Research Institute of Organic Agriculture FiBL
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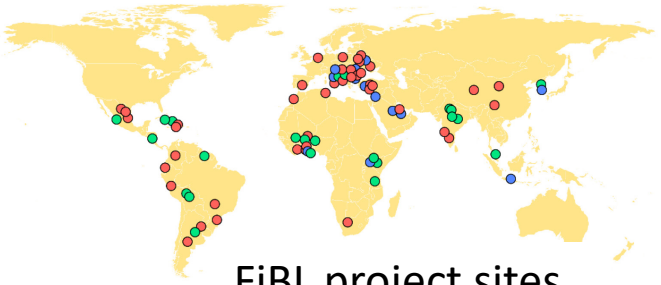


FiBL project sites

Plant protection in agroecological farming systems

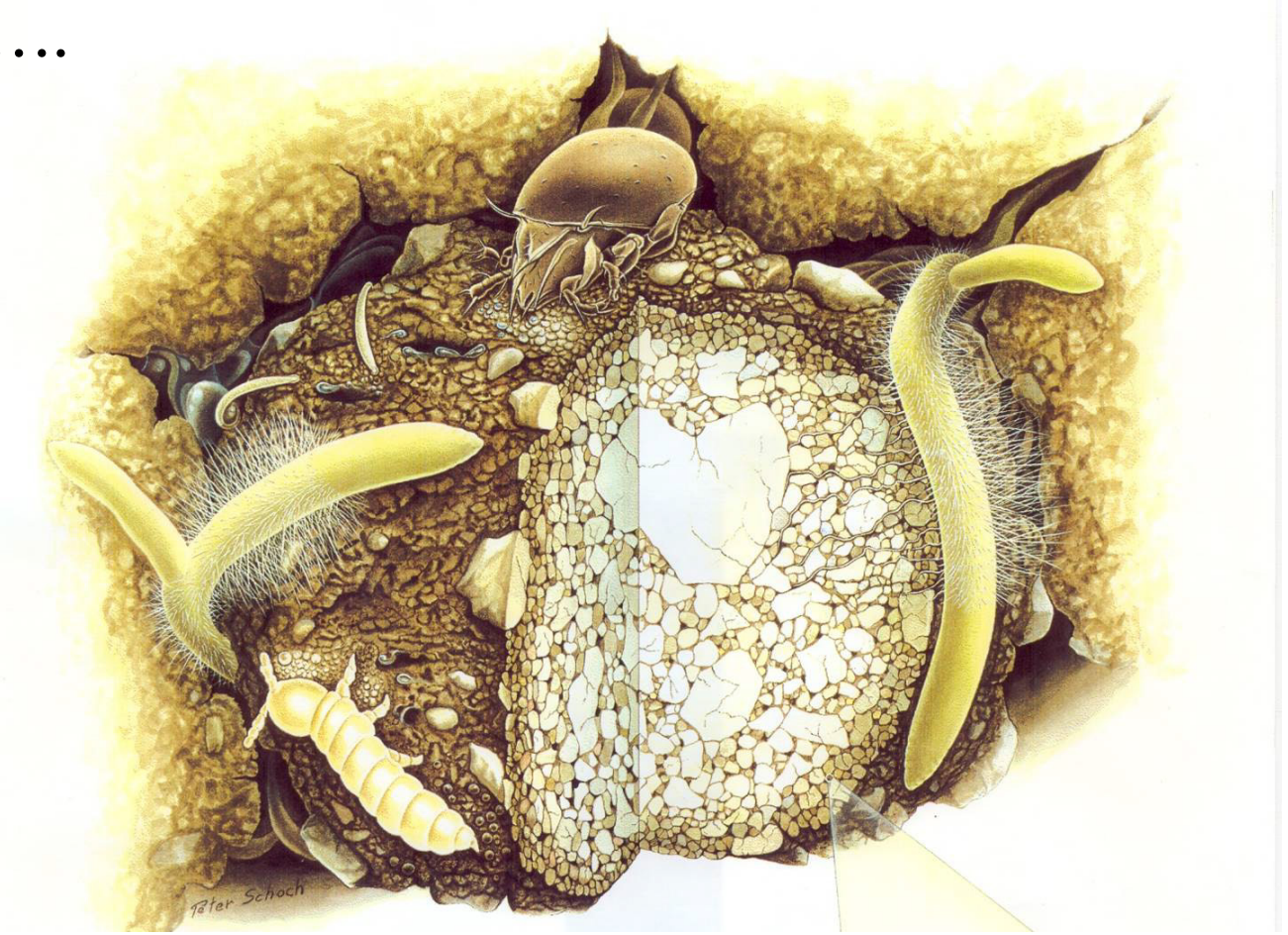
Urs Niggli

FiBL institutes

