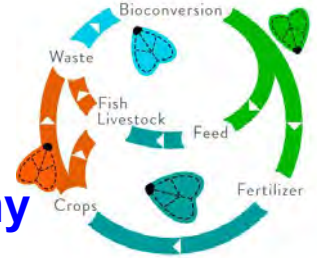
Hej!



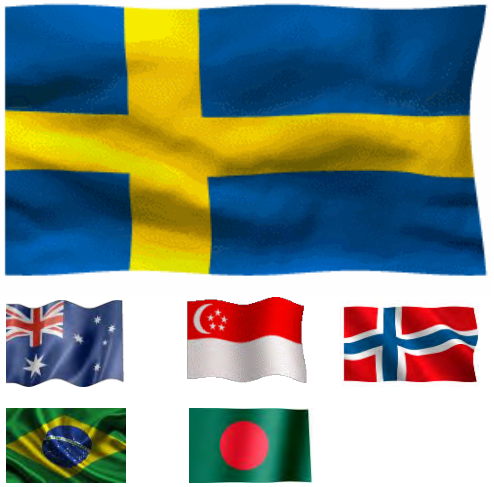
Circular Economy

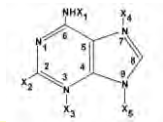
Hortikulturell produktionsfysiologi (HPF), Institutionen för biosystem och teknologi

Horticultural Production Physiology, Department of Biosystems and Technology

SLU

Swedish University of Agricultural Sciences

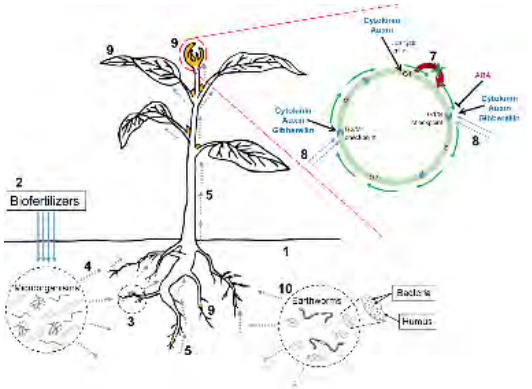


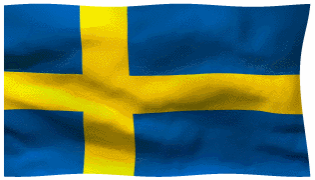


Cytokinins

Understanding the Role of Biostimulants in Cultivation

Jean W. H. Yong ("John")
杨远方





Hortikulturell produktionsfysiologi (HPF),
Institutionen för biosystem och teknologi

SLU

Swedish University of Agricultural Sciences

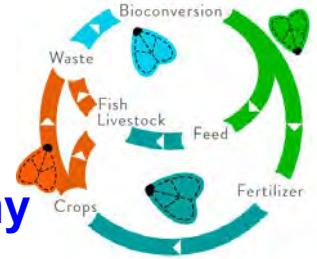
Curtin University

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN
Established in collaboration with MIT

THE UNIVERSITY OF WESTERN AUSTRALIA

NANYANG TECHNOLOGICAL UNIVERSITY

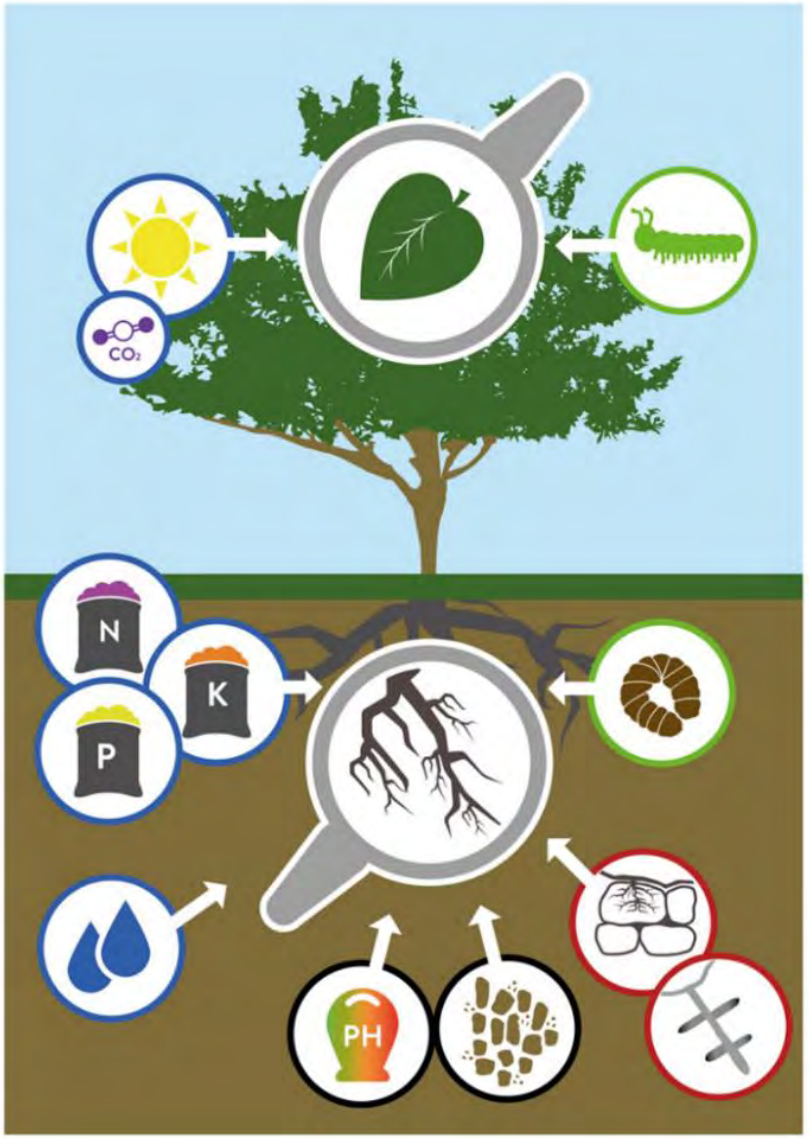
Circular Economy



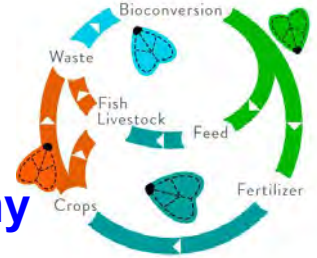
Learning Outcome

What is a GOOD "Fertilizer"?

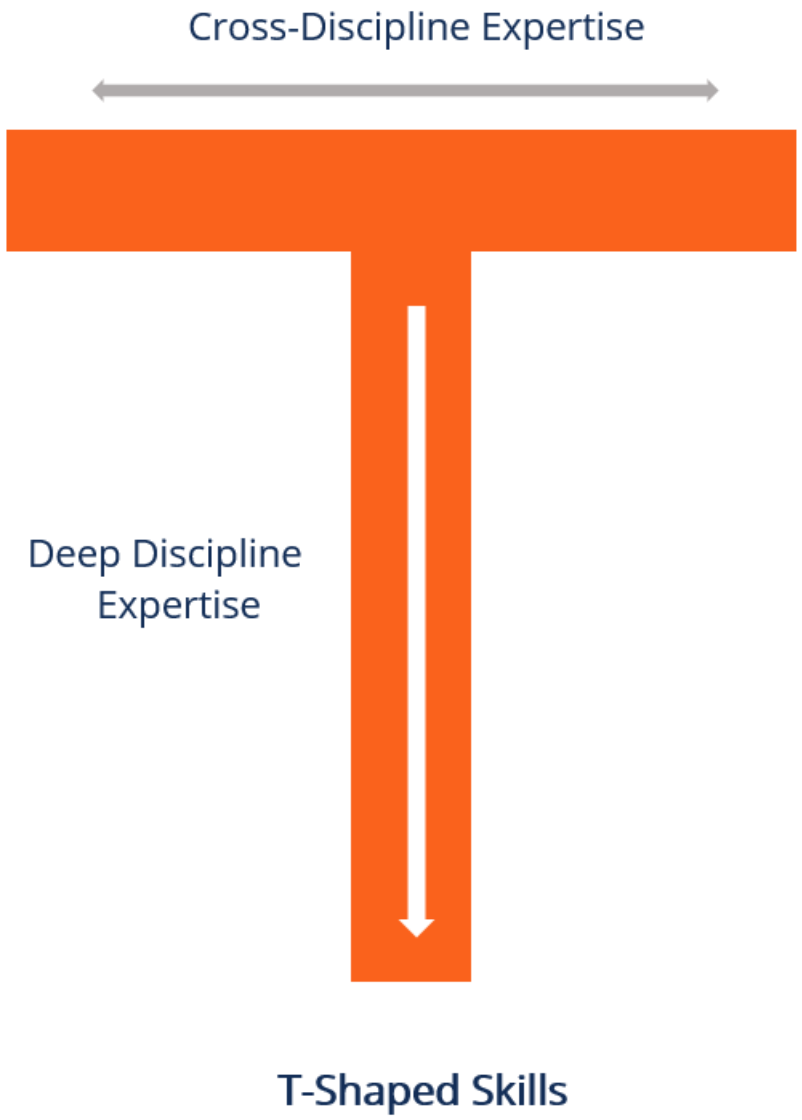
- Essential nutrients
  (Macro - NPK & micro-nutrients as building blocks)
- Improves soil structure & holds water



Circular Economy

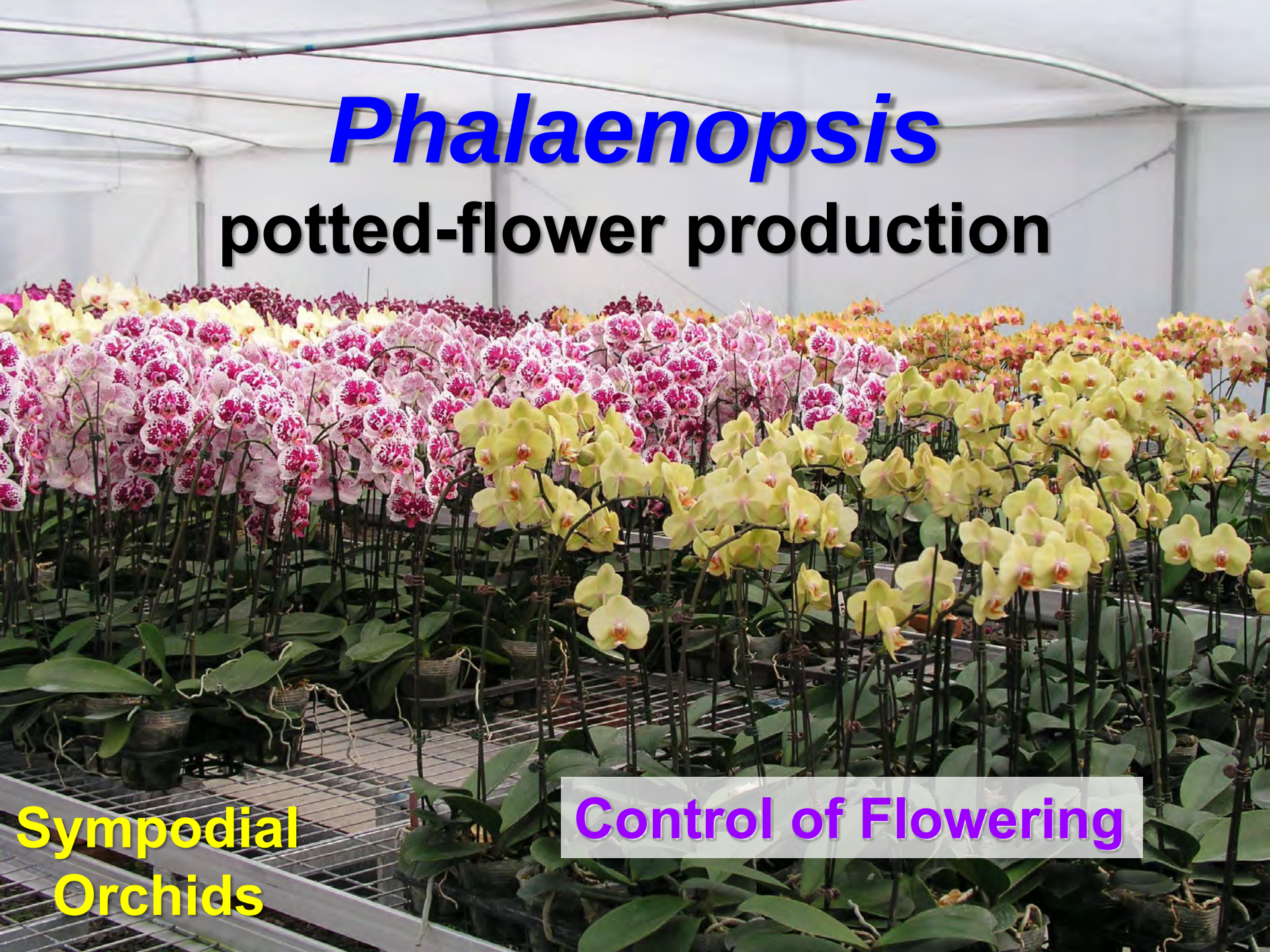


Who am I?

