research

Is plant performance limited by abundance of arbuscular mycorrhizal fungi? A meta-analysis of studies published between 1988 and 2003

Y. Lekberg and R. T. Koide

Effect of soil P-status



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New Phytologist

Research

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New Phytologist

Tansley review

Little evidence that farmers should consider abundance or diversity of arbuscular mycorrhizal fungi when managing crops

Megan H. Ryan[1] **and James H. Graham**[2]

[1]School of Agriculture and Environment and Institute of Agriculture, The University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia; [2]Department of Soil and Water Sciences, Citrus Research and Education Center, University of Florida, Lake Alfred, FL 33850, USA

2018

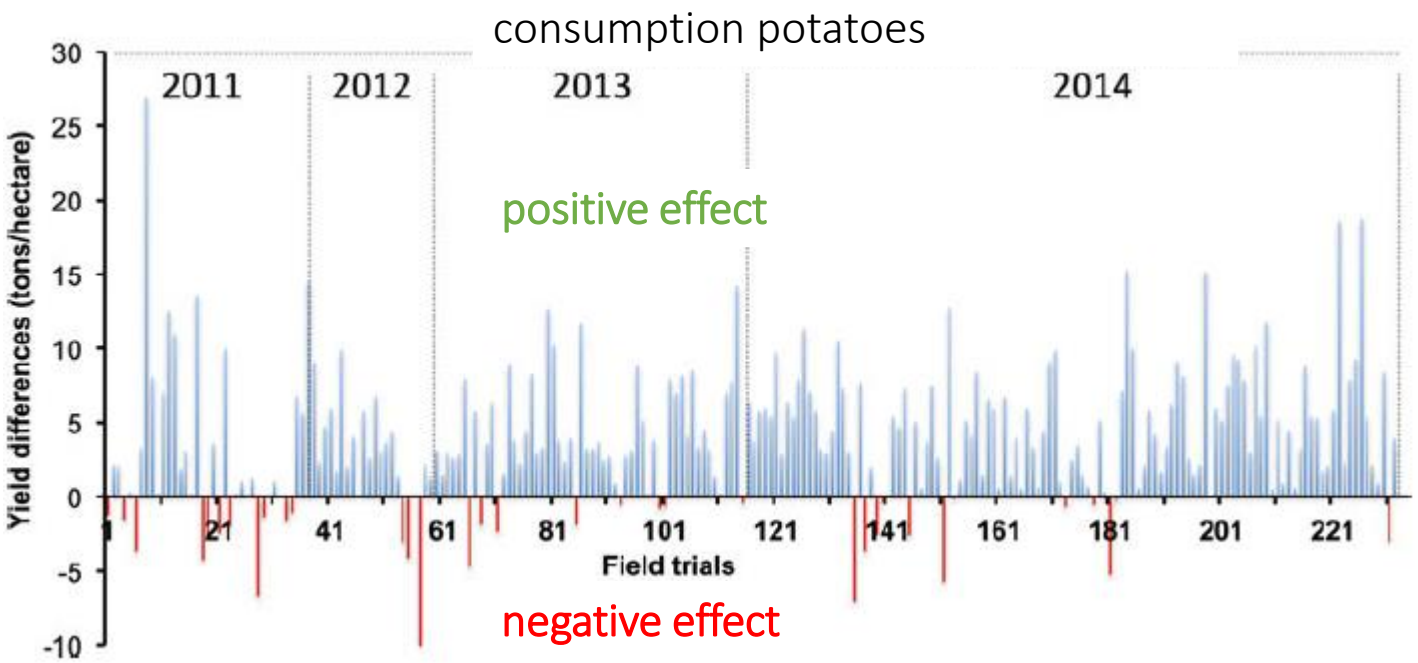
- Literature way too optimistic
- Errors in studies
- "A small body of rigorous research only sometimes reports a positive impact of high colonisation on crop yield, even under P limitation"
- Variation between experiments by interaction between environment (incl. soil) and crop and mycorrhiza species effects
- Soil colonisation of the mycorrhizal fungus is a primary bottle-neck

Successful application of mycorrhiza

- situations where mycorrhiza is absent (with other factors being optimal, including low soil-P) (e.g. irrigated dessert soil)
- cropping plants having exoting mycorrhiza (e.g. *Eucalyptus*)
- chemically polluted soils (trees)
- possibly enhancing rooting of seedlings and/or cuttings

but:

Effect of *Rhizophagus irregularis* DAOM 197198



Hijri, 2016 , Mycorrhiza 26: 209

231 farmer's experiments with/without inoculation with mycorrhiza (70 spores/seed potato) – locations: Canada, US, Switzerland, France, per field no reps & no info on P-levels, avg. yield: 40 t/ha