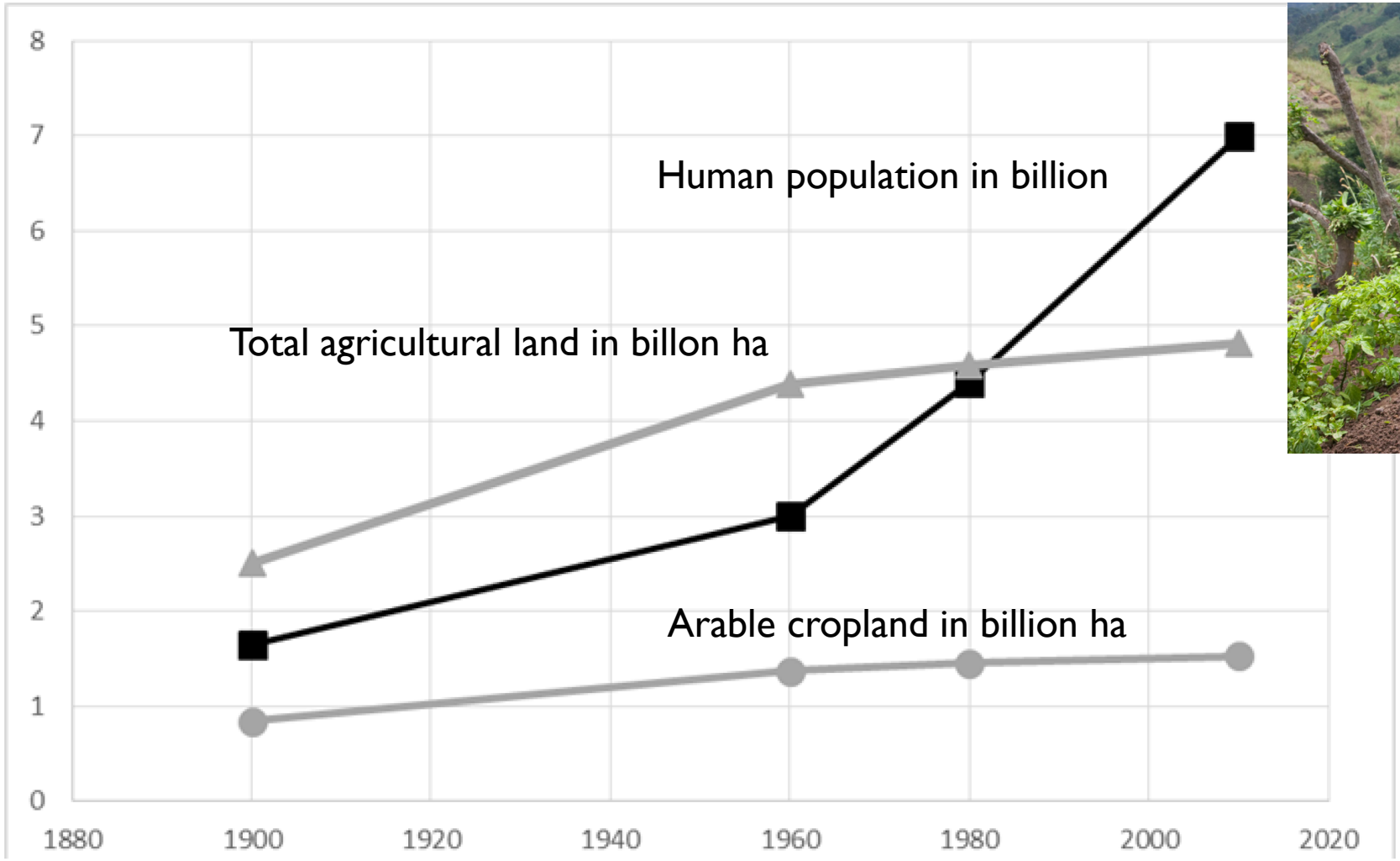
7. Agrocope Nachhaltigkeitstagung, 23. Januar 2020

About

- Business as usual is not an option ….
- … sustainable food supply.
- What do consumers want?
- Plant protection in agroecological farming systems.
- Implications für research activities.
- Conclusions.