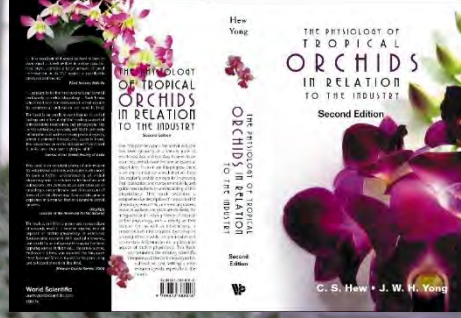


I am a T-shaped Scientist

Pretty Orchids


Phalaenopsis
potted-flower production
Sympodial Orchids
Control of Flowering

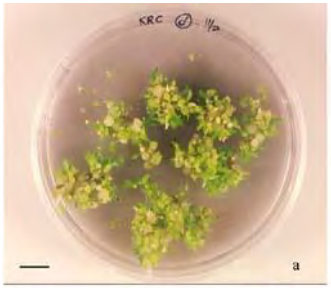

Monopodial
tropical
orchids

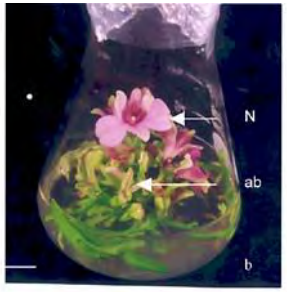


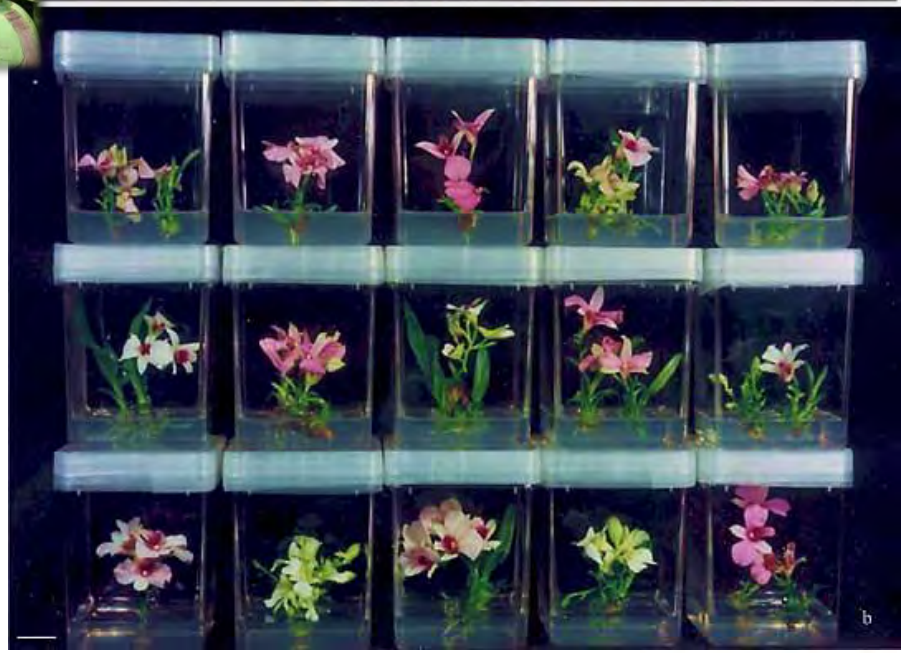
Agribusiness – Control of Flowering

Orchid

In-Vitro flowering

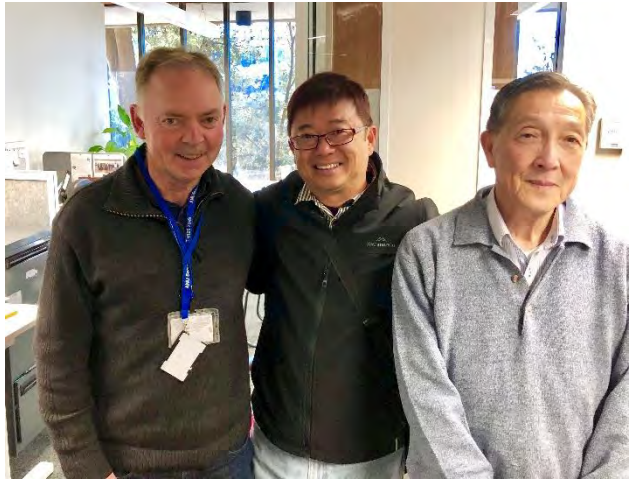






Basic Research

NUS National University of Singapore



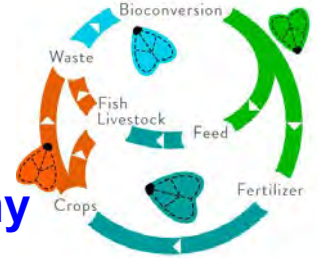
ANU Graham Farquhar & Chin Wong

Importance of Roots-derived Phytohormones

Using a **Root-pressure chamber** to obtain "snap-shots" of xylem sap for various analyses.

Yong et al (2000, 2010, 2014)

Basic Research

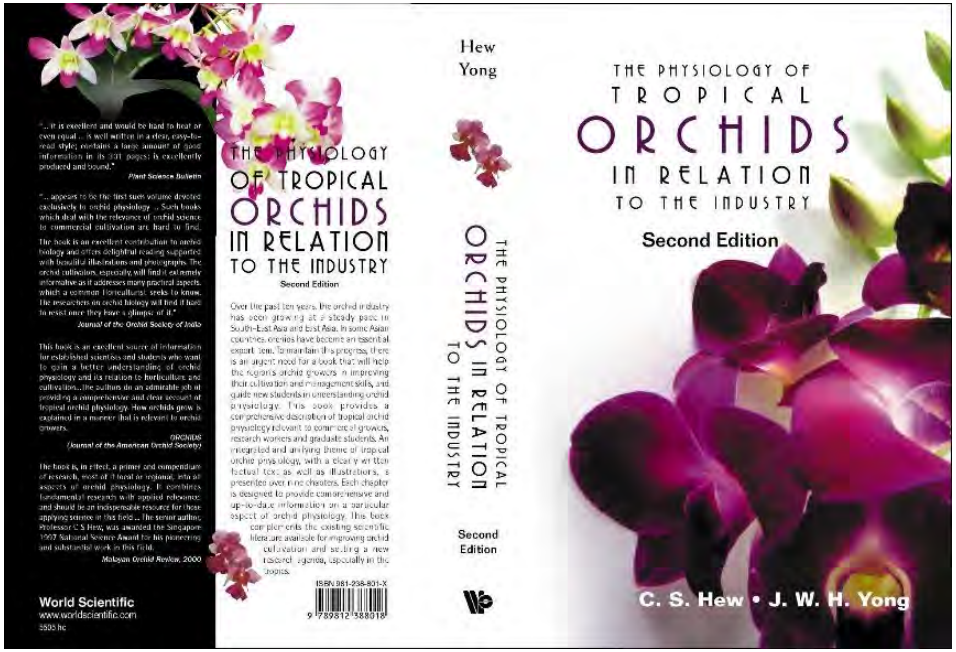


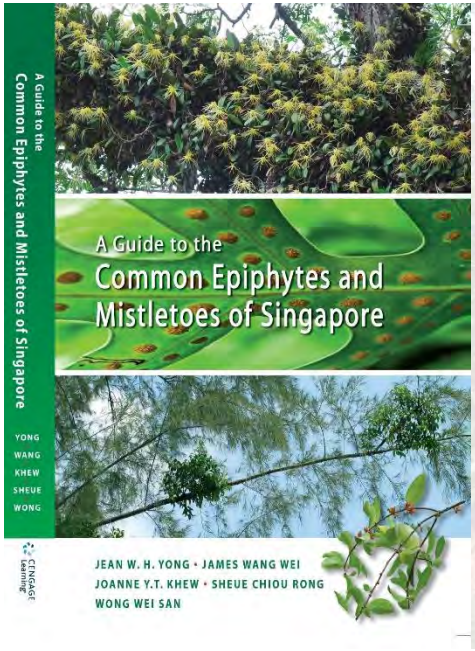
Circular Economy

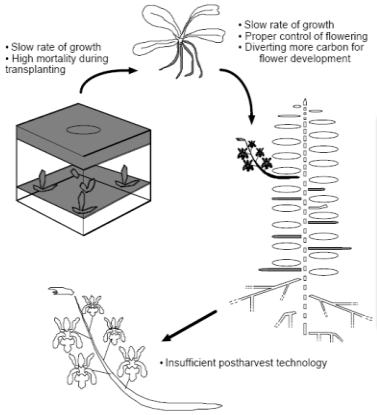
How to connect the different disciplines?

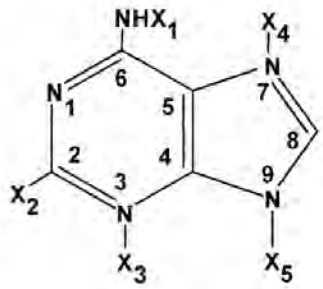
How did I arrived at the understanding of Biostimulants?

Orchid Industry & Conservation









Research

NANYANG TECHNOLOGICAL UNIVERSITY

NUS National University of Singapore

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN
Established in collaboration with MIT

NATIONAL PARKS

Healthy Soils

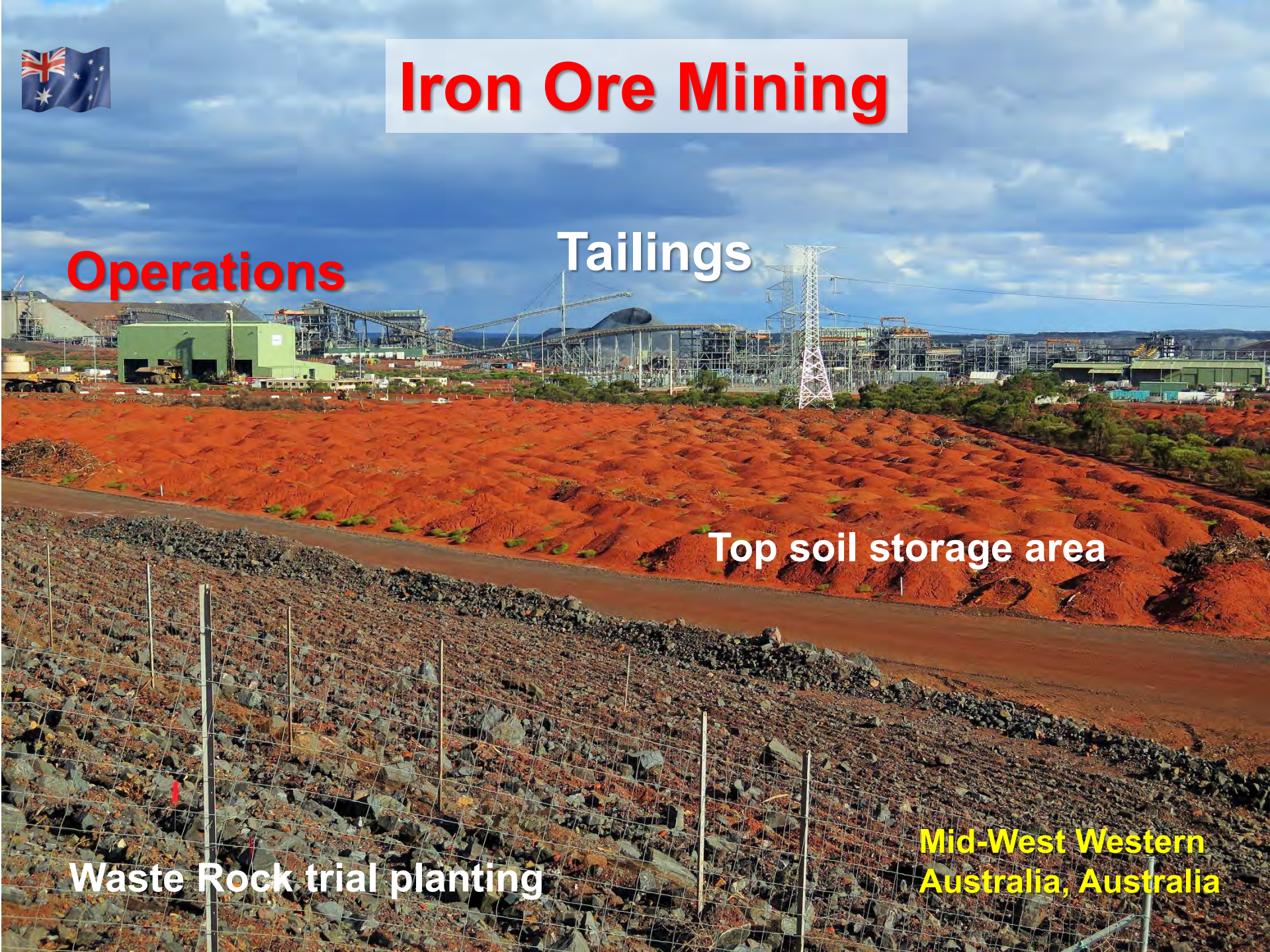
2018

"Accidental" soil scientist!

