



“Making agriculture more sustainable: a climate and energy perspective”



Michel Haring, Plant Physiology, Universiteit van Amsterdam



November 11, 2024

Institute for Advanced Study (IAS)

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- 
- Modern Agriculture
 - Fertilizers: energy consumption and climate change
 - Microbiome
 - Climate change and pests
 - Crop-protection

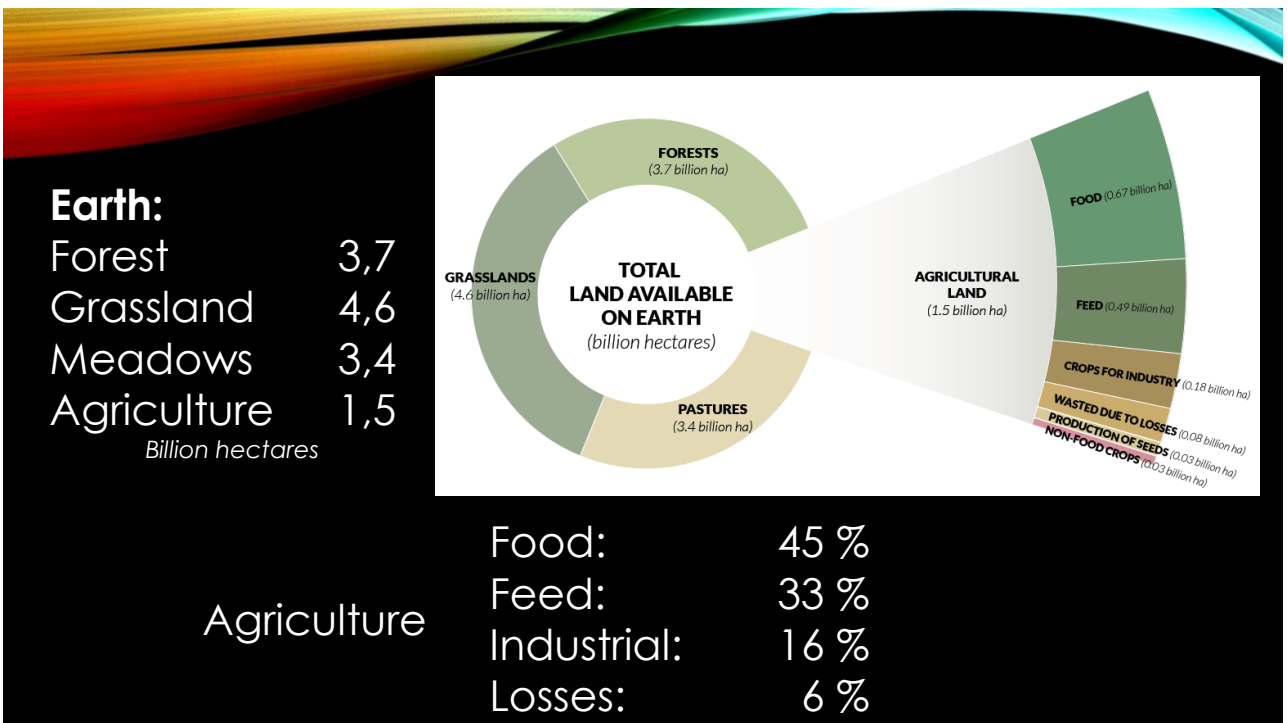


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Background

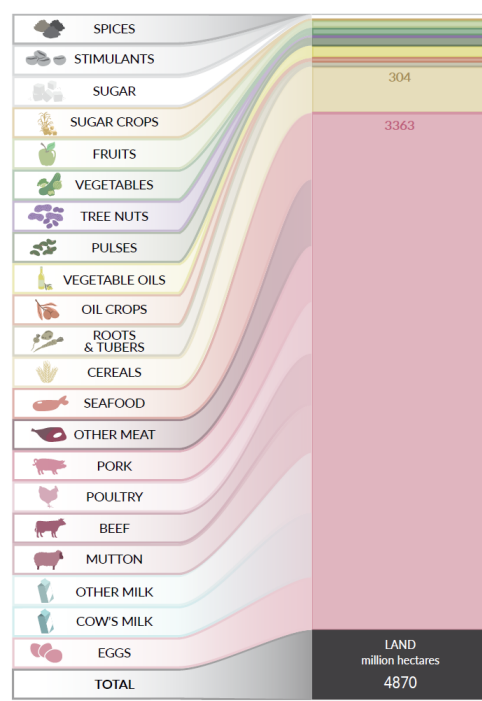
WWF Netherlands
AUTHORS: Eva Gladek, Matthew Fraser, Gerard Roemers, Oscar Sabag Munoz, Peter Hirsch, Erin Kennedy,