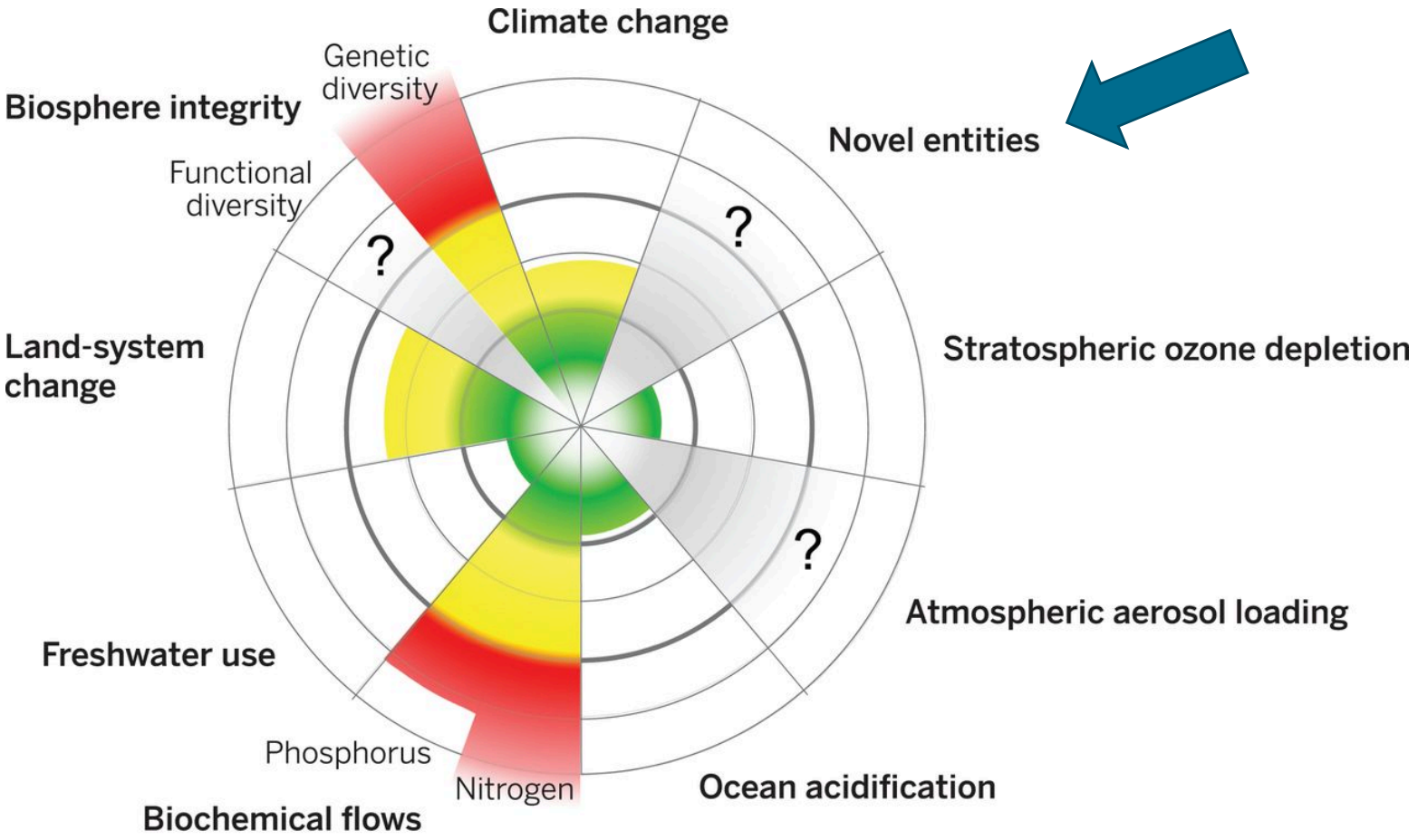


The “success” story of conventional agriculture: Decoupling of population growth from the natural resource soil



… and increased both livestock production and food wastage

Consequences: exceeding the carrying capacity of the planet?



Beyond zone of uncertainty (high risk)
In zone of uncertainty (increasing risk)
Below boundary (safe)
Boundary not yet quantified

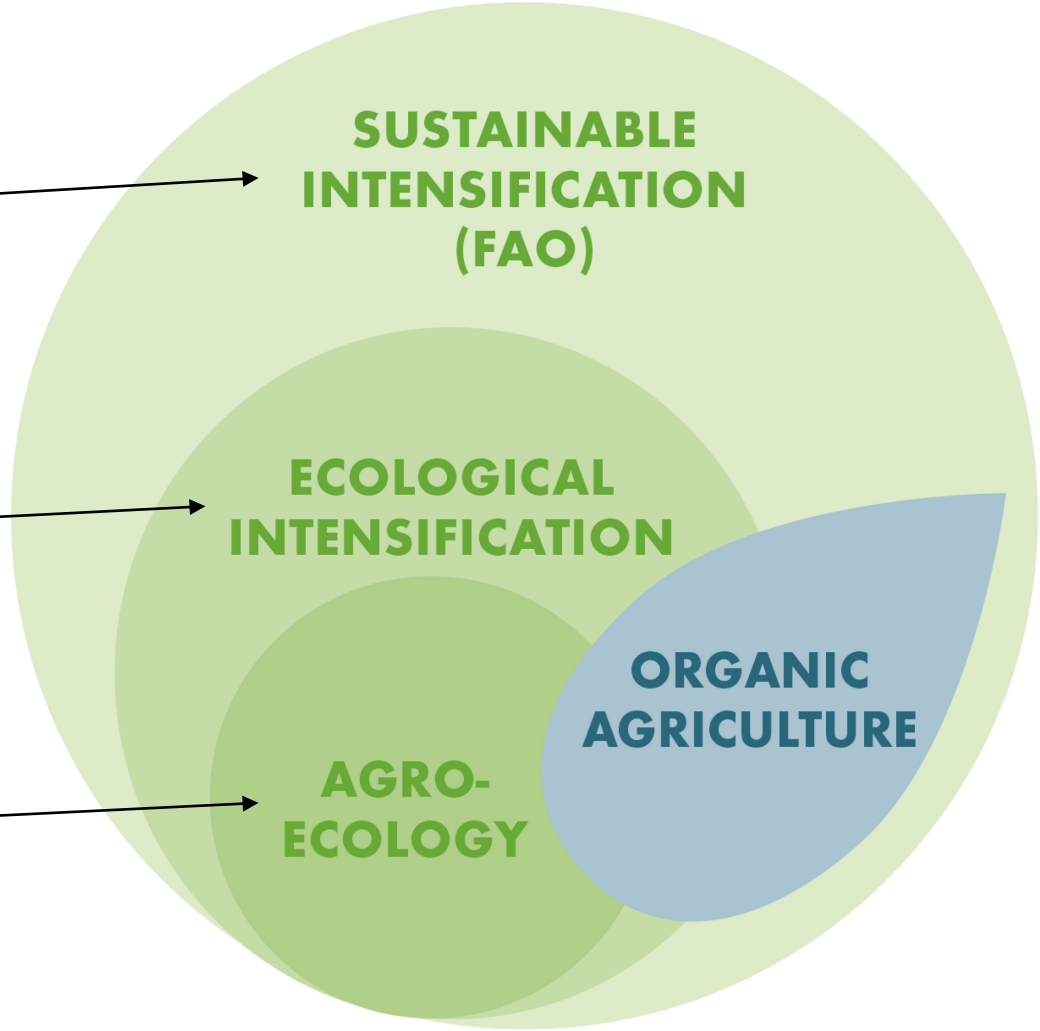
Will Steffen et al: *Planetary boundaries: Guiding human development on a changing planet.* In: Science. (2015), doi:10.1126/science.1259855.

Solution: A paradigm shift towards making food production more sustainable

Less polluting inputs
Less inefficiency
("more from less")

More production with improved ecosystem services (soil fertility, diversity etc.)

Consequent system approach incl. social community integration



Circles:

- The greener the lower the ecological footprint
- The bigger the more yield

Niggli et al., 2020 (submitted)

Different approaches to sustainability

Improved technologies like minimum/ no tillage or GMO crops.

Integrated Production (IP, IPM).

Low Input Agriculture (LIA) or Precision Farming.

Low External Input Sustainable Agriculture (LEISA).

Organic Farming.

Organic Farming & reduced tillage.

Organic (successional) agroforestry systems.