Mid-West Western Australia, Australia

Applied Research

THE UNIVERSITY OF WESTERN AUSTRALIA


Iron Ore Mining
Operations
Tailings
Top soil storage area
Waste Rock trial planting
Mid-West Western
Australia, Australia

Sand Mining

Australia, 2017-2018

Ellenbrook, near
Perth, Australia

Ecological Restoration

Goldfields, WA, Australia

Ricinocarpos brevis

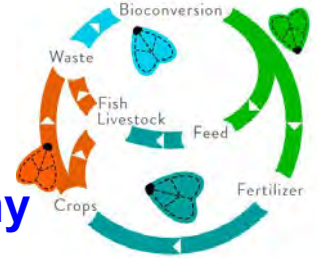
Large-scale Biostimulants' usage & Soil Re-constitution

Lampung, Sumatra, Indonesia

Organic Transformation

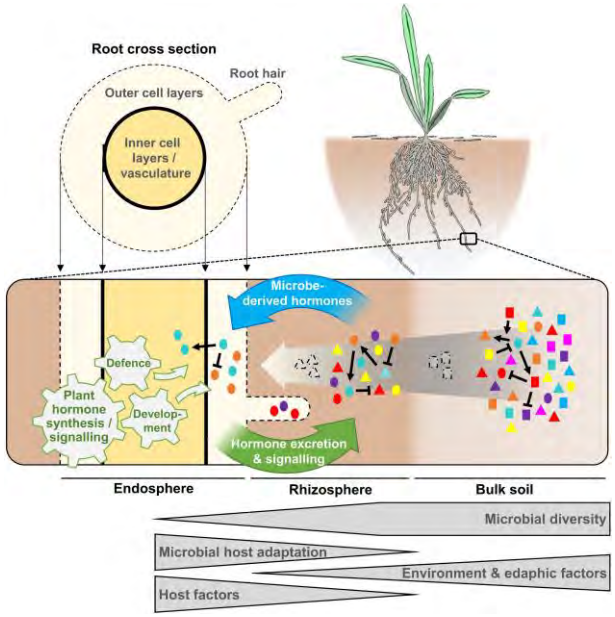
Consultancy

PT Great Giant Pineapple

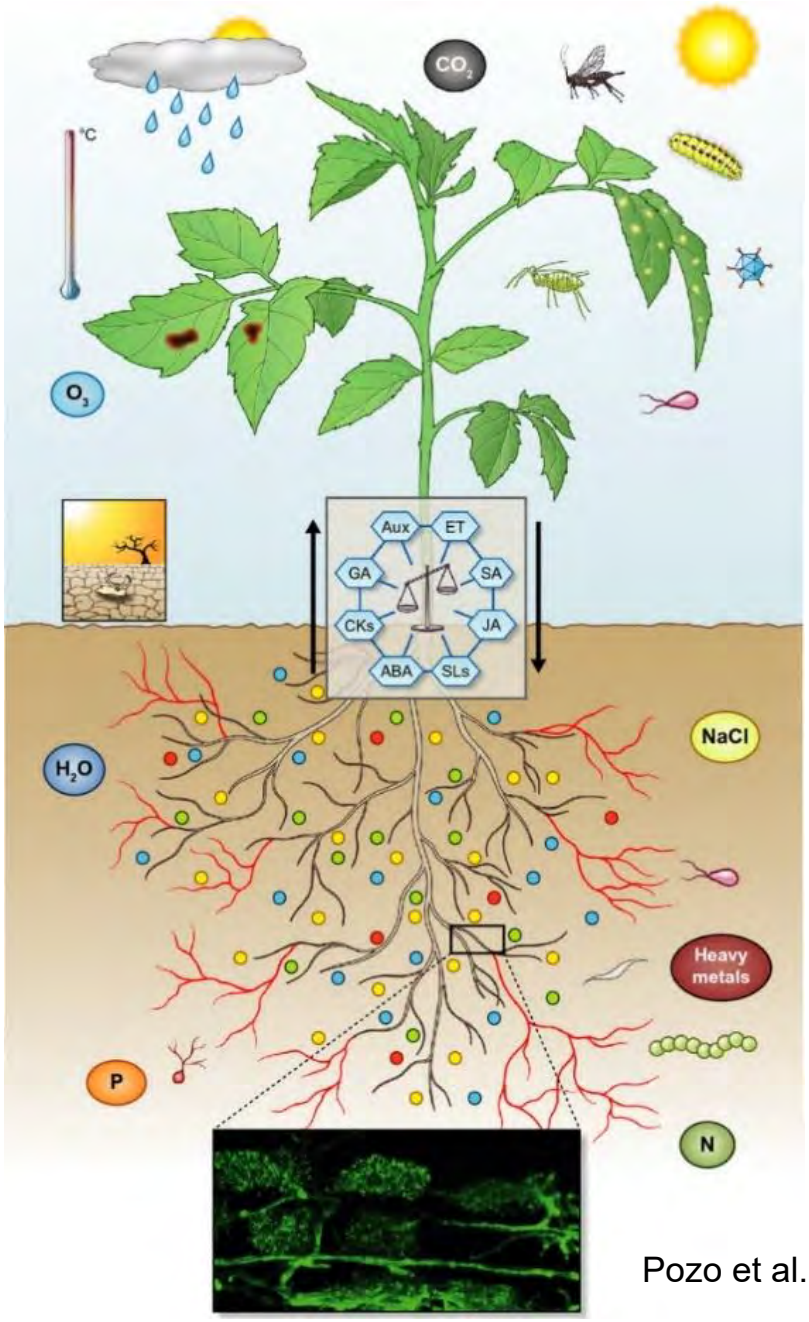


Circular Economy

Conceptual Connections

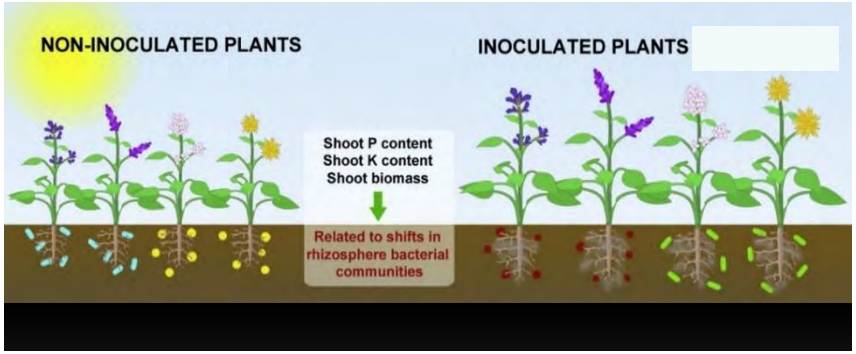


Eichmann et al. 2021



Complexity of Plants' responses

Abiotic vs Biotic factors



Pozo et al. 2015 (New Phyto)

Traditional, Organic/Green Fertilizers

- Composts, Vermi-compost (earthworms), Frass
- Humic substances
- Liquid/pellet microbial inoculants

Biostimulants

Plant biostimulants are **diverse substances** and **microbes** used to **enhance** growth, ***independent*** of the mineral nutritional effects.

Formal Definition!

Plant Biostimulants in FPR

DEFINITION

"A plant biostimulant shall be an EU fertilising product the function of which is to stimulate 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 or the plant rhizosphere:

(a) nutrient use efficiency,

(b) tolerance to abiotic stress,

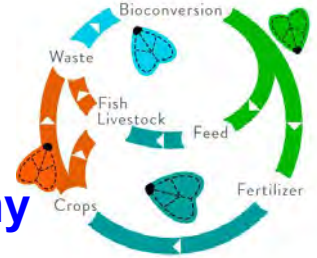
(c) quality traits, or

(d) availability of confined nutrients in the soil or rhizosphere."

Dr Theodora Nikolakopoulou, EU Commission

FPR: Fertilizer Product Registration

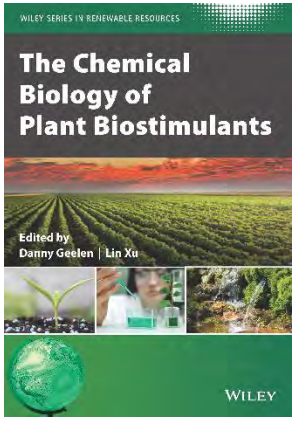
Circular Economy



Biostimulants – where to find it?

SLU
Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

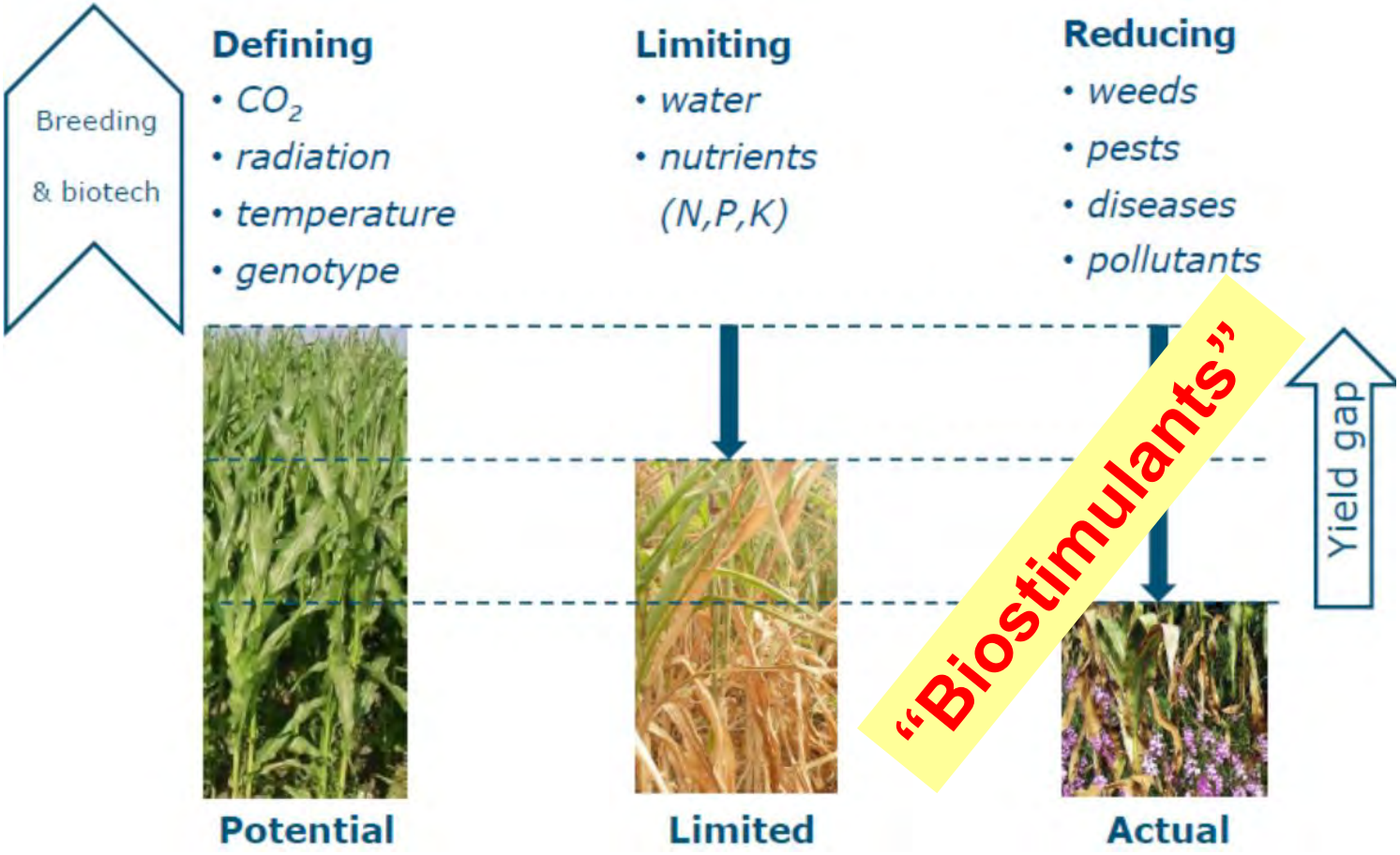
Huge Diversity of ”Compounds”



Biostimulants

https://www.agricen.com/agricultural-biostimulants

Biostimulants – why use it?

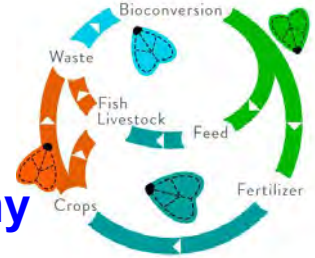


Van Ittersum & Rabbinge (1997) Field Crops Research

Prof. Van Ittersum – Biostimulant World Congress (2019) address

Conceptually,

Circular Economy



Biostimulants

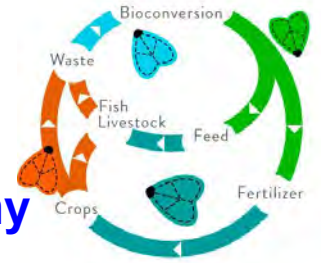
function like

“Catalyst”

Defining the Organics ?