Biostimulants: 7. Bacteria

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Biostimulanten: 7. Bacteriën

products

- N-binding symbiontic: *Rhizobium*
- N-binding free-living: a.o. *Azosporillum*, *Azotobacter*
- other, a.o. *Bacillus*, *Lactobacillus*, *Pseudomonas*
- extension (incl. fungi) via art. 42.4 FPR

effects

- N-binding (soy)
- stress reduction
- effects on root growth and architecture

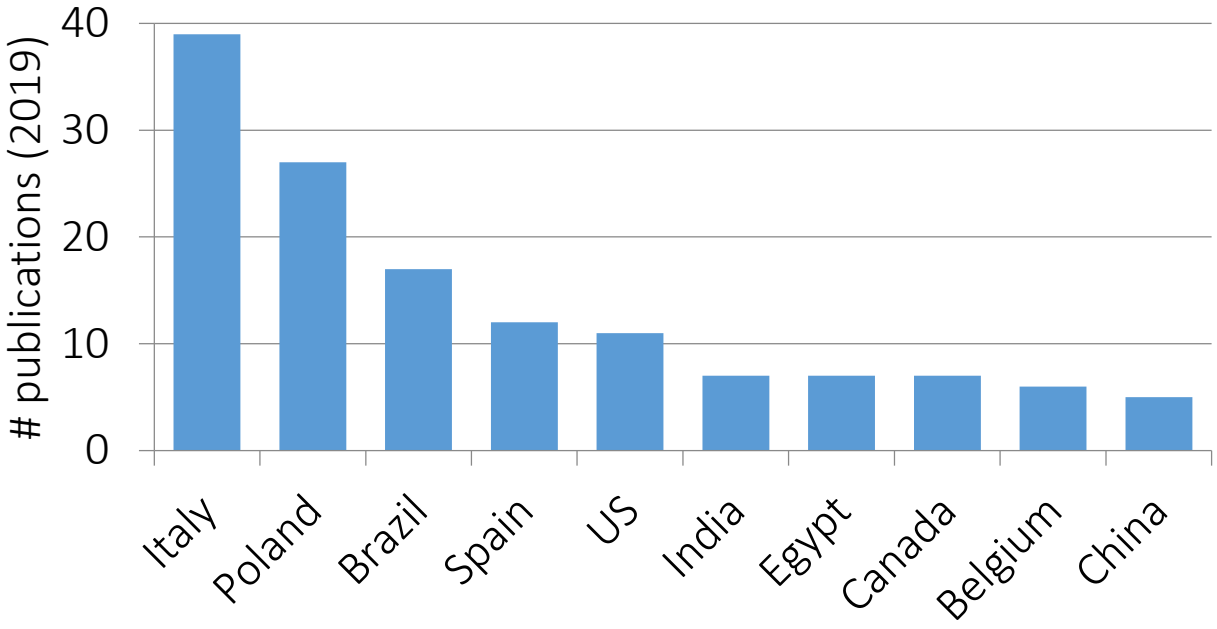
remarks

- For soy, co-inoculation with *Rhizobium* is necessary
- Effect of free-living and endophytic N-binding bacteria is unclear

Response from science

Response from science

- Most research from S-Europe
- Possible sub-optimal conditions play a role in these countries (drought, salinity)



- Little work from NL/Belgium except micro-organismens (PGPR, biocontrol)

Science: small inventory from Wageningen

Wietse de Boer, Ken Giller, Ep Heuvelink, Thom Kuyper, Corné Pieterse, Joeke Postma, Jos Raaijmakers, Sander Schouten, Paul Struik

- Not able to judge because background info is lacking
- Effects disappear outside the experimental environment; too many claims; effects can be clear for seedlings
- Difference biostimulant / antagonist sometimes not so large
- More effective *Rhizobium*-strains by selection (2x) (soy)
- AMF: effects not predictable, varying from neutral to positive
- Cultivated micro-organisms have difficulties to colonize the soil
- Under optimal growing conditions no additional effect