Ecological or eco-functional intensification

"While sustainable intensification is generally loosely defined, so that almost any model or technology can be labeled under it, ecological intensification proposes landscape approaches that make smart use of the natural functionalities that ecosystems offer. The aim is to design multifunctional agroecosystems that are both sustained by nature and sustainable in their nature."
(Tittonell, 2014)

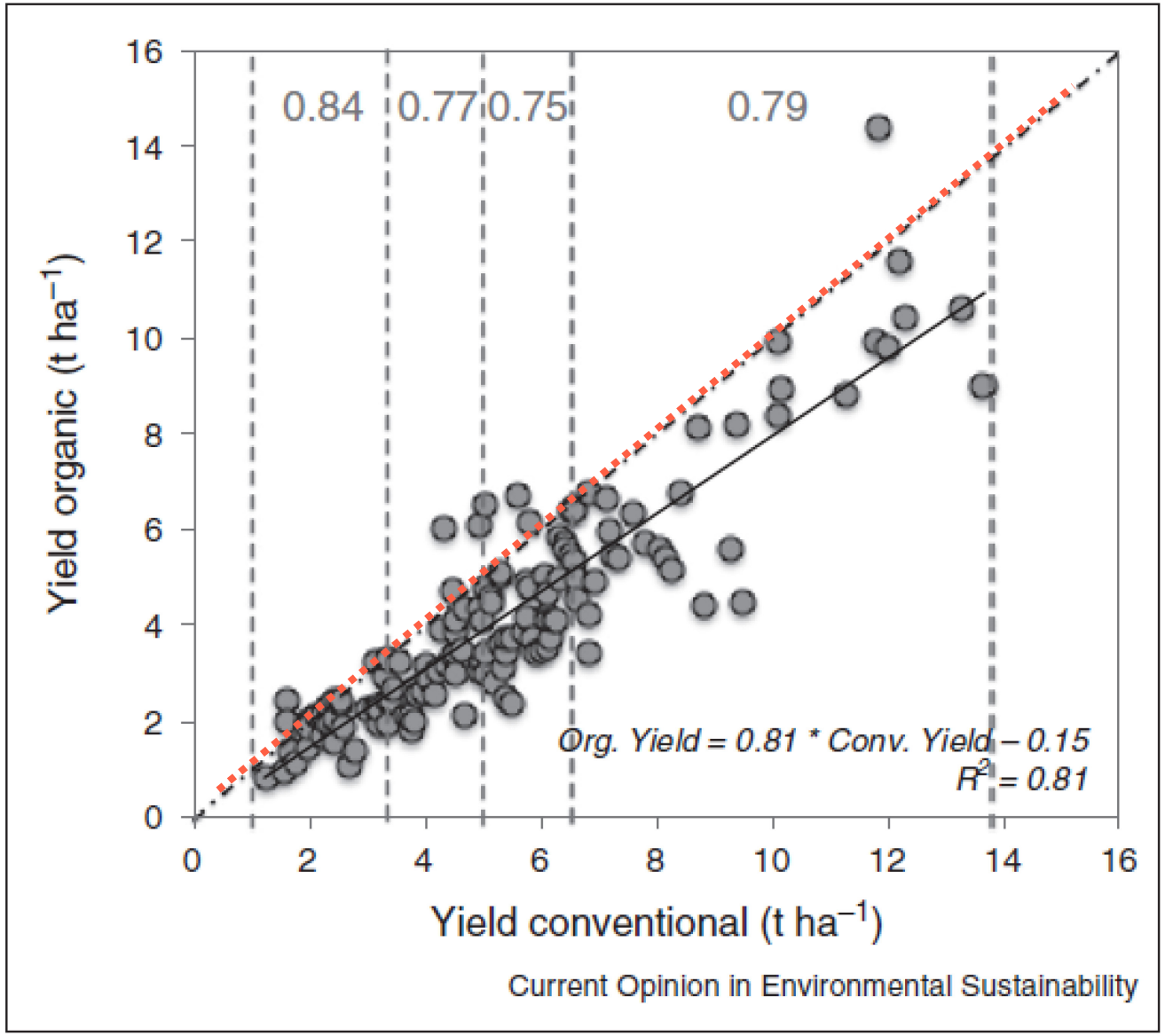
Productivity in terms of yields is a challenge for organic and agroecological practices

Causes:

- lower nitrogen supply
- lower phosphor supply
- insufficient plant protection
- insufficient weed control