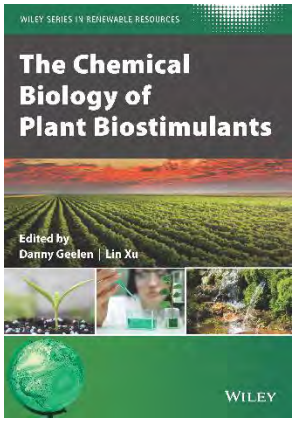
Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Circular Economy

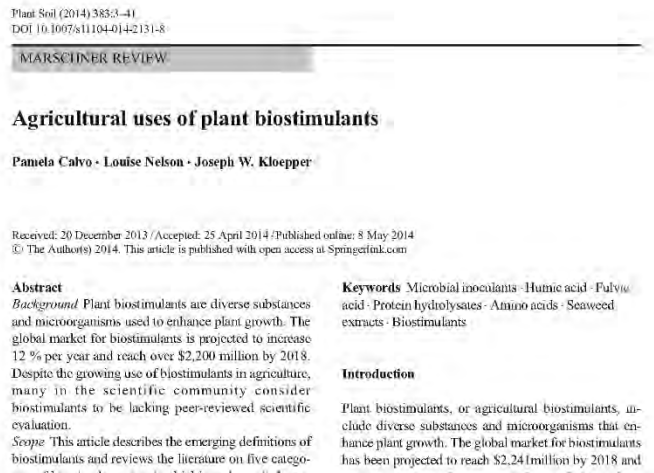


Biostimulants

Eight categories (Calvo et al. 2014)



- Microbial inoculants (**bacteria**, **cyanobacteria, fungi**)
- Humic acids (including Fulvic acids)
- Protein hydrolysates & amino acids (including **MicroProteins**)
- Seaweed extracts
- Complex organic materials (including **Phytohormones**)
- Beneficial chemical elements & Inorganic salts (including phosphite)
- Chitin and chitosan derivatives
- Anti-transpirants


Plant Soil (2014) 383:3–41
DOI 10.1007/s11104-014-2131-8

MARSCHNER REVIEW

Agricultural uses of plant biostimulants

Pamela Calvo · Louise Nelson · Joseph W. Kloepper

Received: 20 December 2013 / Accepted: 25 April 2014 / Published online: 8 May 2014
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Abstract
Background Plant biostimulants are diverse substances and microorganisms used to enhance plant growth. The global market for biostimulants is projected to increase 12 % per year and reach over $2,200 million by 2018. Despite the growing use of biostimulants in agriculture, many in the scientific community consider biostimulants to be lacking peer-reviewed scientific evaluation.
Scope This article describes the emerging definitions of biostimulants and reviews the literature on five catego-

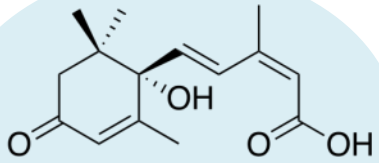
Keywords Microbial inoculants · Humic acid · Fulvic acid · Protein hydrolysates · Amino acids · Seaweed extracts · Biostimulants

Introduction

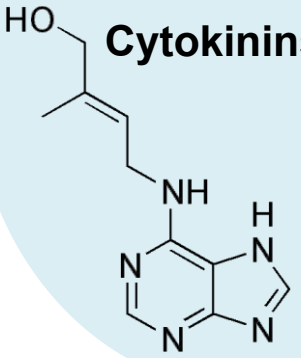
Plant biostimulants, or agricultural biostimulants, include diverse substances and microorganisms that enhance plant growth. The global market for biostimulants has been projected to reach $2,24 [million by 2018 and

Plant & Soil (2014) **Marschner Review**

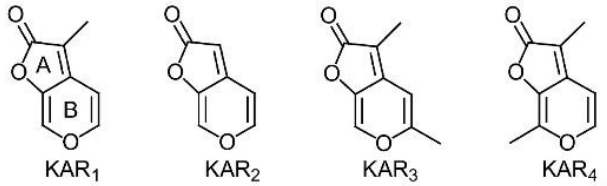
Phytohormones – old timers and newcomers



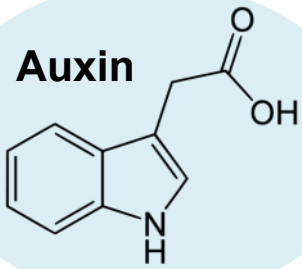
Abscisic Acid



Cytokinins

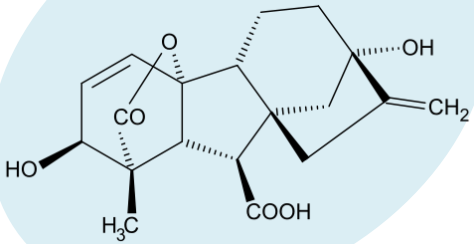


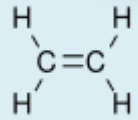
Karrikins



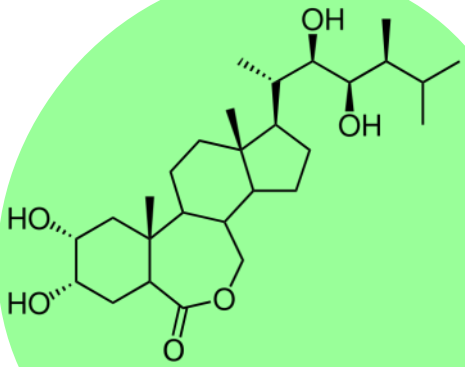
Auxin

Gibberellins

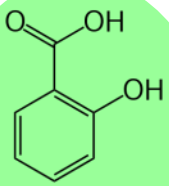




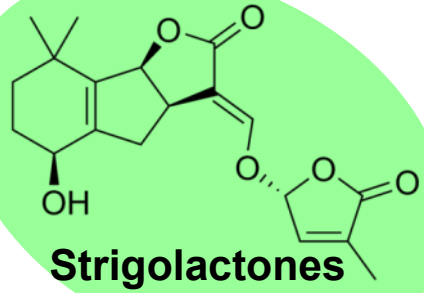
Ethylene



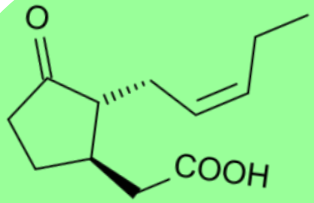
Brassinosteroids



Salicylates



Strigolactones



Jasmonates

Plants can use protein as a nitrogen source without assistance from other organisms

Chanyarat Paungfoo-Lonhienne*, Thierry G. A. Lonhienne†, Doris Rentsch‡, Nicole Robinson*, Michael Christie†, Richard I. Webb§, Harshi K. Gamage*, Bernard J. Carroll†, Peer M. Schenk*, and Susanne Schmidt*¶

*School of Integrative Biology, †ARC Centre of Excellence for Integrative Legume Research, School of Molecular and Microbial Sciences, and School of Land Crop and Food Sciences, and §Centre for Microscopy and Microanalysis, University of Queensland, Queensland 4072, Australia; and ‡Institute of Plant Sciences, University of Bern, 3013 Bern, Switzerland

Edited by Peter Vitousek, Stanford University, Stanford, CA, and approved January 25, 2008 (received for review December 21, 2007)

Nitrogen is quantitatively the most important nutrient that plants acquire from the soil. It is well established that plant roots take up nitrogen compounds of low molecular mass, including ammonium, nitrate, and amino acids. However, in the soil of natural ecosystems, nitrogen occurs predominantly as proteins. This complex organic form of nitrogen is considered to be not directly available to plants. We examined the long-held view that plants depend on specialized symbioses with fungi (mycorrhizas) to access soil protein and studied the woody heathland plant *Hakea actites* and the herbaceous model plant *Arabidopsis thaliana*, which do not form mycorrhizas. We show that both species can use protein as a nitrogen source for growth without assistance from other organisms. We identified two mechanisms by which roots access protein. Roots exude proteolytic enzymes that digest protein at the root surface and possibly in the apoplast of the root cortex. Intact protein also was taken up into root cells most likely via endocytosis. These findings change our view of the spectrum of nitrogen sources that plants can access and challenge the current paradigm that plants rely on microbes and soil fauna for the breakdown of organic matter.

nitrogen uptake | organic nitrogen | plant nutrition | plant roots | soil p

(13), (*ii*) most other heathland plants have mycorrhizal symbioses and/or form symbioses with N_2-fixing microbes (13), and (*iii*) *Hakea* for… of organic nit… *dopsis thaliana*… because it do… habitats that t… of fluorescent … absence of mic…

Results

Axenically Culti… plied Protein as… as the sole nit… cantly more ro… roots than plants grown without nitrogen (Fig. 1*A* and *B*). Shoot bio… bio… wit… was observed with inorganic nitrogen (Fig. 1*A* and *B*). *Arabidopsis* grown with protein (1.5 or 6 mg BSA per ml of growth medium) as the sole nitrogen source had significantly greater dry…

SLU Plant Protein Factory

New Ideas, Original Thinking?

Growing

PNAS 2008

S…

…ite the importance of protein microbes and animals (1, 2). Despite the importance of protein in soils, little research has been carried out to elucidate the role of proteins as a nitrogen source for plants. The exception is ecosystems where the rate of microbial mineralization is slow, such as in boreal forests and heathlands, woody plants rely on ecto- or ericoid mycorrhizal fungal sym-

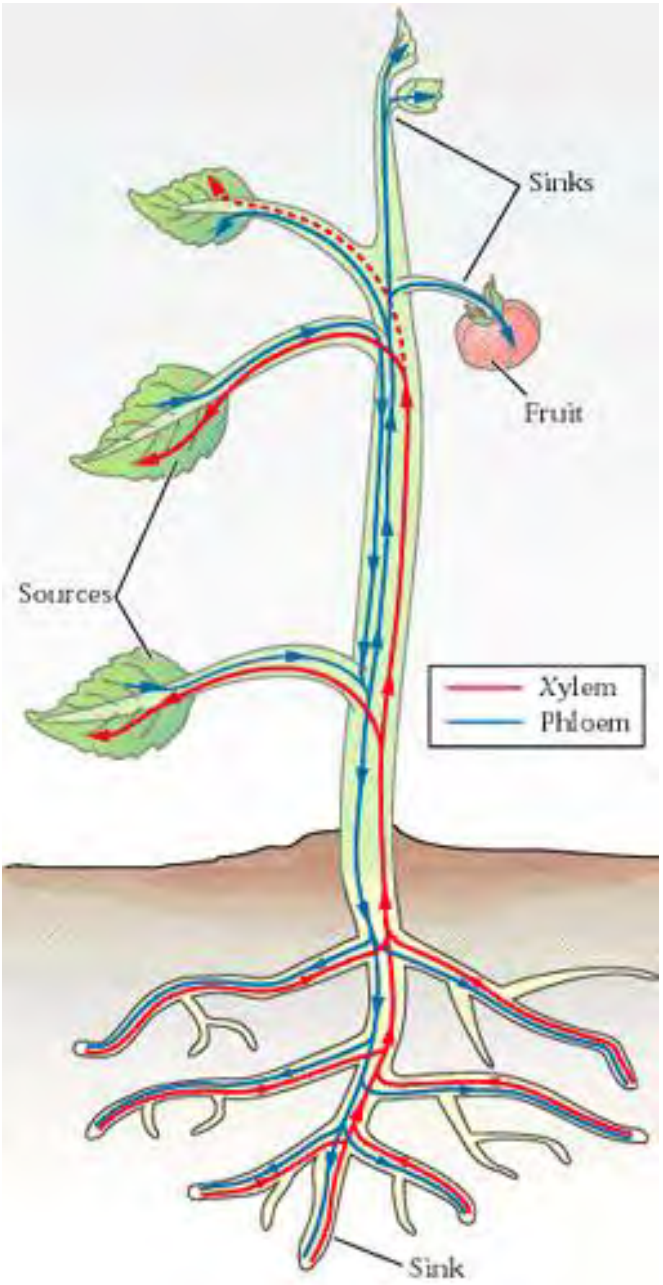
plants grown with 6 mg BSA per ml growth medium. *Arabidopsis* supplied with a mixture of protein and a low amount of inorganic nitrogen (5… mM NH_4NO_3 per liter and 0.04 mg NH_4NO_3 per… growth medium) grew significantly better than plants grown with either nitrogen source individually and produced the same dry weight as plants grown with a high amount of inorganic nitrogen

Phytohormones help coordinate growth, development, & responses to stimuli

- **Phytohormones** are chemical signals that modify or control one or more specific physiological processes within a plant
- **Phytohormones** are produced in very low concentration, but a minute amount can greatly affect growth and development of a plant organ
- In general, **Phytohormones** control plant growth and development by affecting the division, elongation, and differentiation of cells
- They have **multiple**, **overlapping**, & **interacting functions**

N-P-K is in mg

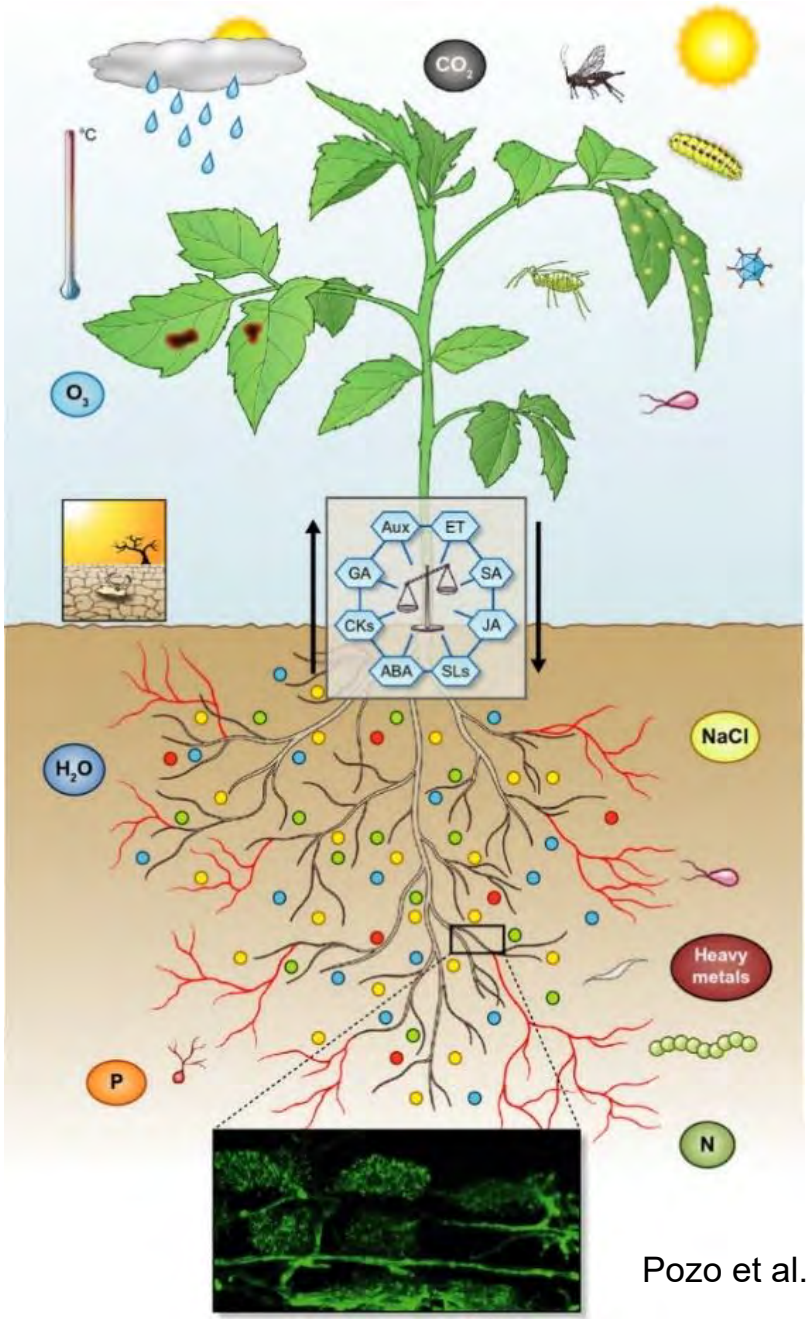
Phytohormones is in **µg** to **ng**



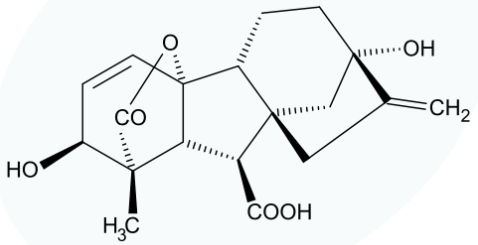
Movement of Plants' Signalling Substances