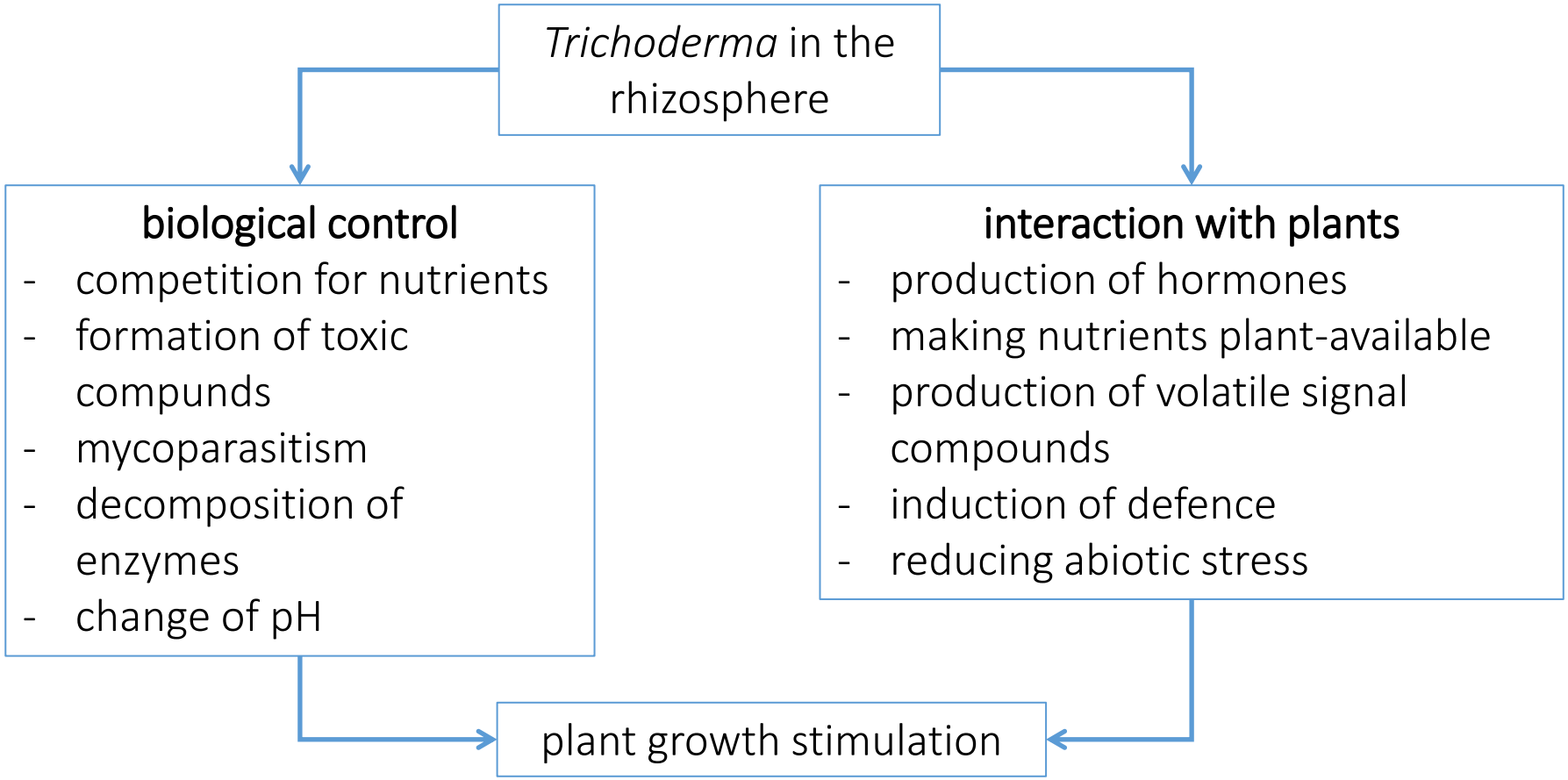
Current research:

- Tailor-made bioconsortia are promosing, incl. breeding for this (NWO-project Zwaartekracht)
- Importance of volatile compounds produced by micro-organisms
- Endophytische micro-organisms

Difference between science and practice

- Science finds nice effects, usually in an artificial environment (e.g. sterile soil or *Arabidopsis*)
- Practice markets it too quickly

Example: *Trichoderma*



naar Contreras-Cornejo et al., 2016

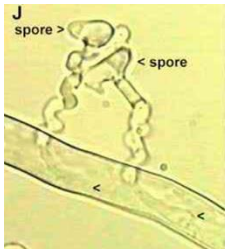
Trichoderma

- After a lot of research, some strains are now registered as biocontrol agents, e.g. *Trichoderma harzianum* T22
- Now, other Trichoderma's are sold as biostimulant
- What do we know about these Trichoderma's?
  - if they also have biocontrol properties, then they are by definition not a biostimulant
  - would proving on absence of biocontrol properties be needed?

Multiple effects

or, when is something a pesticide?