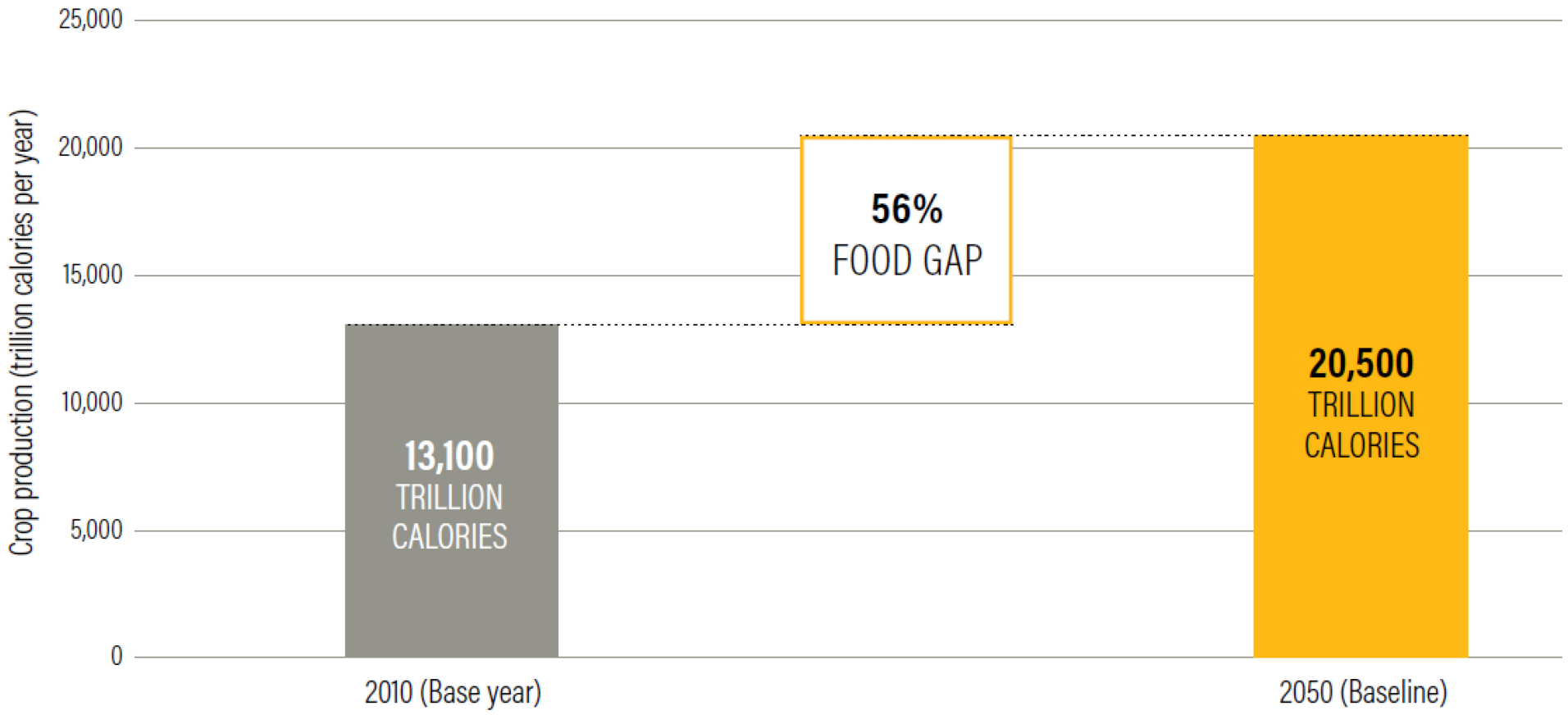
Niggli et al. (2016)
State of the art research results and best practices.
OKnet Arable.

Global yield losses due to failure to take crop protection measures are estimated and modelled to be between **17 and 40 %** *(Savary et al., 2019).*



Tittonell, 2014

Food demand in the scenario “business as usual” (FAO)



Note: Includes all crops intended for direct human consumption, animal feed, industrial uses, seeds, and biofuels.
Source: WRI analysis based on FAO (2017a); UNDESA (2017); and Alexandratos and Bruinsma (2012).

Consequences: 593 million hectare more agricultural land needed:
401 million hectare grassland
192 million hectare arable land

Sustainable farming systems and land use change

more arable land in %

Muller, A., Schader, C., El-Hage Scialabba, N., Hecht, J., Isensee, A., Erb, K.-H., Smith, P., Klocke, K., Leiber, F., Stolze, M. and Niggli, U., 2017, Strategies for feeding the world more sustainably with organic agriculture, **Nature** Communications October/2017.