Biostimulants

Complexity of Plants' responses



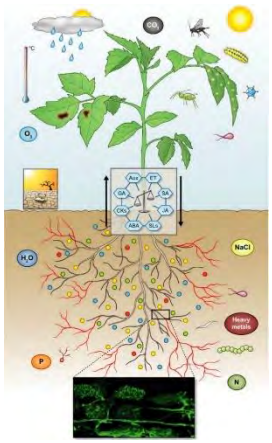
Gibberellins

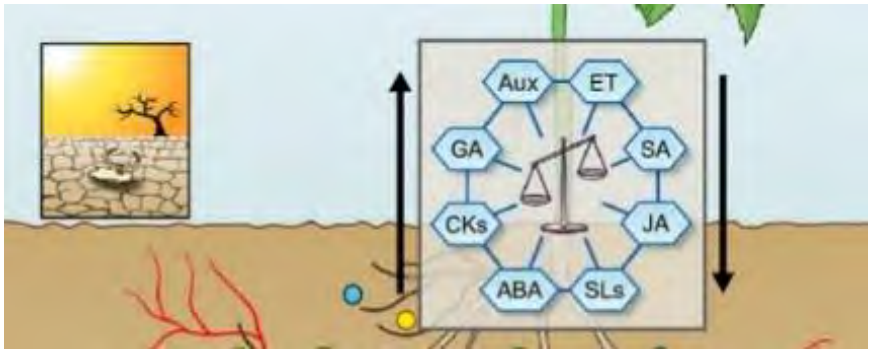


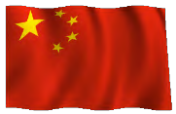
Pozo et al. 2015 (New Phyto)

Gibberellins (GA)

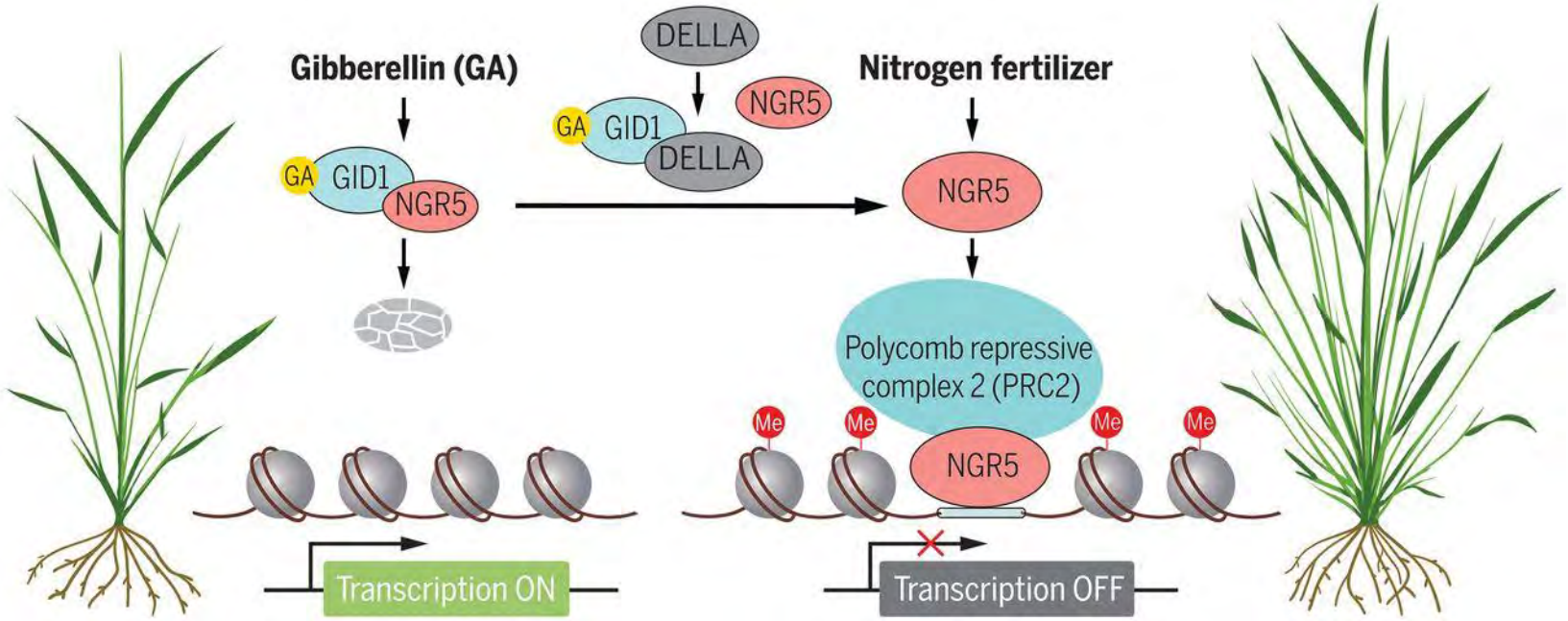
- **Gibberellins** have a variety of effects, such as stem elongation, fruit growth, and seed germination.







Nitrogen-responsive chromatin modulation enhances rice tillering.



Kun Wu et al. Science 2020;367:eaaz2046

Science
AAAS

Cell Cycle Control & Cytokinins

Planta (1996) 200: 2–12

Cytokinin controls the cell cycle at mitosis by stimulating the tyrosine dephosphorylation and activation of p34^{cdc2}-like H1 histone kinase

Kerong Zhang[1], **David S. Letham**[1,2], **Peter C.L. John**[1,2]

[1] Plant Cell Biology Group, Research School of Biological Sciences, The Australian National University, ACT 2601, Australia
[2] Cooperative Research Centre for Plant Science, GPO Box 475, Canberra, ACT 2601, Australia

Received: 27 October 1995/Accepted: 8 January 1996

Abstract. In excised pith parenchyma from *Nicotiana tabacum* L. cv. Wisconsin Havana 38, auxin (naphthalene-1-acetic acid) together with cytokinin (6-benzylamino-purine) induced a greater than 40-fold increase in a p34^{cdc2}-like protein, recoverable in the p13^{suc1}-binding fraction, that had high H1 histone kinase activity, but enzyme induced without cytokinin was inactive. In suspension-cultured *N. plumbaginifolia* Viv., cytokinin (kinetin) was stringently required only in late G2 phase of the cell division cycle (cdc) and cells lacking kinetin arrested in G2 phase with inactive p34^{cdc2}-like H1 histone kinase. Control of the Cdc2 kinase by inhibitory tyrosine phosphorylation was indicated by high phosphotyrosine

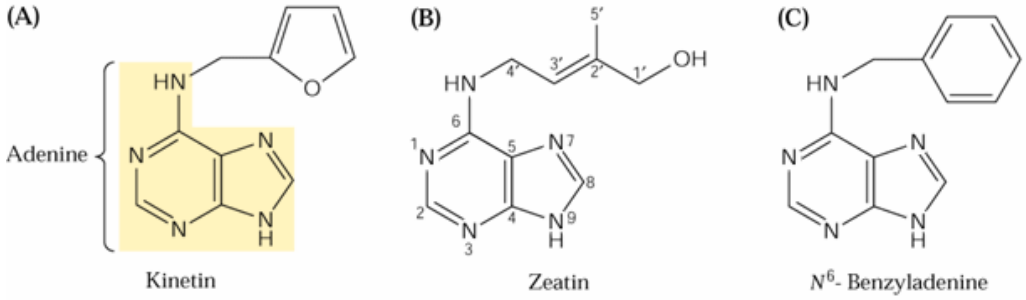
Introduction

Cell cycle control can be exercised by interaction of the key cell division cycle (cdc) catalyst p34^{cdc2} (the 34-kDa product of the *cdc2* gene) with different cyclin subunits that direct its protein kinase activity to specific substrates (Peeper et al. 1993), by cyclin dependent kinase inhibitor (CKI) proteins (Pines 1995) and by enzymes that control its enzyme activity through phosphorylation (Gould and Nurse 1987; Millar et al. 1991), so providing a likely universal mitotic control (Nurse 1990).

In plants we have noted changes in the level of p34^{cdc2}-like protein that are consistent with an hypothesis

Planta
© Springer-Verlag 1996

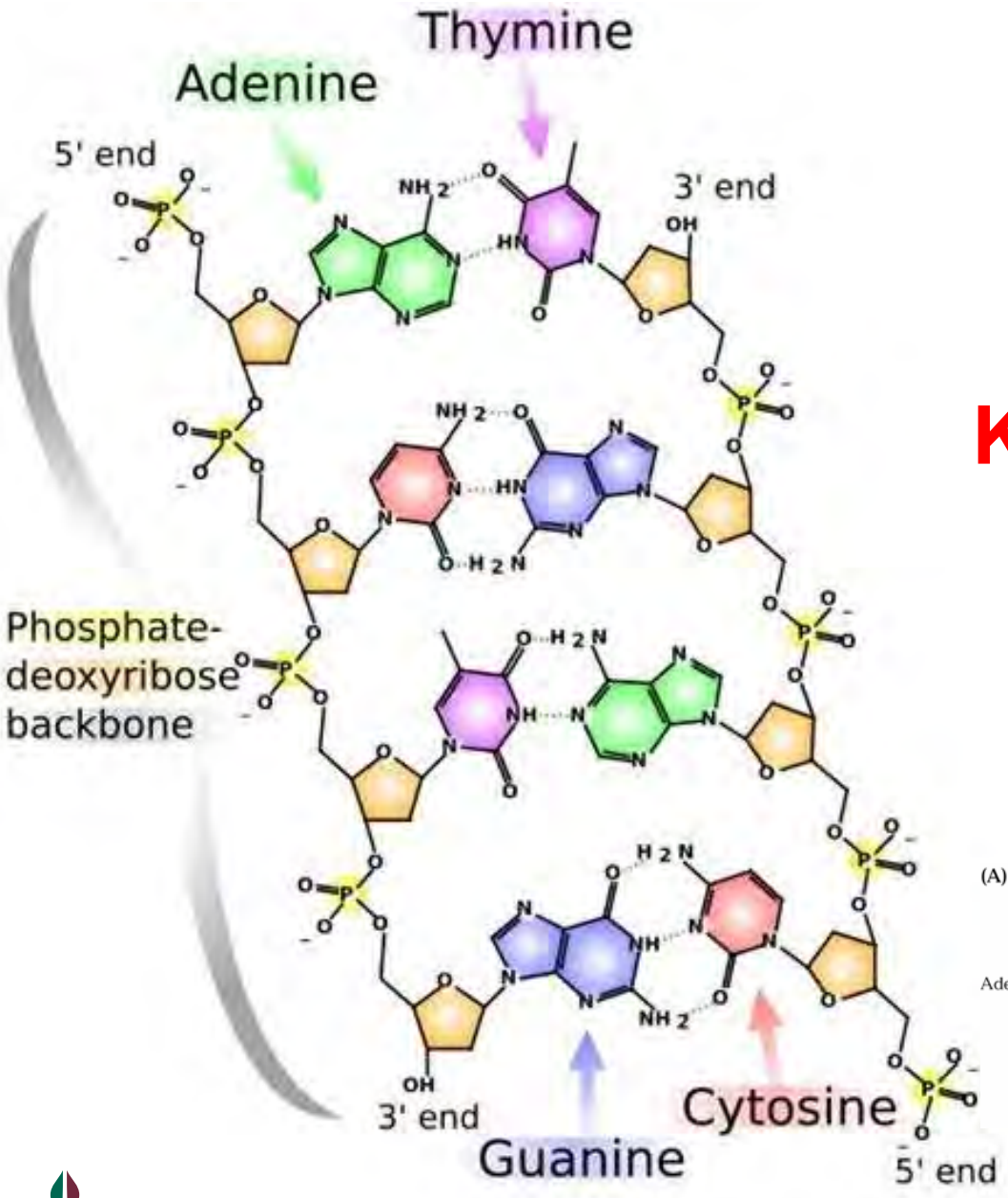
D. Stuart Letham



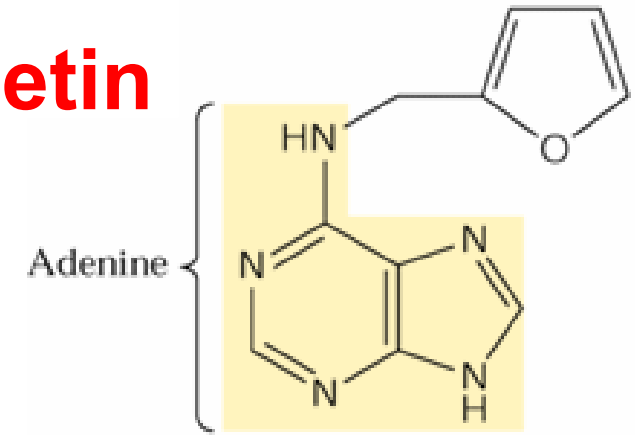
Cytokinins
细胞分裂素

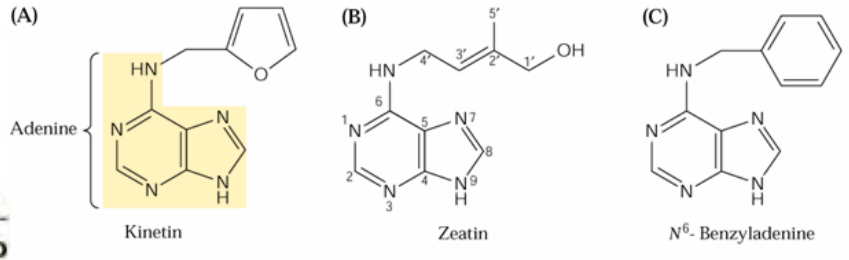
Cytokinins form a major group of **Biostimulants**