- *Trichoderma*, combining the properties of biocontrol agent and biostimulant
- Can (e.g.) *Trichoderma* be marketed only as biostimulant?
- *Verticillium biguttatum*



Inputlijst

De Skal inputlijst is een publieke lijst van commerciële producten die gebruikt mogen worden in de biologische landbouw. De lijst beperkt zich tot meststoffen, bodemverbeteraars, gewasbeschermingsmiddelen en gerelateerde producten, kortweg "inputs". Het gebruik van inputs is toegestaan wanneer andere teeltmaatregelen onvoldoende blijken. Voor gebruik van de middelen op de Skal inputlijst gelden de in Nederland van toepassing zijnde gebruiksvoorschriften.
Laatste update: 16-12-2019

Informatie over Verticillium biguttatum. Dit product mag gebruikt worden in de Biologische Landbouw in Nederland.

Productnaam	Verticillium biguttatum
Categorie	Meststoffen, compost, groeimedia en biologisch afbreekbare materialen
Subcategorie	Micro-organismen

- Combined properties (pesticide/biostimulant) also possible for:
  - mycorrhiza
  - algae
  - …?

Journal of Applied Phycology
Volume 31, Issue 6, 1 December 2019, Pages 3759-3776

Methods of analysis for the in vitro and in vivo determination of the fungicidal activity of seaweeds: a mini review (Review)

O' Keeffe, E., Hughes, H., McLoughlin, P., Tan, S.P., McCarthy, N.

Department of Science, Eco-Innovation Research Centre, Waterford Institute of Technology, Waterford, Ireland

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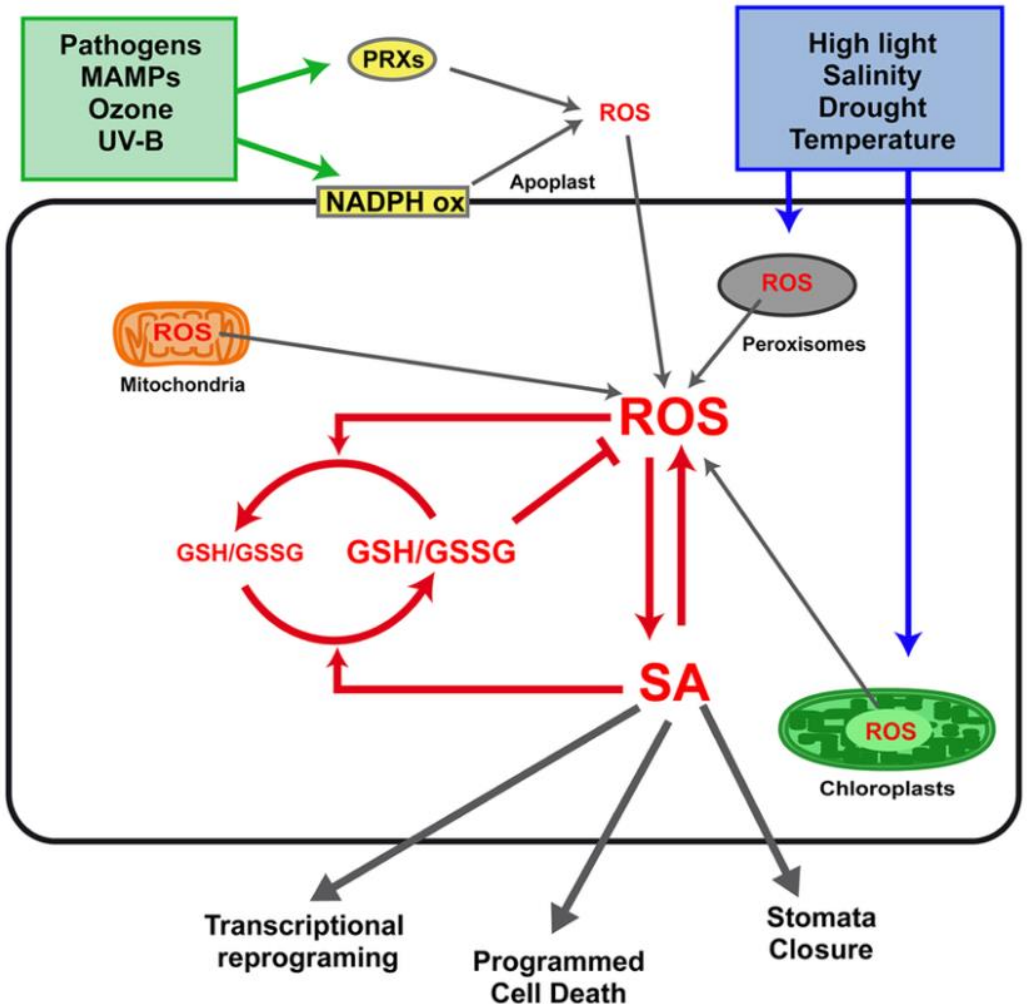
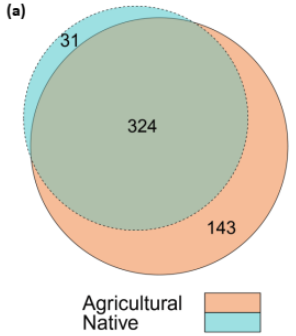
Multiple effects: Stress from different sources runs partially along the same pathways