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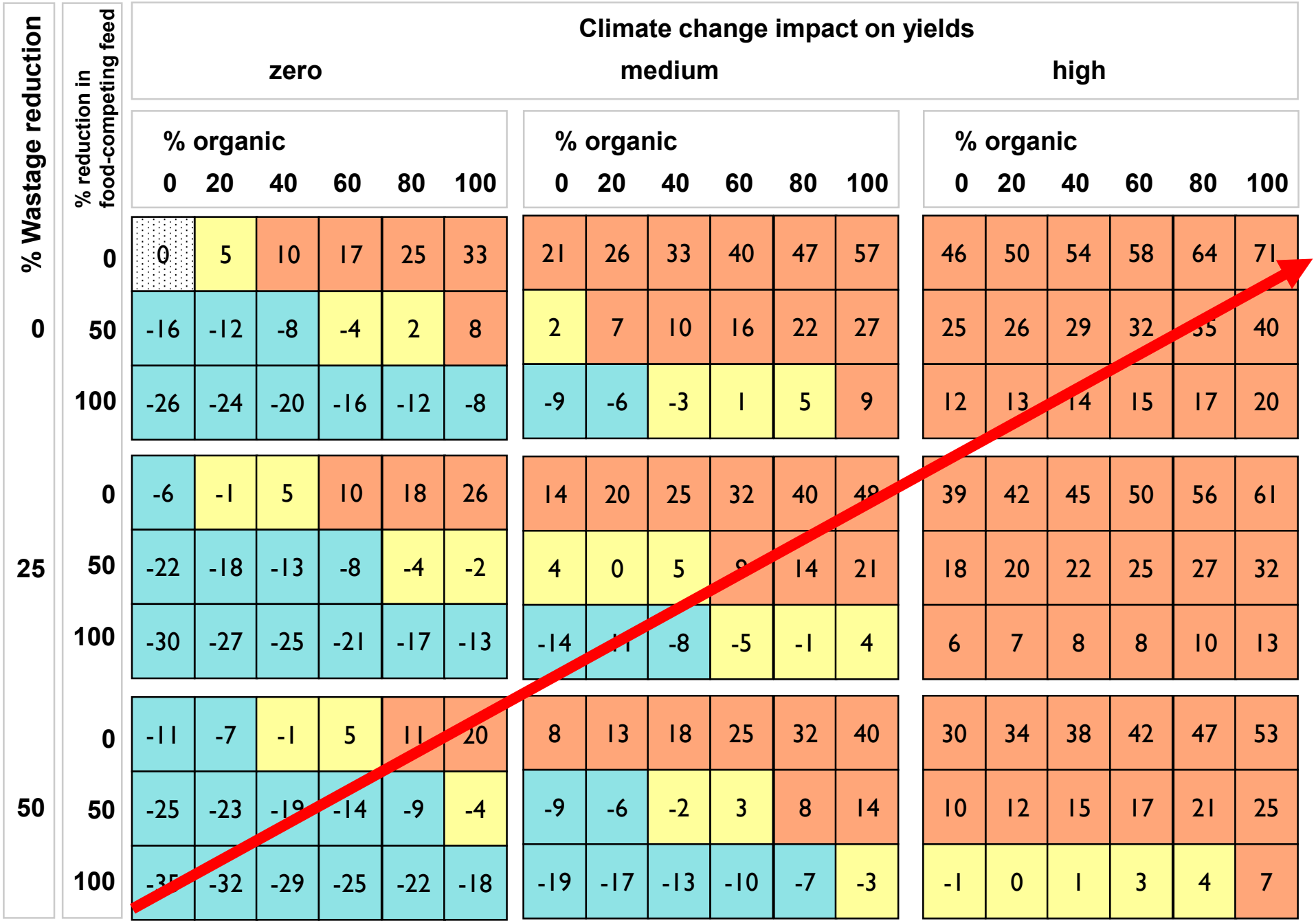
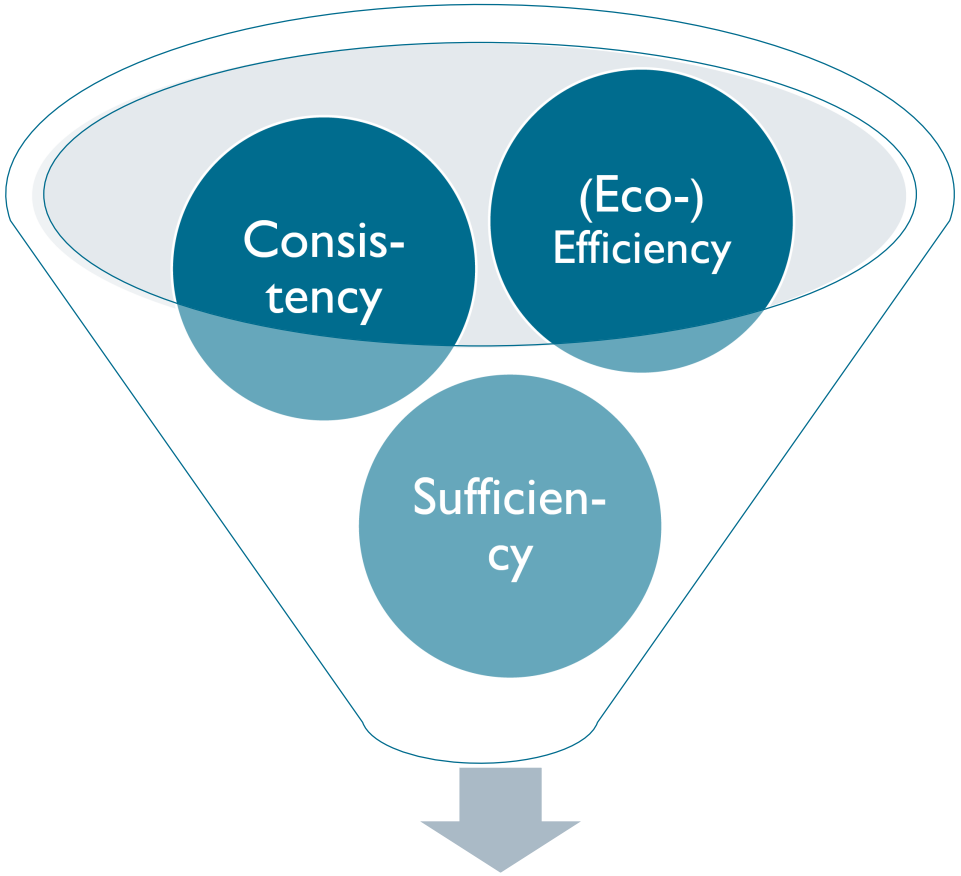


A sustainable economy is defined by 3 narratives:



Sustainable Food Systems

(Eco-)Efficiency:
More output with less input and less environmental footprint

Consistency:
Adaptation to territorial, cultural and socio-economic context, resilience, anthropogenic and natural flow of material compatible, cradle-to-cradle.

Sufficiency:
Reduction of consumption and waste, temperance, avoidance of rebound effects

Best scenario for food and farming:

- Reduce arable land for feedstuff **by 50 %**
- Reduce food wastage **by 50 %**
- Expand agroecological or organic farming **up to 60 %**
- Keep global warming under **2 degree Celsius**

Citizens have already made up their minds: there won't be a future for "pesticides"

RESEARCH ARTICLE

More than 75 percent decline over 27 years in total flying insect biomass in protected areas

Caspar A. Hallmann[1]*, Martin Sorg[2], Eelke Jongejans[1], Henk Siepel[1], Nick Hofland[1], Heinz Schwan[2], Werner Stenmans[2], Andreas Müller[2], Hubert Sumser[2], Thomas Hörren[2], Dave Goulson[3], Hans de Kroon[1]

Pflanzenschutz und Biodiversität in Agrarökosystemen
Stellungnahme des Wissenschaftlichen Beirats des Nationalen Aktionsplan Pflanzenschutz (NAP) beim Bundesministerium für Ernährung und Landwirtschaft

Niggli et al. 2019

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Pest and disease management strategy in agro-ecological farming systems:

5th phase: Chemical or synthetic pesticides (including copper).

4th phase: Insecticides and fungicides of biological and mineral origin, mating disruption, physical control. Reference FiBL Input list.

3rd phase: Inundative and inoculative release of biological control agents, competitive antagonists against fungal diseases (e.g. *Trichoderma harzianum* against botrytis in strawberries).

2nd phase: Vegetation management to enhance natural enemy impact and exert direct effects on pest populations, soil microbiome inducing resistance in plants.

1st phase: Cultural practice compatible with natural processes, such as crop rotation, soil management, non-transgenic host plant resistance, farm/field location.