Components of the DNA



Kinetin





Electrophoresis 2006, *27*, 2171–2181

Liya Ge[1]
Jean Wan Hong Yong[1]
Swee Ngin Tan[1]
Eng Shi Ong[2]

[1]Natural Sciences and Science Education Academic Group, Nanyang Technological University, Singapore, Singapore
[2]Applied Science School, Temasek Polytechnic, Singapore, Singapore

Research Article

Determination of cytokinins in coconut (*Cocos nucifera* L.) water using capillary zone electrophoresis-tandem mass spectrometry

The applicability of CZE in combination with MS and MS/MS methods for the simultaneous separation and determination of 12 cytokinins was investigated for the first time. Cytokinins were first completely separated by CZE within less than 20 min using a

Electrophoresis 2008, *29*, 0000–0000

Liya Ge[1]
Jean Wan Hong Yong[1]
Swee Ngin Tan[1]
Lin Hua[2]
Eng Shi Ong[3]

[1]Natural Sciences and Science Education Academic Group, Nanyang Technological University, Singapore, Republic of Singapore
[2]Genome Institute of Singapore, Biopolis, Singapore, Republic of Singapore
[3]Department of Community, Occupational, and Family Medicine, Yong Loo Ling School of Medicine, National University of Singapore, Singapore, Republic of Singapore

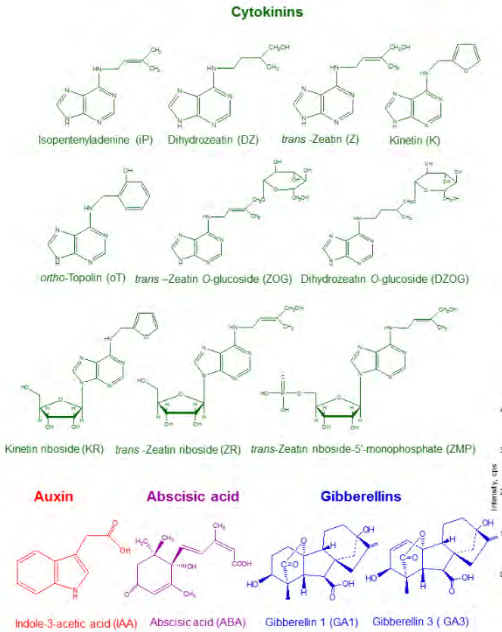
Research Article

Analyses of gibberellins in coconut (*Cocos nucifera* L.) water by partial filling-micellar electrokinetic chromatography-mass spectrometry with reversal of electroosmotic flow

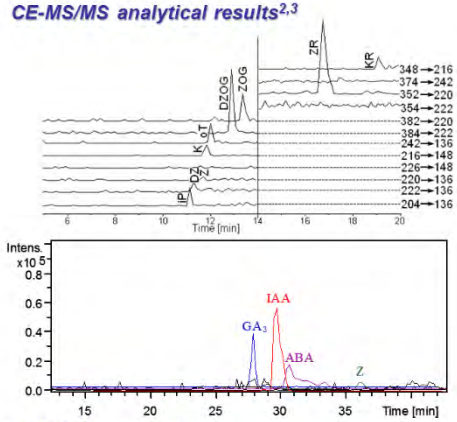
In this paper, we present the results of simultaneous screening of eight gibberellins (GAs) in coconut (*Cocos nucifera* L.) water by MEKC directly coupled to ESI-MS detection. During the development of MEKC-MS, partial filling (PF) was used to prevent the micelles from reaching the mass spectrometer as this is detrimental to the MS signal, and a cationic surfactant, cetyltrimethylammonium hydroxide, was added to the electrolyte to reverse the EOF. On the basis of the resolution of the neighboring peaks, different pa-

Several Phytohormones are found in young coconut water especially cytokinins, auxins and gibberellins.

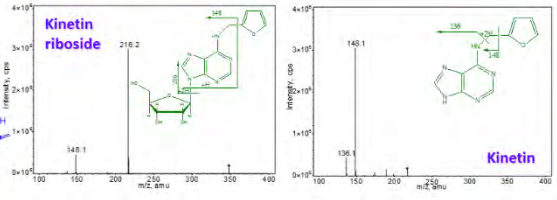
Structures of endogenous phytohormones in coconut water[1,2]



CE-MS/MS analytical results[2,3]



LC-MS/MS spectra[4]



Naturally-occurring phytohormones identified in coconut water[1-6]

Phytohormones		Estimated original concentration ($\times 10^{-3}$ μM)
Cytokinins	isopentenyladenine	0.26
	dihydrozeatin	0.14
	trans-zeatin	0.09
	kinetin	0.31
	ortho-topolin	3.29
	dihydrozeatin *O*-glucoside	46.6
	trans-zeatin *O*-glucoside	48.7
	trans- zeatin riboside	76.2
	kinetin riboside	0.33
	trans-zeatin riboside-5'-monophosphate	10.2
	14-*O*- (3-*O*- [β-D-galactopyranosyl - (1→2) - α-D- galactopyranosyl- (1→3) -α-L-arabinofuranosyl] -4-*O*- (α-L-arabinofuranosyl) -β-D-galactopyranosyl) - *trans*-zeatin riboside	*Present*
Gibberellins	gibberellin 1	16.7
	gibberellin 3	37.8
Auxin	indole-3-acetic acid	150.6
Abscisic acid	Abscisic acid	65.5

Coconut water

NANYANG TECHNOLOGICAL UNIVERSITY

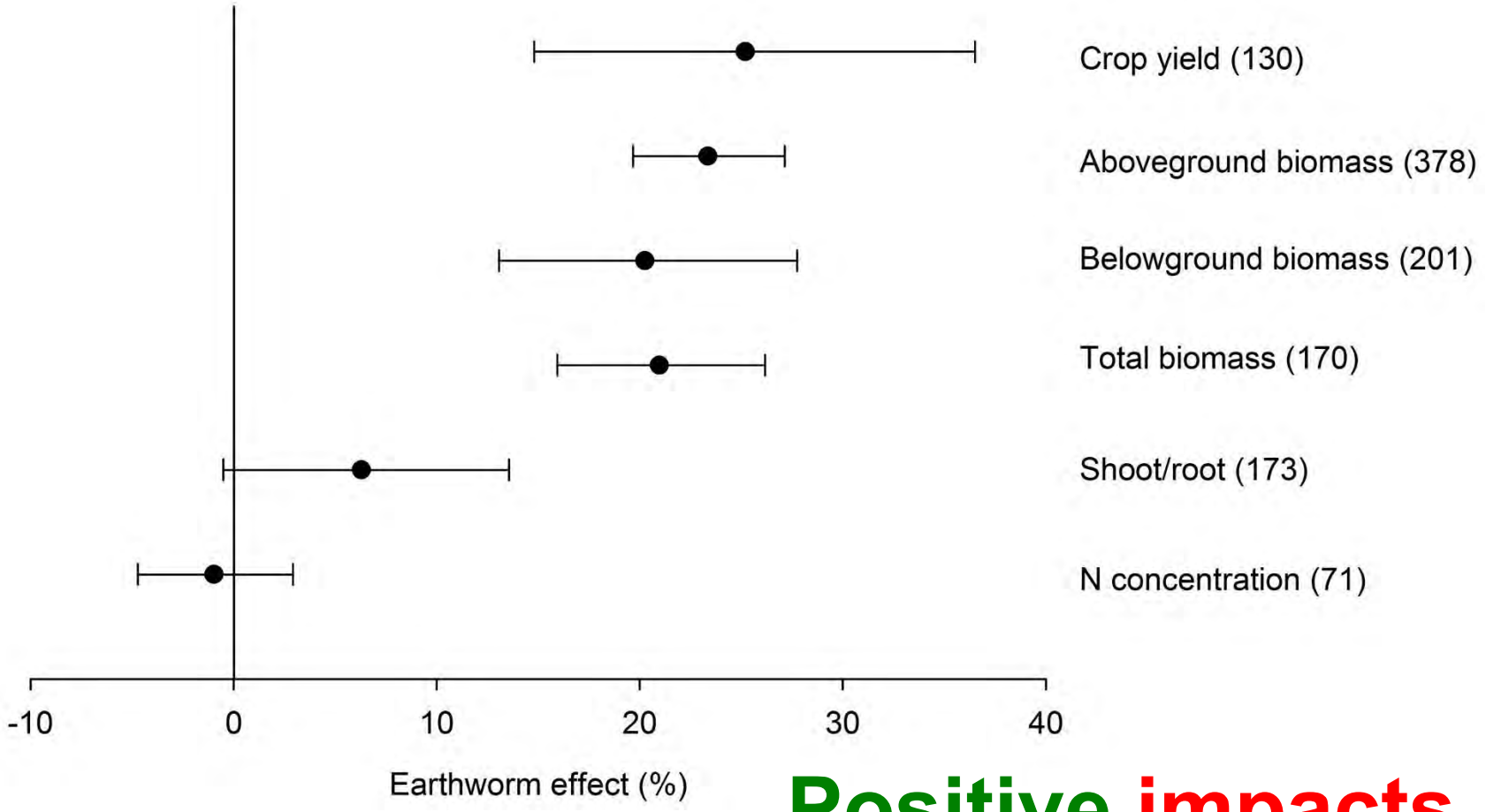
Natural Soil Fertility

Earthworms
(vermi-compost)

Perionyx excavatus and *Eisenia foetida*
at 65:35 ratio

Earthworms' "effects"

A meta-analysis on the effects of earthworm presence on plant biomass



Positive impacts

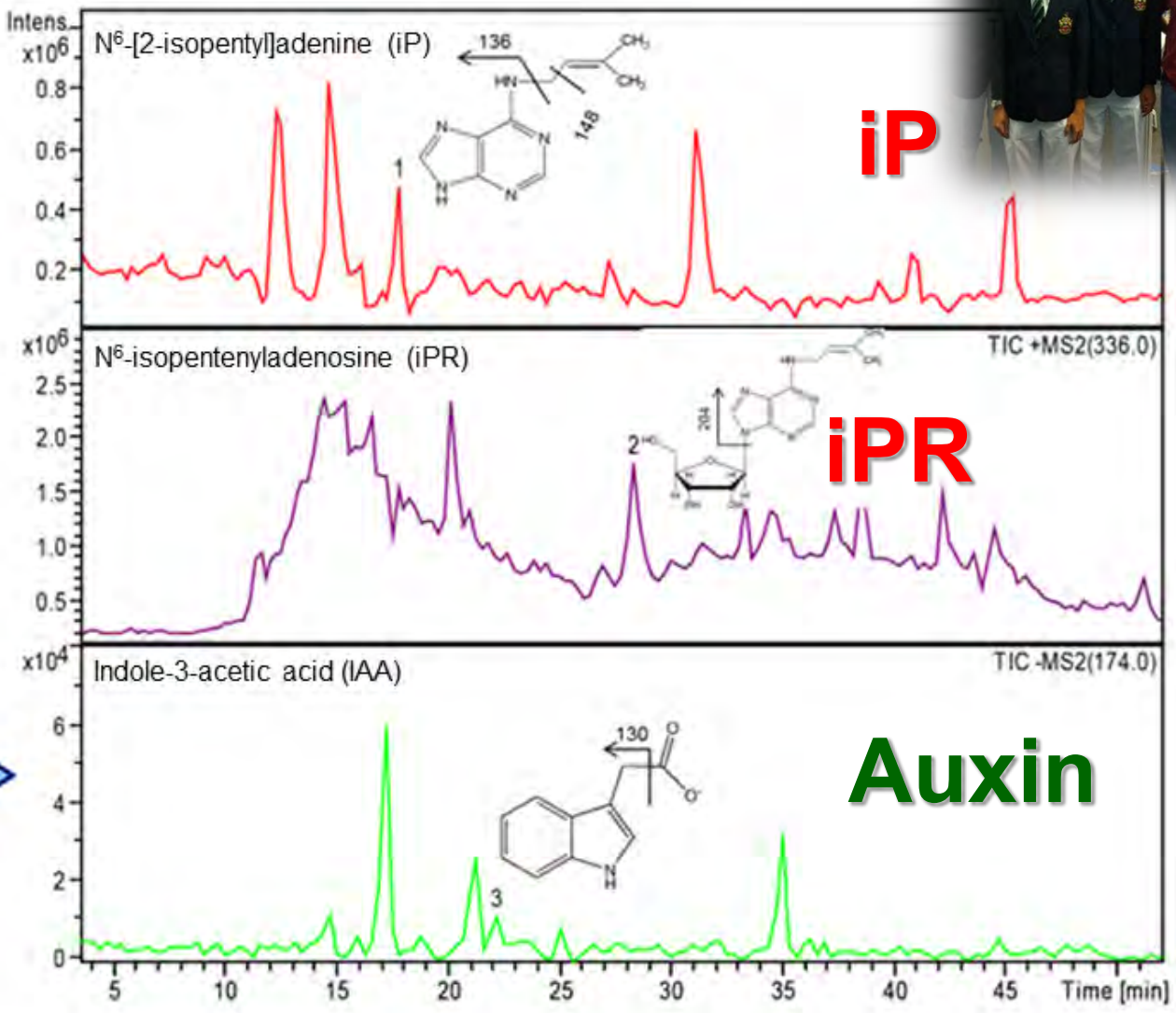
Mechanism(s)?