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69% off all arable land is being used for the production of **meat, seafood, milk and eggs**

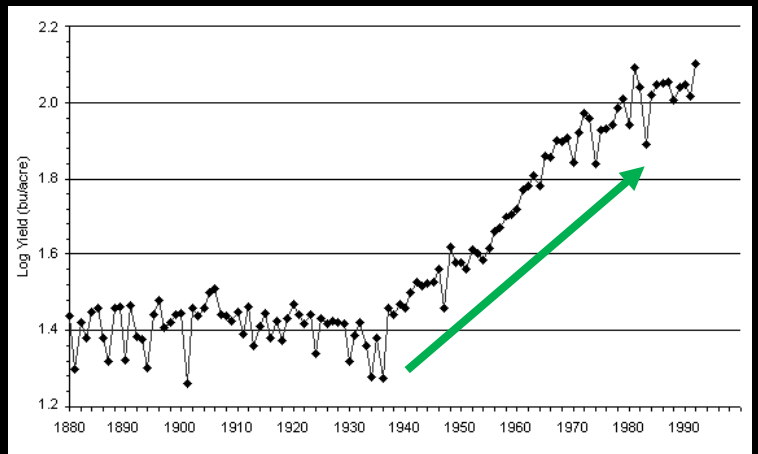


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Green Revolution:

- Chemical fertilizer
- Crop protection
 - Herbicides
 - Pesticides
 - Fungicides
- Monocultures
- Mechanisation
- Plant Breeding

Yield Maize (USA) 1880-2000



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Green Revolution:

- Plant Breeding
- Domestication
- Adaptation
- Commercial**

There are **250,000** to **300,000** edible plant species

150 to 200 are used for food

12 of these edible plant species provide 75% of the world's food

Only **3** contribute 60% of the calories and proteins obtained by humans from edible plant species

Wheat
Maize
Rice

TOP 5 MOST PRODUCED CROPS

Crop	1st Producer	2nd Producer	3rd Producer	4th Producer	5th Producer	
1 SUGARCANE	BR	MO	IN	TH	PH	
	732,895,389	405,416,180	323,002,172	109,943,447	66,888,011	
	2 MAIZE (CORN)	US	BR	IN	PH	TH
		347,847,570	146,957,662	101,136,617	58,801,704	35,888,050
		3 RICE	IN	TH	PH	BR
214,461,231			146,957,662	101,136,617	58,801,704	35,888,050
4 WHEAT			US	FR	IN	TH
	146,957,662		101,136,617	58,801,704	35,888,050	21,446,123
	5 POTATOES		FR	US	IN	TH
		91,881,997	58,801,704	35,888,050	21,446,123	14,695,766

The wild ancestor

Timeline: 7000 years (Tehuacana, America) → 1494 (First corns, Mexico) → 1494 (Populations, South of Europe Introduction) → 1947 (Hybrids, First creation of hybrids in France)

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Seed Industry Structure 1996 - 2013

Legend: Seed Companies (blue), Chemical Companies (red), Other Companies (green). Lines indicate Full Ownership (solid) and Partial Ownership (dashed).

Highly concentrated seed market

Company	Market Share (%)
Other companies	24.7
Monsanto	26
DuPont	18.2
Pioneer	18.2
Syngenta	9.2
Vilmorin	4.8
WinField	3.9
KWS	3.6
Bayer	3.1
Dow Agro-Sciences	3.1
Sakata	1.6
Takii	1.6


Source: ETC Group (2013)

Seed Companies Market Share (2021)

Company	Market Share (%)
Bayer	16.9%
Corteva Agriscience	13.3%
Syngenta	5.6%
BASF	4.7%

Chemical industry key player in seed market

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Pros:

- ⬆ Bigger Harvest
- ⬆ Cheap production


MONOCULTURE FARMING

Cons:

- ⬇ Environmental damage
- ⬇ Spread of diseases

Effect of the Green Revolution:

Monocultures, mechanisation and large scale input of chemicals




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Crop protection

(3,9 billion ton/yr)

- 27 % Orchards
- 27 % Cereals
- 9 % Vegetables
- 9 % Potatoes
- 9 % Rapeseed, Oilpalm
- 9 % Cotton
-



Green Revolution

Fertilizer

(200 billion ton/yr)

- 71% Cereals
- 15 % Feed
- 5 % Rapeseed, Oilpalm

Water-usage

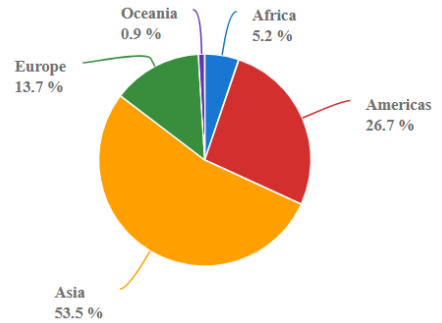
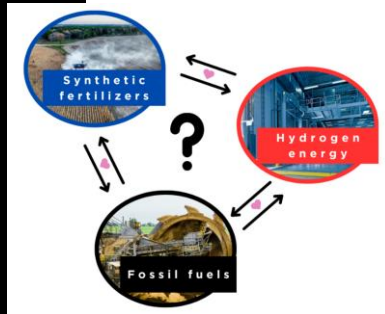
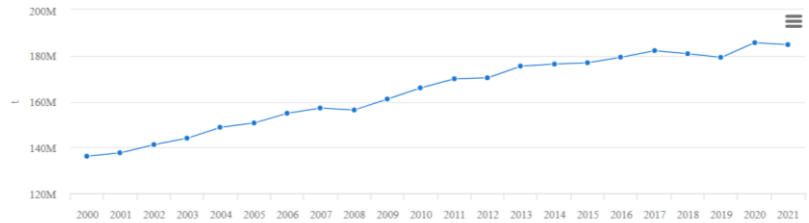
69 % Agriculture

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Chemical Fertilizer
input increased
by 28% over the
past 20 years

Cropland nitrogen by Input + (Total)

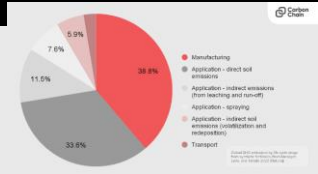
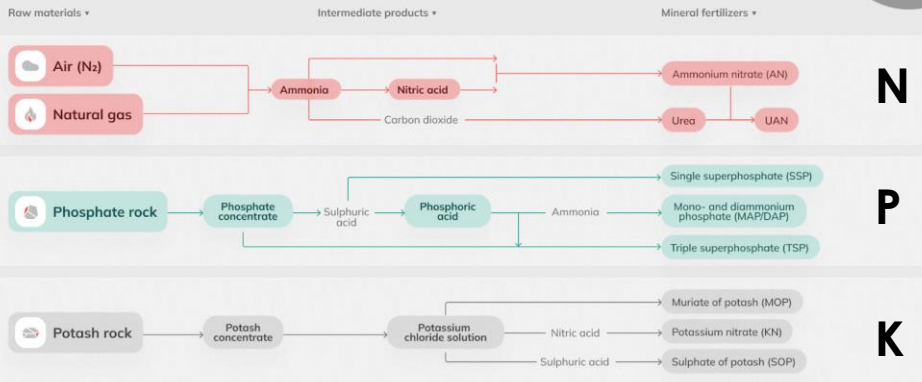
2000 - 2021



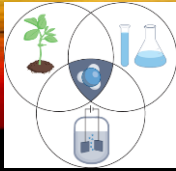
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Fertilizer production consumes approximately **2% of the world's energy** and is responsible for approximately **1.8% of the total emission of the greenhouse gases** in the world