Zehnder et. al. 2007, Reinhard, 2017, modified by Niggli

A need for the redesign of farming systems

Strip and contour farming

Redesign of farms and crop rotation towards higher system integration with precision farming (GPS, sensors, cameras, databases on soil quality, robots etc.).

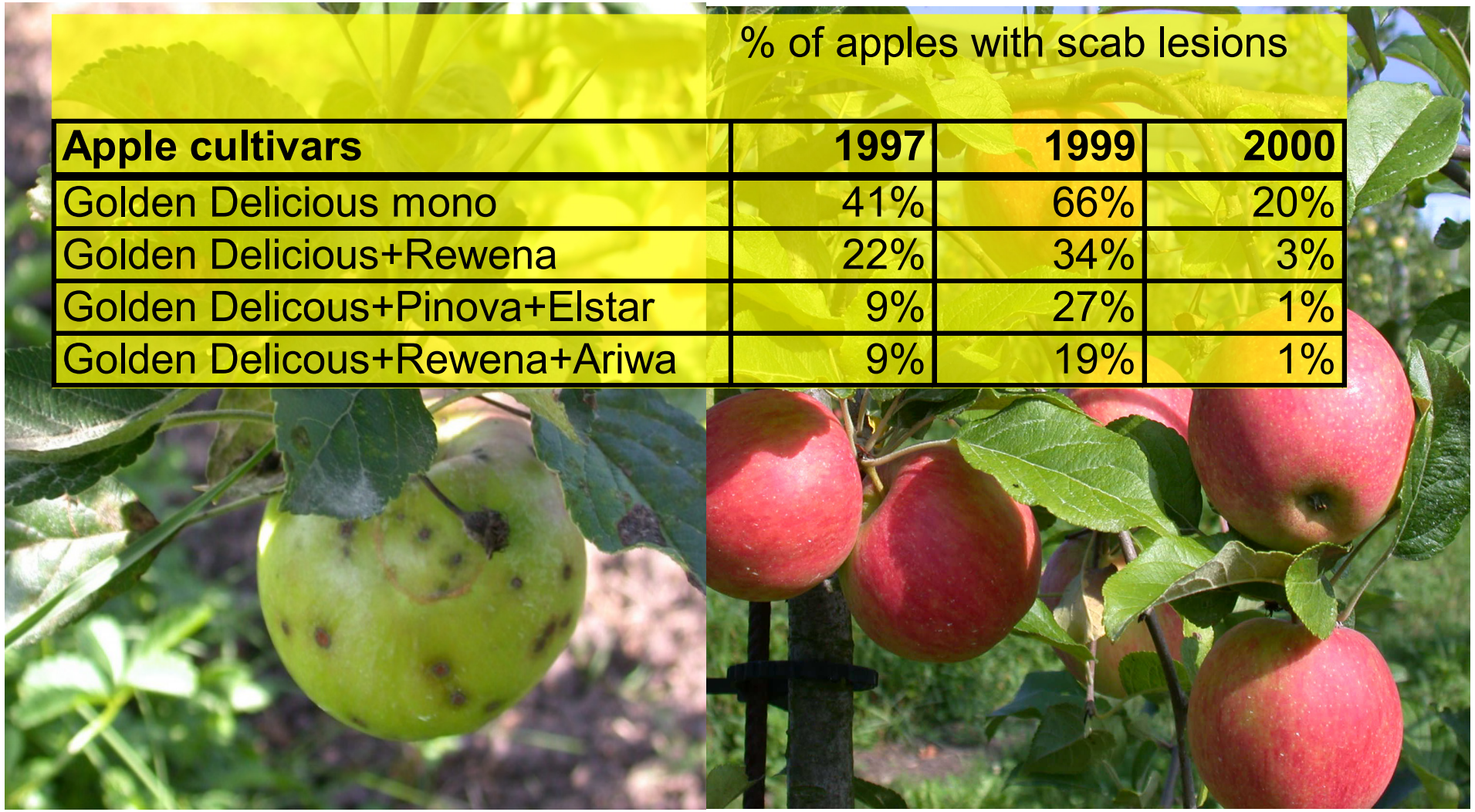
Example shown is a 3000 hectare organic farm in Argentina owned by the Tompkins family.

E.g. digitalisation*: Clever use of novel technologies versus *dummies*

Monocropping systems

Cultivar mixtures and plant health

	% of apples with scab lesions		
Apple cultivars	**1997**	**1999**	**2000**
Golden Delicious mono	41%	66%	20%
Golden Delicious+Rewena	22%	34%	3%
Golden Delicous+Pinova+Elstar	9%	27%	1%
Golden Delicous+Rewena+Ariwa	9%	19%	1%



Kellerhals *et al.*, 2003

Cocoa production systems, Rio Alto Beni, Amazonian watershed, Bolivia (FiBL projet)

Monocultures

Organic
Conventional

Agroforestry systems

Organic
Conventional

Successional agroforestry systems

Organic
(no external input)

Moniliophtora perniciosa
"Witches' Broom Disease"