Herrera-Vasquez & al., 2015
Front. Plant Science

Some scientific results

- Immunity effects leading to growth stimulation occurring in 42% of rhizosphere isolates (of *A. thaliana*; n=48).
- In modern agriculture, there is no impoverishm in rhizosphere bacterial diversity
- PGPR can have multiple effects (Fe, S, biolcontrol, hormones, secundary metabolites); plant pathogens can induce PGPR
- Consortia of micro-organisms can act synergistically
- Rhizosphere composition is plant, cultivar and situation dependent
- Crosstalk above/belowground



PGPR = plant growth promoting rhizobacteria

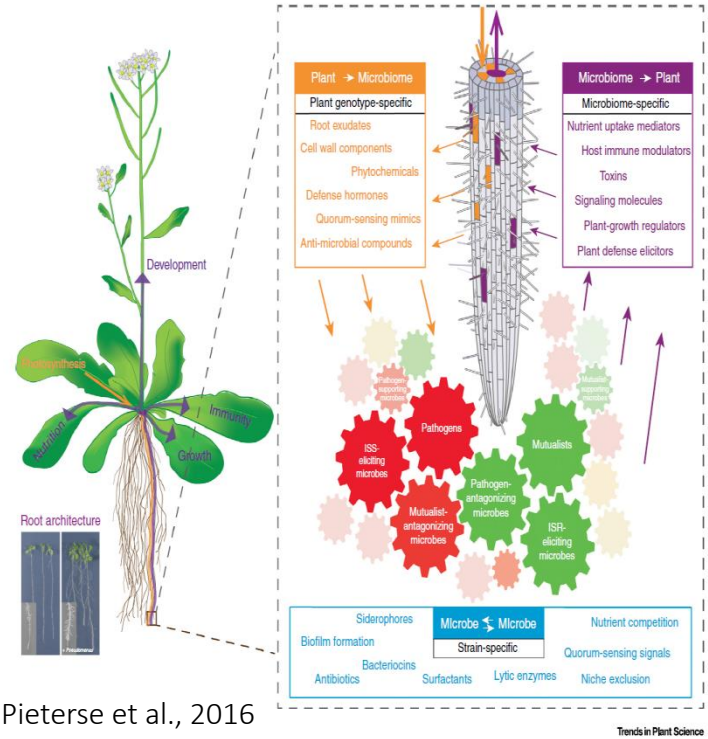
Yu et al., 2019, Yu et al., https://doi.org/10.1016/j.cub.2019.09.015
Carrión et al., Science 366, 606–612 (2019)
Mendes & al., 2018, ISME Journal
Santhanam & al., 2015, PNAS
Berendsen & al., 2018, ISME Journal
Cheng & al., 2017, Environ. Microbiol.

Science vs. practive?

Science

Testing principles:

- usually on economically unimportant test plants
- often on unnatural substrates
- with overdosis
- short-duration experiment



Pieterse et al., 2016

Praktice

It has to work:

- on agricultural important crops
- on natural soil
- at economically viable doses
- leading to a robust positive effect

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Practice shortlist

- Effects situation-dependent: strong interaction between crop, biostimulant and environment (weather, soil type, moisture)
- Therefore, results are strongly field-dependent
- Test producten on own field
- See www.soilcrop.nl/news for more details on this
- There are advisors who can assist with this

Conclusions

- There are many biostimulants on the market
- How they will adapt to the Fertiliser Product Regulation is yet unclear
- Currently, applications mainly in horticulture and fruit farming
- For arable farming little evidence for useful applications of biostimulants
- Claims on label must be verifiable
  - how will this be checked?
- Is NL lagging behind?
- Difference biostimulant / pesticide; multiple effects
- What if biostimulant controls a disease/pest while it is not being claimed? – Fair playing field necessary
- Considerable distance between practice and science

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Plantenpathogenen

Thank you for your attention!

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this presentation can be downloaded at www.soilcrop.nl

thanks to Wietse de Boer, Ken Giller, Ep Heuvelink, Thom Kuyper, Corné Pieterse, Joeke Postma, Jos Raaijmakers, Sander Schouten & Paul Struik

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