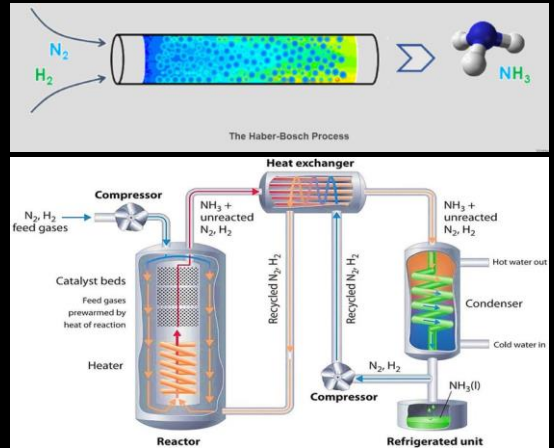
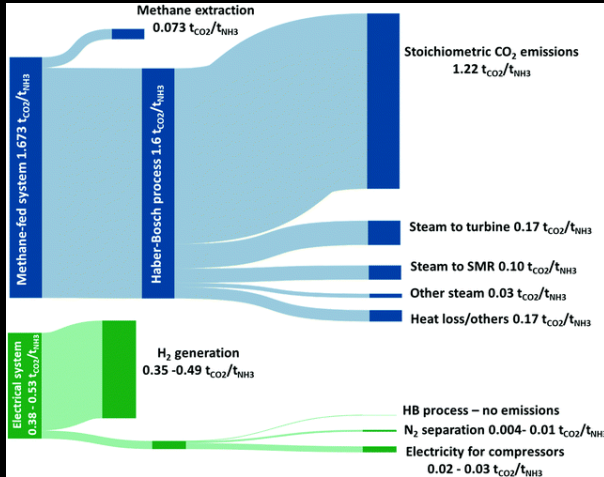
Production of main fertilizers products



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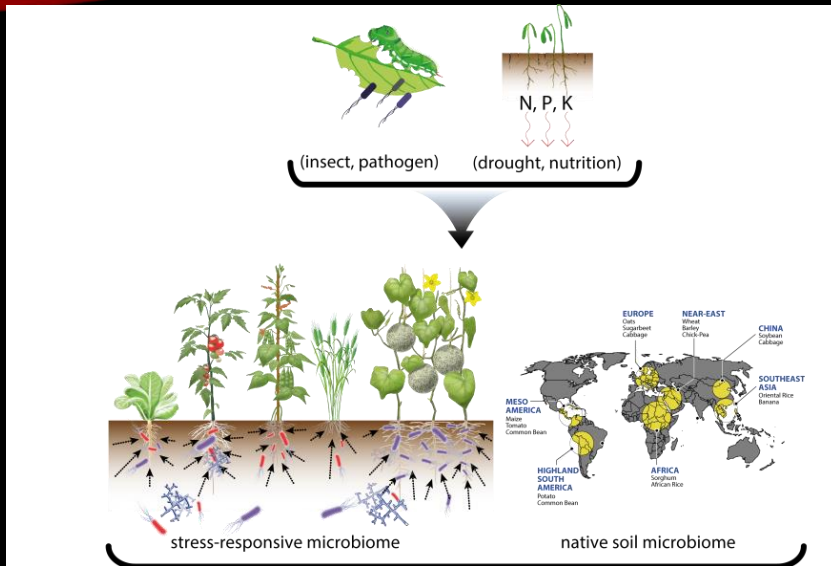


Fertilizer production: Ammonia generated from N₂ and H₂ is energy consuming



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Soil microbiome: Make nutrient acquisition by crops more efficient



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nature reviews microbiology <https://doi.org/10.1038/s41579-024-01079-1>

Review article Check for updates

Harnessing the plant microbiome for sustainable crop production

Microbial communities improve plant performance without extra fertilizers

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Influencing factors

- Agro-management**
Farming practices
- Abiotic environment**
Climate, pH, temperature, soil properties, water content
- Target plant**
Genotyping, physiology, immune response, secondary metabolism, root exudates
- Biotic environment**
Resident microbiome, pathogens, pests, soil fauna, weeds

Intra-/interspecies communication

Improving plant nutrition


- Mobilization**
Siderophores, enzymatic activities, P, K, Fe, micronutrients
- N₂ fixation**
- Enhanced uptake**
e.g. through activation of plant transporters