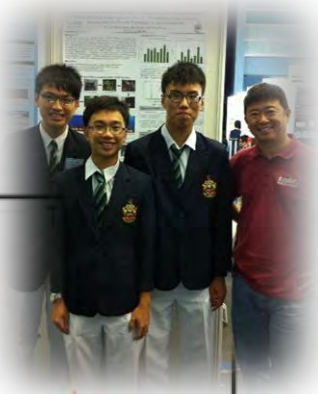
van Groenigen et al. 2016

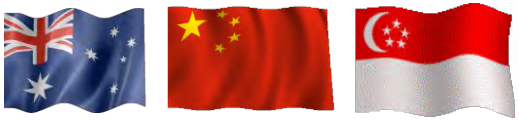
Vermicomposts

1.UAE
2.SPE

LC-MS analysis







UAE - Ultra-Sound Assisted Extraction

Zhang et al. 2015, Talanta

Vermicompost tea – Other Research Groups

Plant Growth Regul (2015) 75:483–492
DOI 10.1007/s10725-014-0011-0

ORIGINAL PAPER

Evidence of phytohormones and phenolic acids variability in garden-waste-derived vermicompost leachate, a well-known plant growth stimulant

Adeyemi O. Aremu · Wendy A. Stirk · Manoj G. Kulkarni · Danuše Tarkowská · Veronika Turečková · Jiří Gruz · Michaela Šubrtová · Aleš Pěnčík · Ondřej Novák · Karel Doležal · Miroslav Strnad · Johannes Van Staden

Received: 7 October 2014 / Accepted: 10 December 2014 / Published online: 18 December 2014

Abstract Cytokinins, auxins, abscisic acid, gibberellins (GAs) and brassinosteroids (BRs) as well as the phenolic acid content in three batches of vermicompost leachate (VCL) were quantified using ultra high performance liquid chromatography–tandem mass spectrometry. N^6-isopentenyladenine formed the major (60 %) proportion of the CK content while dihydrozeatin had the lowest (<0.02 %) concentration. Indole-3-acetic acid ranged from approximately 0.55–0.77 pmol/mL. A total of 18 GAs including bioactive forms and metabolic end products were observed in the VCL samples. Cathasterone had the highest (2,500–3,200 fg/mL) concentration while brassinolide was the lowest (1–5 fg/mL) abundant BRs found. Phenolic acids quantified were protocatechuic acid (3–3.6 μg/mL), *p*-hydroxybenzoic acid (2.5–2.8 μg/mL), *p*-coumaric acid (1–1.7 μg/mL) and ferulic acid (0–4 μg/mL). These results provide an indication of the rich diversity in natural PGRs and phytochemicals in VCL which may inevitably contribute to the numerous favorable physiological responses elicited by VCL application to plants.

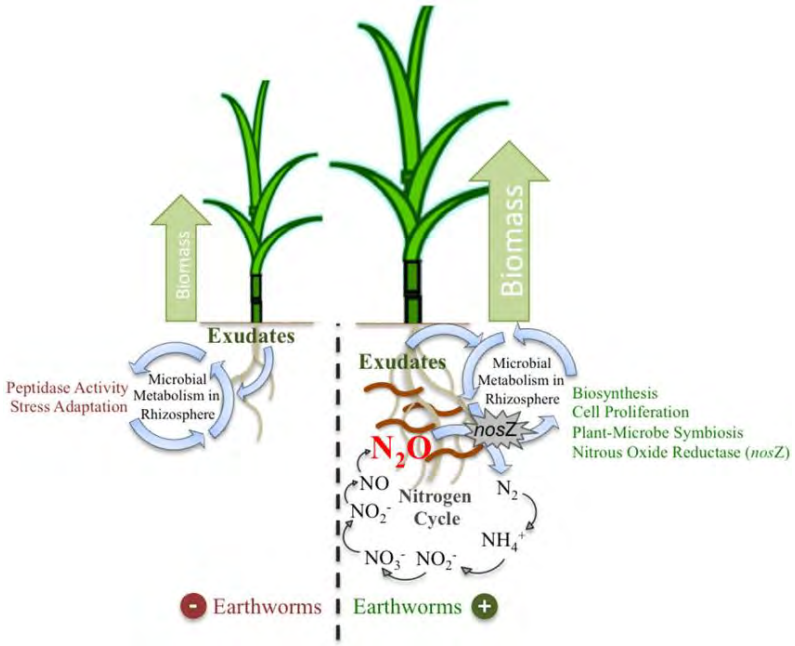
Keywords Abscisic acid · Biostimulant · Brassinosteroids · Cytokinins · Gibberellins · Phenolics

Abbreviations

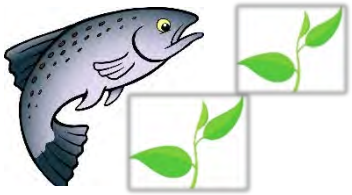
ABA	Abscisic acid
BRs	Brassinosteroids
CKs	Cytokinins
cZ	*cis*-Zeatin
*cZ*9G	*cis*-Zeatin-9-glucoside
*cZO*G	*cis*-Zeatin-*O*-glucoside
*cZ*R	*cis*-Zeatin riboside
*cZ*RMP	*cis*-Zeatin riboside-5′-monophosphate
*cZRO*G	*cis*-Zeatin-*O*-glucoside riboside
DHZ	Dihydrozeatin
DHZ9G	Dihydrozeatin-9-glucoside
DHZ*O*G	Dihydrozeatin-*O*-glucoside
DHZR	Dihydrozeatin riboside
DHZRMP	Dihydrozeatin riboside-5′-monophosphate
DHZR*O*G	Dihydrozeatin-*O*-glucoside riboside
GAs	Gibberellins
IAA	Indole-3-acetic acid
IAC	Immunoaffinity chromatography

In addition to Auxins and Cytokinins

+ Gibberellins
+ Brassinosteroids



Is Fish Waste a GOOD Fertilizer?



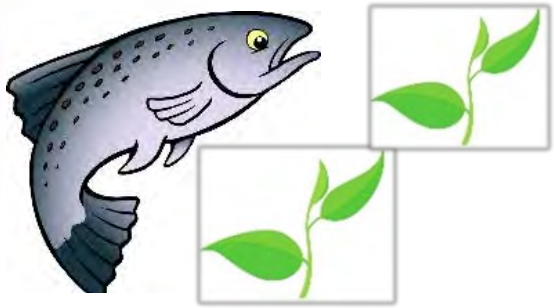
SLU

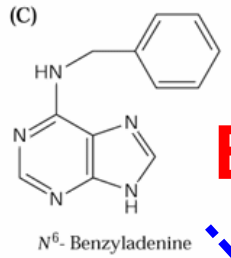
SWECO

Jordbruks verket

The levels of Biostimulants in Fish Sludge as determined by LC-MS/MS

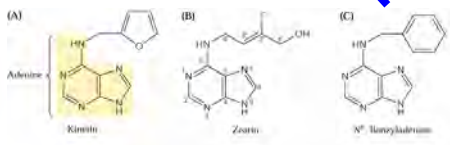
	Biostimulant	Concentration (pmol gDW)	Concentration (pmol gDW) + polymer	
Cytokinins	iPR	105.2 – 138.4	95-120	
	iP	* 26.5 in one sample	21 – 32	
	cis Z	2.4 – 5.9	24 – 27	
	BA	1.8 – 2.3 x 10^6	1.5 – 2.7 x 10^6	
Auxins	IAA	*804 in one sample	2.6 - 8.0 x 10^3	Some effects after adding polymer
	oxIAA	27 – 34 x 10^3	22 – 28 x 10^3	
Salicylic acid	SA	10 – 14 x 10^3	4.6 – 6.6 x 10^3	





N^6- Benzyladenine

BA



n = 4 replicates of fish sludge

Zhang et al. 2015, Talanta, with modifications Tarkowski and Yong (unpublished)

Research Partnership

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Jordbruks verket

SWECO

Is Compost Tea a GOOD Fertilizer?

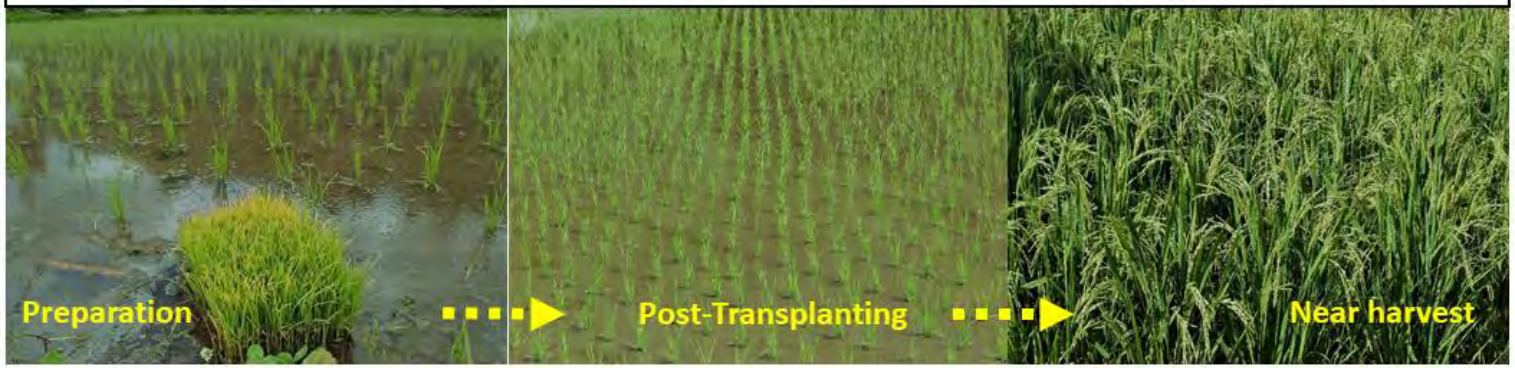
SLU
Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Splendor Plant

LRF LANTBRUKARNAS RIKSFÖRBUND

Growing **Together** Gives **More** Rice & Food

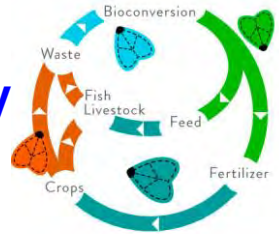
Benefits of Rice – Aquatic Animal Co-cultures	Rice yield increase (%)	Aquatic animal yield (kg/ha)	Weed biomass (kg/ha)	Nitrogen use efficiency (%)	Soil nitrogen and phosphorus (g/kg)
+	9.1	850	↓	–	–
+	12.1	560	↓	↑	–
+	8.7	2660	↓	↑	–