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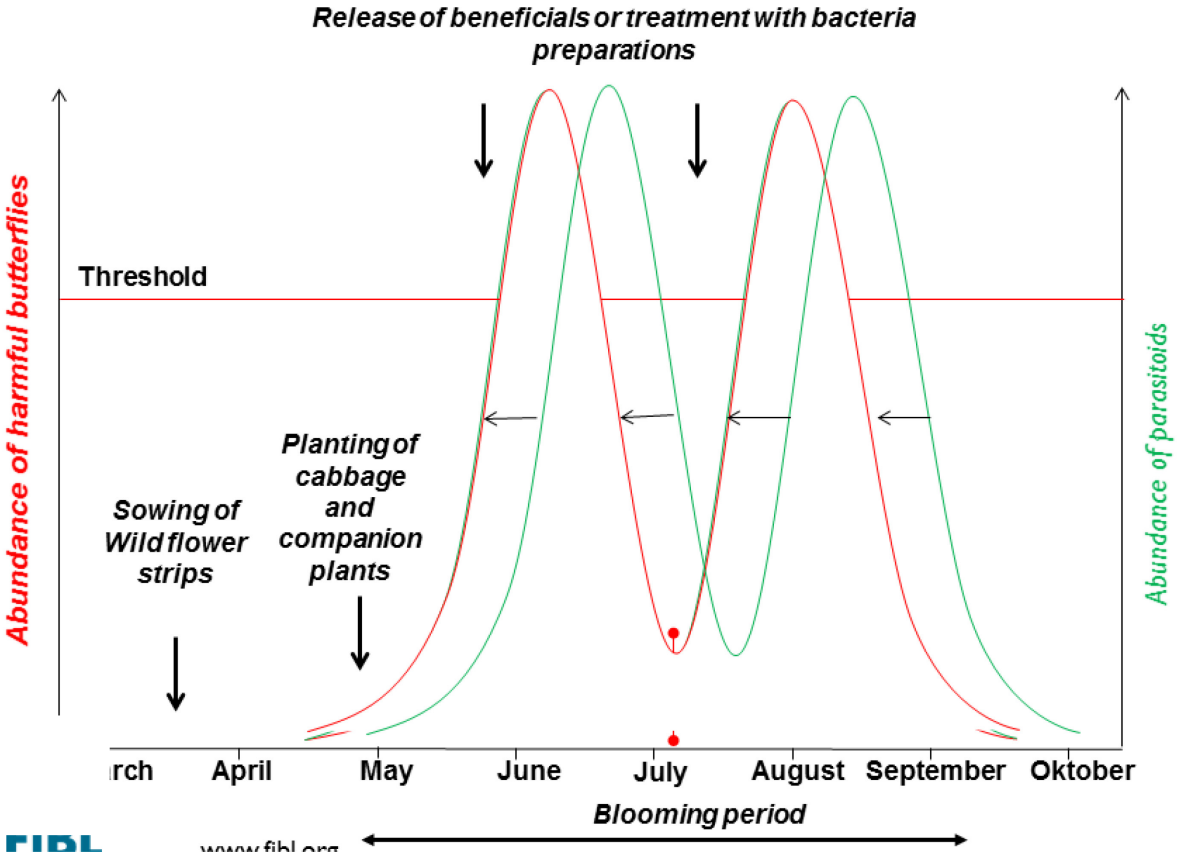
System design or habitat management: functional biodiversity

Companion plants increase life span, fecundity and mobility of parasitoids in fields by factor 10

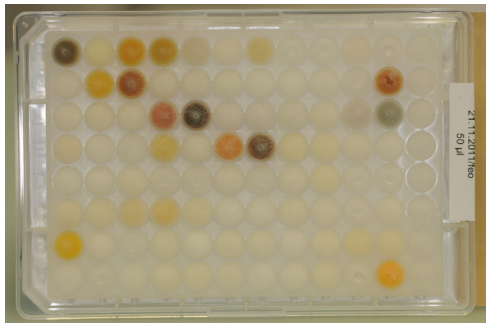
Centaurea cyanus



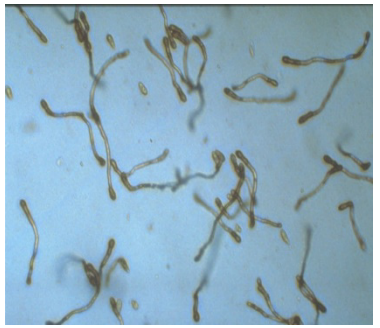
Biocontrol and digitalisation

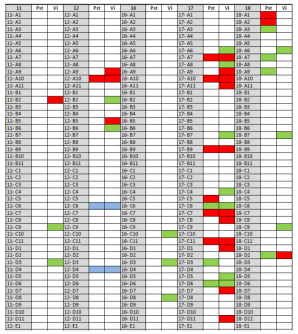
Example with *Trichogramma* polyphagous wasps (endo-parasitoids) against European corn borer (*Ostrinia nubilalis*), applied by drones (see right) instead of by hand (see below).

Speeding up biocontrol and botanicals

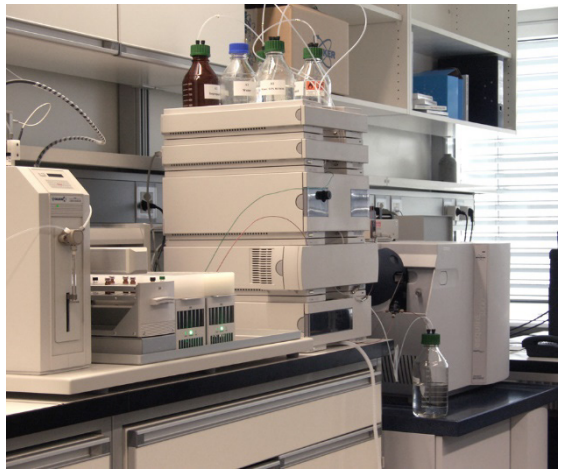


FiBL tested >> 3000 plant extracts of the library of the University of Basel on fungicidal effects





1% of the tested extracts of the tested extracts significantly inhibited spore germination of 1-3 pathogens.



Screening in the growth chamber and in the field; identification of active compounds in the plant extracts with GC-MS or HPLC, **feasibility of mass production & formulation, EU registration**

What can be learnt?

- Trade-offs between "feeding the world" and "safeguard the planetary boundaries" require an extension of the sustainability narratives (efficiency, consistency and sufficiency).
- System redesign with higher complexity is an excellent context for biocontrol and botanicals
- A redesign of research methods needed and it has to be geared to complex systems.
- Biocontrol and botanicals are imminent parts of the future agriculture.
- Innovation has been insufficiently funded, publicly and privately.