Microbial processes to improve plant performance

UNIVERSITY OF AMSTERDAM RPA - SYSTEMS BIOLOGY

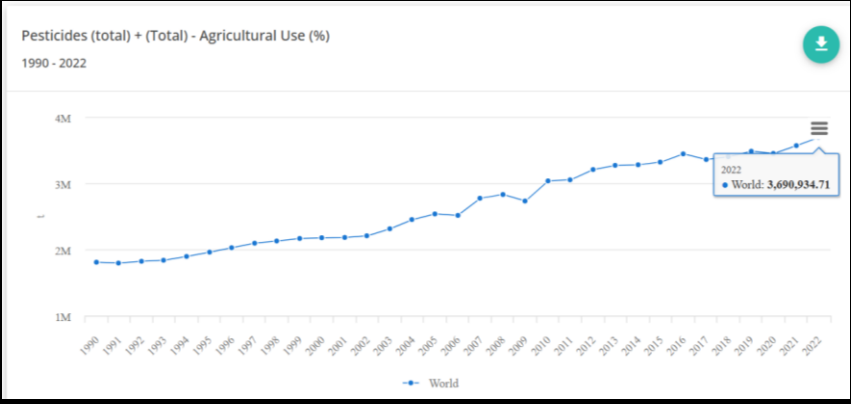
Microbial Imprinting for Crop Resilience (MiCRop)

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1990 till 2022 Increase use pesticides

Pesticides (total) + (Total) - Agricultural Use (%)
1990 - 2022



Year	World Pesticide Use (Millions)
1990	1.8
1991	1.8
1992	1.8
1993	1.8
1994	1.9
1995	1.9
1996	2.0
1997	2.1
1998	2.1
1999	2.2
2000	2.2
2001	2.2
2002	2.3
2003	2.4
2004	2.5
2005	2.6
2006	2.6
2007	2.8
2008	2.8
2009	2.7
2010	3.0
2011	3.1
2012	3.2
2013	3.3
2014	3.3
2015	3.3
2016	3.4
2017	3.4
2018	3.4
2019	3.4
2020	3.5
2021	3.5
2022	3.69093471

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The effect of genetically modified soybean: Roundup Ready



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GREENPEACE The challenges we face Take action Email sign up

Industrial soybean cultivation in the Amazon area: Climate change

Soya

Soya beans are an excellent source of protein and an important part of many people's diets. The agricultural industry has also become reliant on these beans for animal feed. But the drive to produce greater amounts of cheap meat and dairy is accelerating climate change and destroying forests.

Like palm oil, the global food industry has become utterly reliant on soya. The size of the global meat and dairy industry has exploded and soya production has vastly increased to meet it.

Most soya comes from the Americas and nearly half from just two countries, Brazil and Argentina. Growth of the soya industry has been meteoric – production in Brazil has quadrupled in just 20 years. The UK imports huge quantities of soya and globally some 90% of soya is used to feed animals, including cows, pigs and chickens.

The challenges we face

- Air Pollution
- Air Travel
- Arctic

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Tree cover loss 2001 - 2012

globalforestwatch.org/map/country/BRA/map=eyJZWSZkXl0nsibG0jotM1cuOTUzMTkxNTZlNTUyMTc0L2sbmco0i01M42MzE3MzQ3NTQ3MzA4MjY5L299j0zjC5MDQ3NDMwMDM3OTc0ODI0ImlmNhhkVndW5kIjpmYWZ2SwZGF0YXNldHMOIR7imR...

GLOBAL FOREST WATCH

LEGEND ANALYSIS

- Tree cover gain - 2000-2020
- Tree cover gain
- Tree cover loss - 2001-2023
- Tree cover loss
- Displaying Tree cover loss with canopy density > 30%
- Tree cover - 2010
- Tree cover
- Displaying Tree cover with canopy density > 30%
- Displaying Tree cover for: 2010
- PLANET SATELLITE IMAGERY (TROPICS)

South Atlantic Ocean

Tree cover loss 2001 - 2012

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Tree cover loss 2012 - 2024



Tree cover loss 2012 - 2024

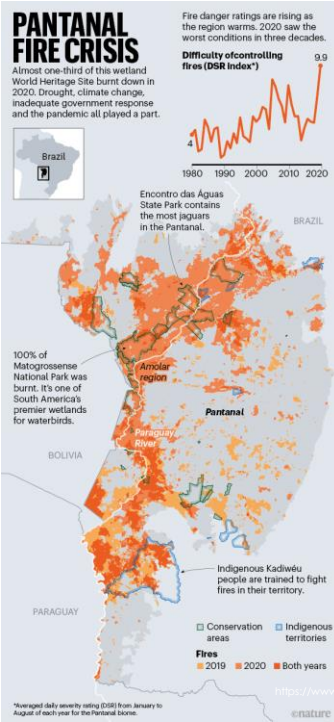
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Tree cover loss 2001 - 2024