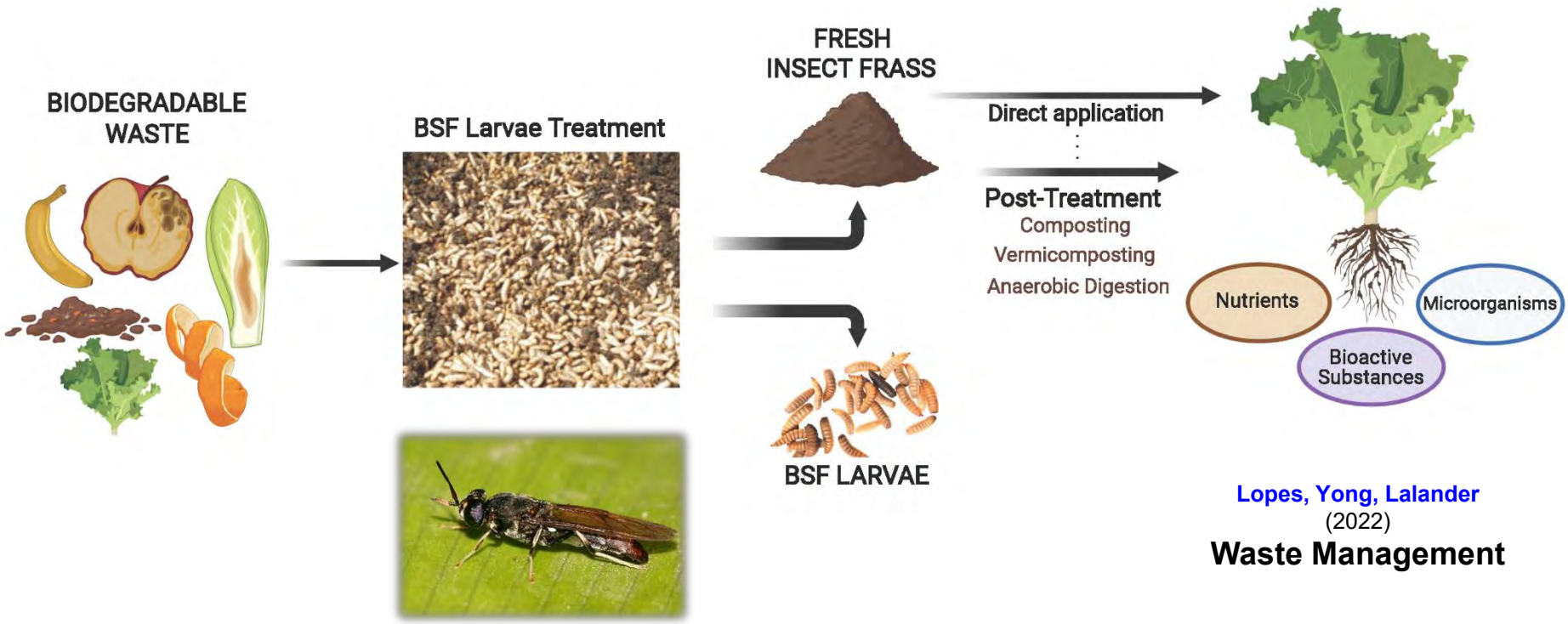
Liu, Caspersen, Yong
(2022)
eLife

Circular Economy

2022



Insect (Black Solider Fly Larvae, BSFL) frass



Lopes, Yong, Lalander
(2022)
Waste Management

Insectta - SG

Ivã Guidini Lopes, Cecilia Lalander


Nils Andersen

CARL TRYGGERS STIFTELSE FÖR VETENSKAPLIG FORSKNING

FORMAS

SLU Sveriges lantbruksuniversitet Swedish University of Agricultural Sciences

Splendor Plant

Insect (Black Solider Fly Larvae, BSFL) frass

Insectta - SG

ORGANIC WASTE

Mineral nutrients - NPK
Bioactive compounds

MICRO-ORGANISMS

Biostimulants

PHYTOHORMONES

Cytokinins Gibberelins
Auxins

HUMIC SUBSTANCES

Humic and Fulvic Acids

PROTEINS AND PEPTIDES

Amino Acids
Peptides Small proteins

Enhancing gas exchange

Resistance to abiotic stress

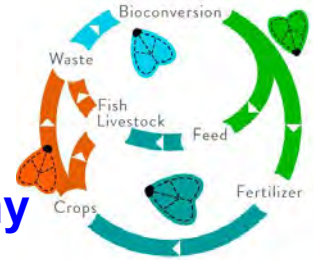
Enhanced growth

Beneficial microorganisms

Enhancing root development

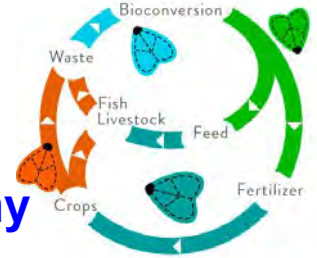
Nutrients uptake

Lopes, Yong, Lalander
(2022)
Waste Management



Circular Economy

Ivã Guidini Lopes, Cecilia Lalander



Circular Economy

The Real World

tebrito
Transforming the future of protein supply

Splendor Plant

LRF LANTBRUKARNAS RIKSFÖRBUND

Jordbruks verket

SWECO

SLU
Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

CARL TRYGGERS STIFTELSE
FÖR VETENSKAPLIG FORSKNING

FORMAS

Emerging market for Biostimulants

Organic Amendments

Quality Control & Natural Product
CONSISTENCY

SNI 6729-2016

NO.	PARAMETER	UNIT	QUALITY STANDARD Based on Permentan No. 70/Permentan/SR.140/10/2011	RESULT
1.	*Azotobacter*	CFU/ml	≥ 10^7	1,32 X 10^7
2.	*Pseudomonas*	CFU/ml	≥ 10^7	1,77 X 10^8
3.	*Lactobacillus*	CFU/ml	≥ 10^7	1,62 X 10^8
4.	*Saccharomyces*	CFU/ml	≥ 10^7	1,20 X 10^8

1.	Nitrogen Fixing Activity	--	Positive	Positive
2.	Pathogenity Test	--	Negative	Negative
3.	pH	--	3,0 – 8,0	7,6
4.	IAA	Mg/L	--	0,79
5.	Gibberelin	Mg/L	--	1,72
6.	Zaetin	Mg/L	--	1,23
7.	Kinetin	Mg/L	--	0,40

1.	*Escherichia coli*	MPN/ml	< 10^3	< 30
2.	*Salmonella sp.*	MPN/ml	< 10^3	< 30

SUMMARY PRODUCT SPECIFICATION

in accordance of Laboratory Tested BALITTANAH BOGOR West Java - Indonesia

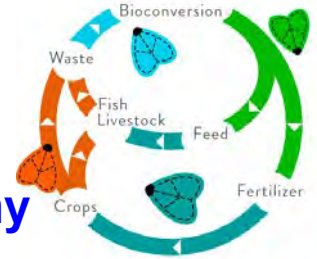
Note :

* The Laboratory Testing by Balai Penelitian Tanah (Balittanah) Bogor, West Java - Indonesia.

Multi-functional Biofertilizer

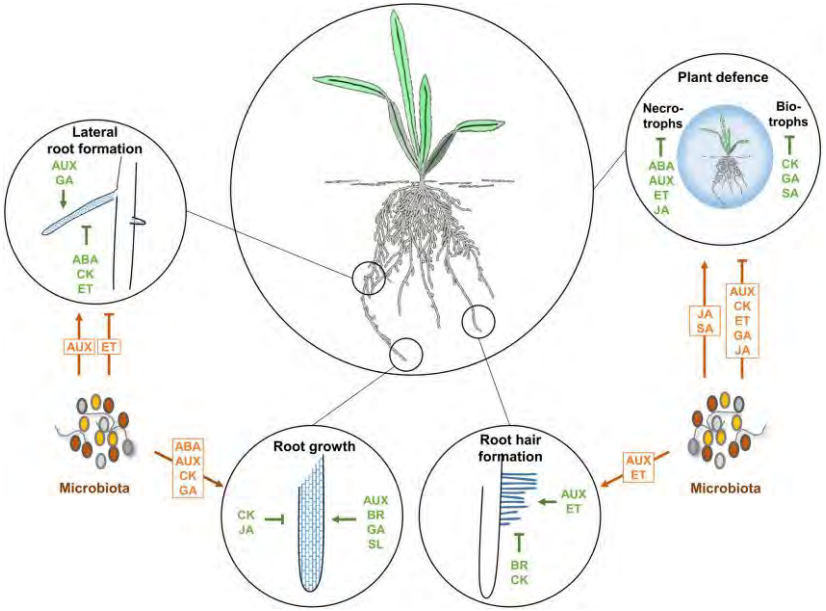
2nd Prize

SEOUL INTERNATIONAL INVENTION FAIR – SIIF 2021, 1-4 DEC 2021



Circular Economy

Summary



SLU
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Swedish University of Agricultural Sciences

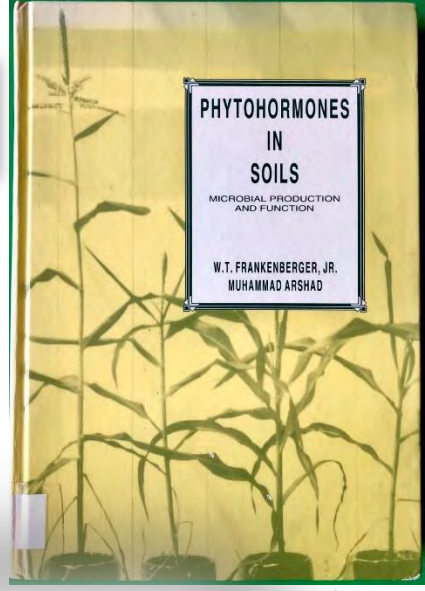
Eichmann et al. 2021

Good to know

Coconuts = Earthworms = Birch sap

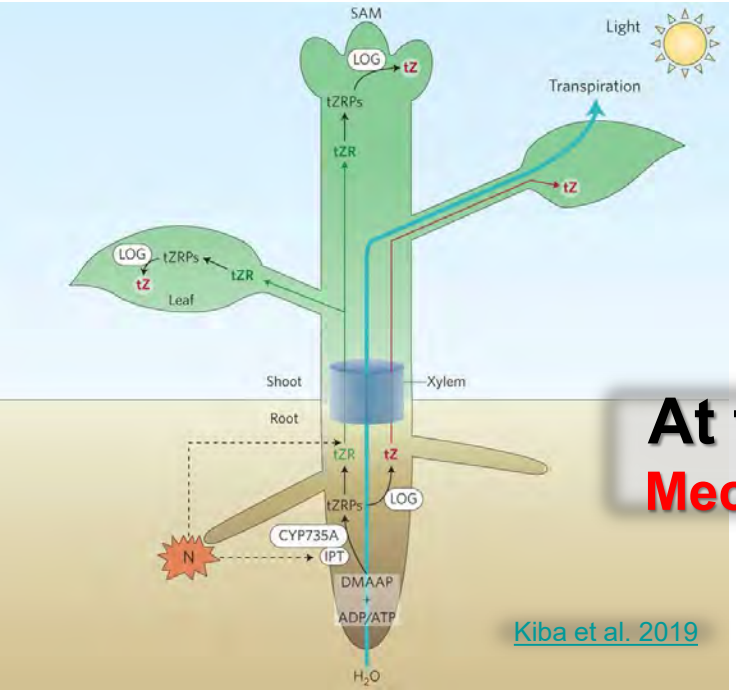
Kokosnötter = Daggmaskar = Björksav

At the Field
Applications



How to increase **Phytohormones** in **Soils**?

Soils
Microbes

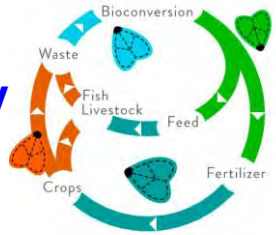


Kiba et al. 2019

At the Lab
Mechanisms

Soils
Organic
Amendments

Circular Economy



Biostimulant(s) signals influencing plant growth

"Biostimulants"

(Microbe) Root-to-Shoot signalling

Wong et al. (2020) Wiley

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New paradigm for Plant Nutrition

Plant growth

Cell Proliferation

Building blocks for cellular machinery, DNA, cell walls, etc.

Mineral nutrients e.g. N, P, K, trace elements

Active Cell Division and Growth

Drives cell cycle

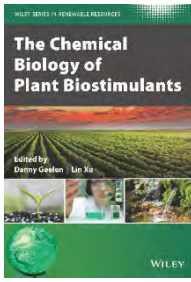
Fertilizers (organic/chemical)

Phytohormones

Signalling

Microorganisms e.g. bacteria, fungi

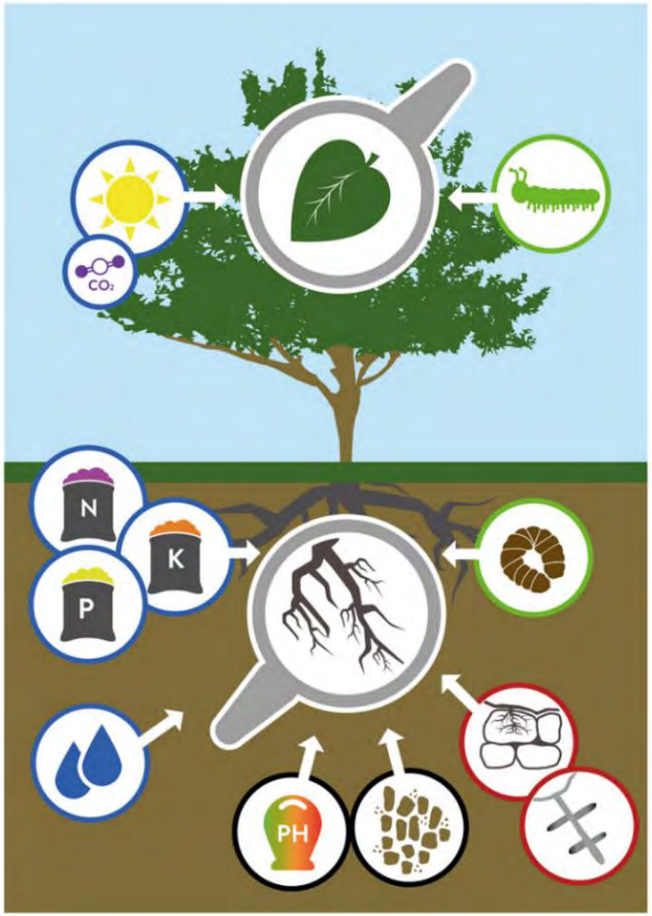
"Biostimulants"



Wong et al. (2020) Wiley
Wong et al. (2015) Springer
Wong et al. (2016) Acta Horticulturae

What is a GOOD BioFertilizer?
What is a HEALTHY Soil?

- Contains suitable mineral nutrients **(NPK)**
  (Macro - NPK & micro-nutrients as the building blocks)
- Contains natural **growth promoting substances (Biostimulants)**
- Improving **soil structure** & holds **water**
- Reduced incidence of plant diseases



“The true voyage of discovery lies not in finding new landscapes, but in having new eyes.”

- Marcel Proust

Thank You!

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