Tree cover loss 2001 - 2024

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- Industrial soybean cultivation in the Amazon area: Climate change

BdF

Opinião Política Direitos Humanos Cultura Geral Saúde Internacional Especiais

Agribusiness, cattle and dams: find out the causes of the drought and fires devastating the Pantanal biome

The biome, also known as 'Brazilian wetlands,' is facing a lack of water and a record number of fires

Vinicius Konchinski
Translated by: Ana Paula Rocha

Brasil de Fato | Curitiba (Paraná state) | 19 de julho de 2024 às 11:54

[Leia em português](#)

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https://www.wnf.nl/custom/LPR_2016_fullreport/

THE STORY OF SOY

3. worldwide demand threatens the Cerrado

High in protein and energy, soy is a key part of the global food supply. Mainly used as animal feed, soy has become one of the world's biggest crops due to rising demand worldwide for meat products. But the growth has come at a cost. Vast areas of forest, savannah and grassland have been cleared over the last few decades as soy production has expanded. In total, the area of land in South America devoted to soy grew from 17 million hectares in 1990 to 47 million hectares in 2016, mainly on land converted from natural ecosystems. And forests and other natural ecosystems are coming under ever greater pressure as production and demand continues to grow. Soy production is expected to increase rapidly as economic development leads to higher animal protein consumption, especially in developing and emerging countries. Today's main and fastest growing soy exporter is China, for animal feed and cooking oil. China's meat consumption is rapidly increasing, and perspectives indicate a steady steep long-term increase of soy imports which is likely to increase pressure on the Cerrado, the Amazon, the Páramo and other threatened ecosystems.

(source: WWF-Brazil; WWF, 2014)



Dramatic effect of Gentech Soy: deforestation and monocultures for animal industry of EU

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Climate change allows pest to colonize new niches in agriculture, forestry and ecosystems



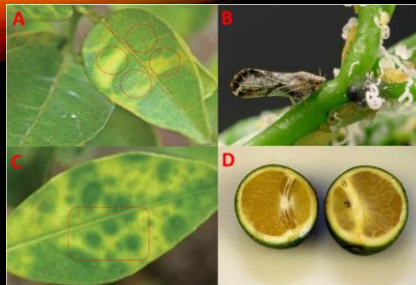
Food and Agriculture Organization of the United Nations

International Plant Protection Convention

Scientific review of the impact of climate change on plant pests

A global challenge to prevent and mitigate plant pest risks in agriculture, forestry and ecosystems

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equinox CITRUS GREENING DISEASE

CAUSE, DISTRIBUTION, PREVENTION AND POSSIBLE CURE: AN INFOGRAPHIC

HLB is caused by bacteria spread via insect vectors

1. Yellow shoot appears. Huanglong means yellow shoot in Chinese.
 2. Leaves start to appear a mottled yellow until entire canopy turns yellow.
 3. Fruits begin to grow smaller and in irregular shapes.
 4. Foliage becomes sparse.
 5. Twig 'dies back'.

1943 the disease was first reported in China

60 MILLION trees were destroyed by the disease by the 1990's

90% of Florida's citrus trees are infected

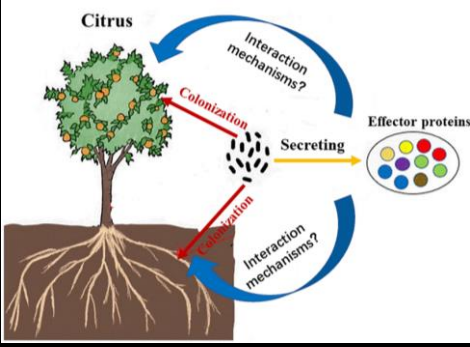
Climate change allows pest to migrate and survive in other ecosystems.

Example of citrus greening disease

BASIC SOLUTIONS

- Crop protection agents help to stem the spread of the psyllids.
- The psyllid's natural enemy *Tamarixia radiata* parasitizes psyllid nymphs.
- Anti-bacterial solutions may be able to selectively combat the bacteria in the long term. This may also make it possible to cure infected plants.

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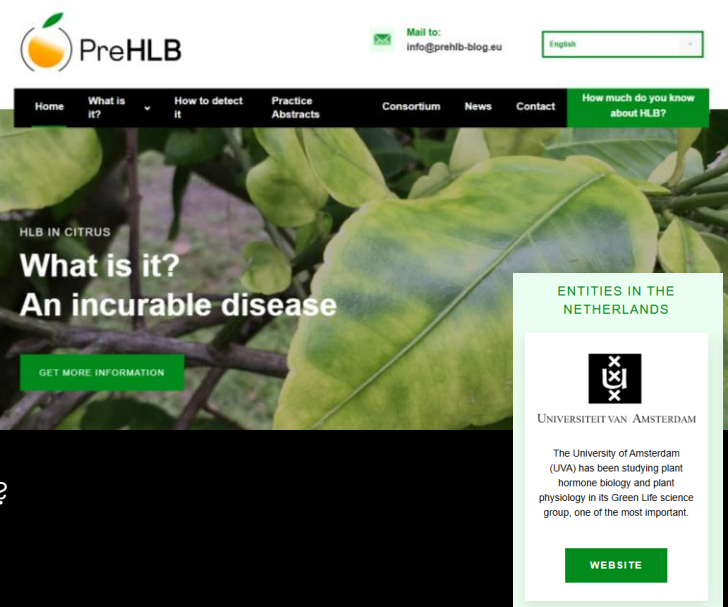
Citrus

Colonization

Secreting

Effector proteins

Interaction mechanisms?



PreHLB

Home What is it? How to detect it Practice Abstracts Consortium News Contact

How much do you know about HLB?

HLB IN CITRUS

What is it?
An incurable disease

GET MORE INFORMATION

ENTITIES IN THE NETHERLANDS

UNIVERSITEIT VAN AMSTERDAM

The University of Amsterdam (UVA) has been studying plant hormone biology and plant physiology in its Green Life science group, one of the most important.

WEBSITE

How to mitigate risks of new pests?

- Resistant cultivars
- Protective microbiome

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System "lock-ins"

- Concentration Power
- Short term policies
- Cheap food
- Export oriented
- Measures of success
- No integration
- "Fake Science"

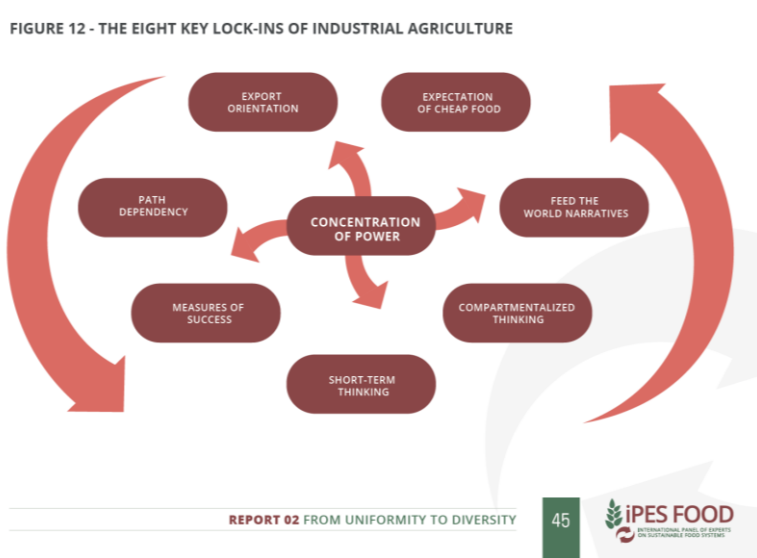


FIGURE 12 - THE EIGHT KEY LOCK-INS OF INDUSTRIAL AGRICULTURE

EXPORT ORIENTATION

EXPECTATION OF CHEAP FOOD

FEED THE WORLD NARRATIVES

COMPARTMENTALIZED THINKING

SHORT-TERM THINKING

MEASURES OF SUCCESS

PATH DEPENDENCY

CONCENTRATION OF POWER

REPORT 02 FROM UNIFORMITY TO DIVERSITY

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iPES FOOD

INTERNATIONAL PANEL OF EXPERTS ON SUSTAINABLE FOOD SYSTEMS

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Swammerdam Institute for Life Sciences