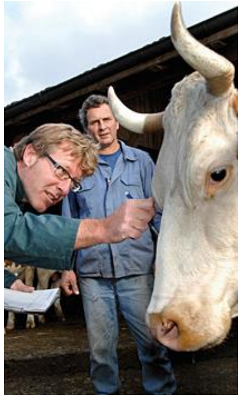
FiBL
EXCELLENCE FOR SUSTAINABILITY

Research Institute of Organic Agriculture
Forschungsinstitut für biologischen Landbau
Institut de recherche de l’agriculture biologique








Science agenda to feed the world – the role of agro-ecology, organic farming and biocontrol.

Urs Niggli

Trade-offs between food production and other ecosystem services: the challenge!

Soil erosion

Climate change

Water waste and pollution

Losses of biodiversity

Food production

Extract from the conclusions of the MEA (2005)

“The challenge of reversing the degradation of ecosystems while meeting increasing demands for their services can be partially met under some scenarios that the Millennium Assessment has considered, **but these involve significant changes in policies, institutions, <u>and practices that are not currently under way</u>.** Many options exist to conserve or enhance specific ecosystem services in ways that reduce negative trade-offs or that provide positive synergies with other ecosystem services”.

Millennium Ecosystem Assessment MEA (2005) Ecosystems a
Human Well-being: Synthesis. Island Press, Washington,

Time for a change in agriculture

« All the evidence … indicates that the hegemonic model of global agriculture is obsolete. It is unable to feed the world, it is thermodynamically and socially unsustainable, it pollutes the environment, it is directly and indirectly responsible for biodiversity loss, it impacts seriously on human health.

… **conventional agriculture is simply not able to feed the world today, and even less 50 years time. <u>We need alternatives</u>.»**

Professor Pablo A. Tittonell
Farming Systems Ecology at Wageningen University,
Netherlands, on 16 May 2013

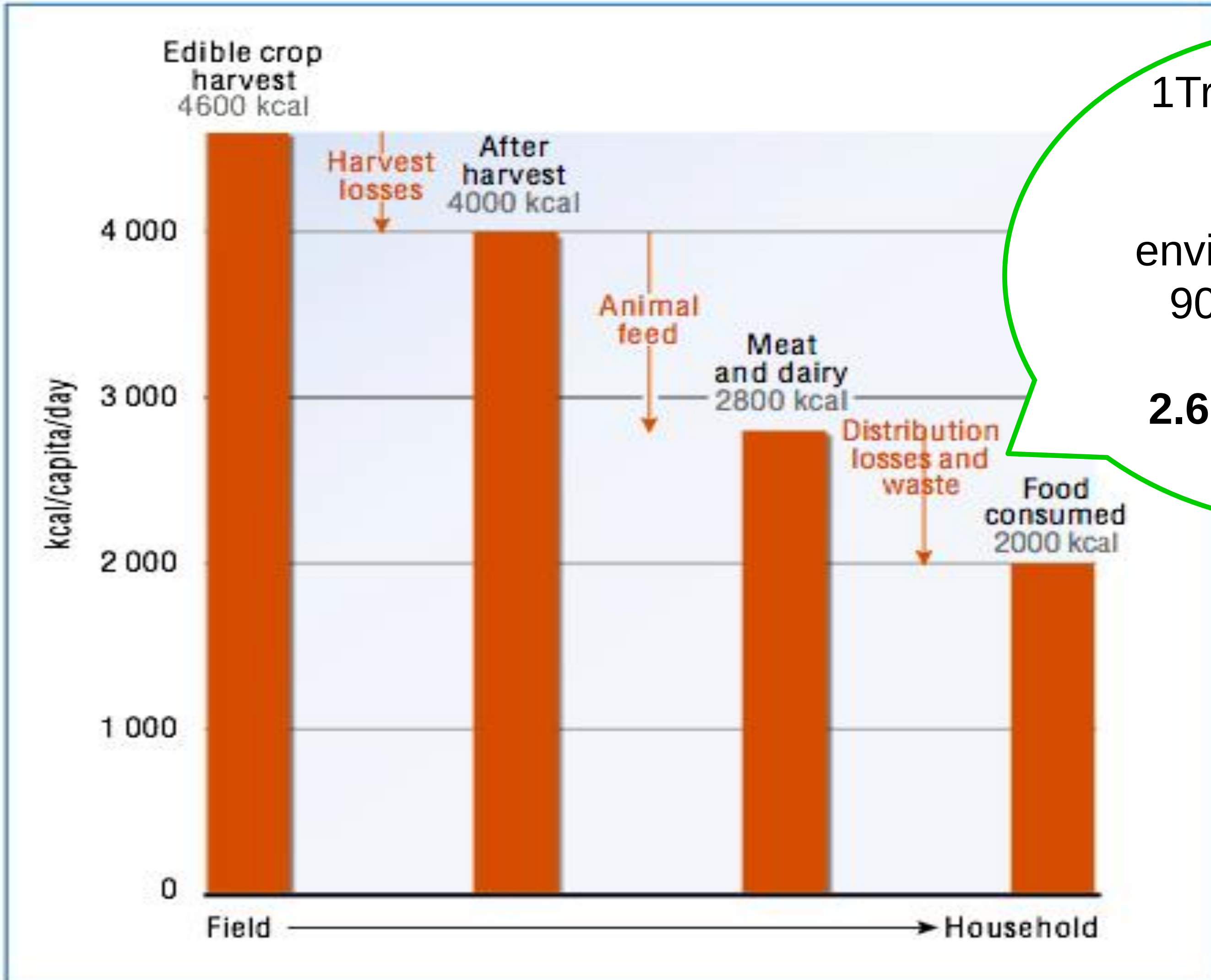


Figure 9a-b: The makeup of total food waste[11]

Source: Lundqvist et al., Godfray

1Trillion US $ food lost
700 billion environmental costs
900 billion social costs
2.6 billion US $ in total

Different scientific approaches to sustainability

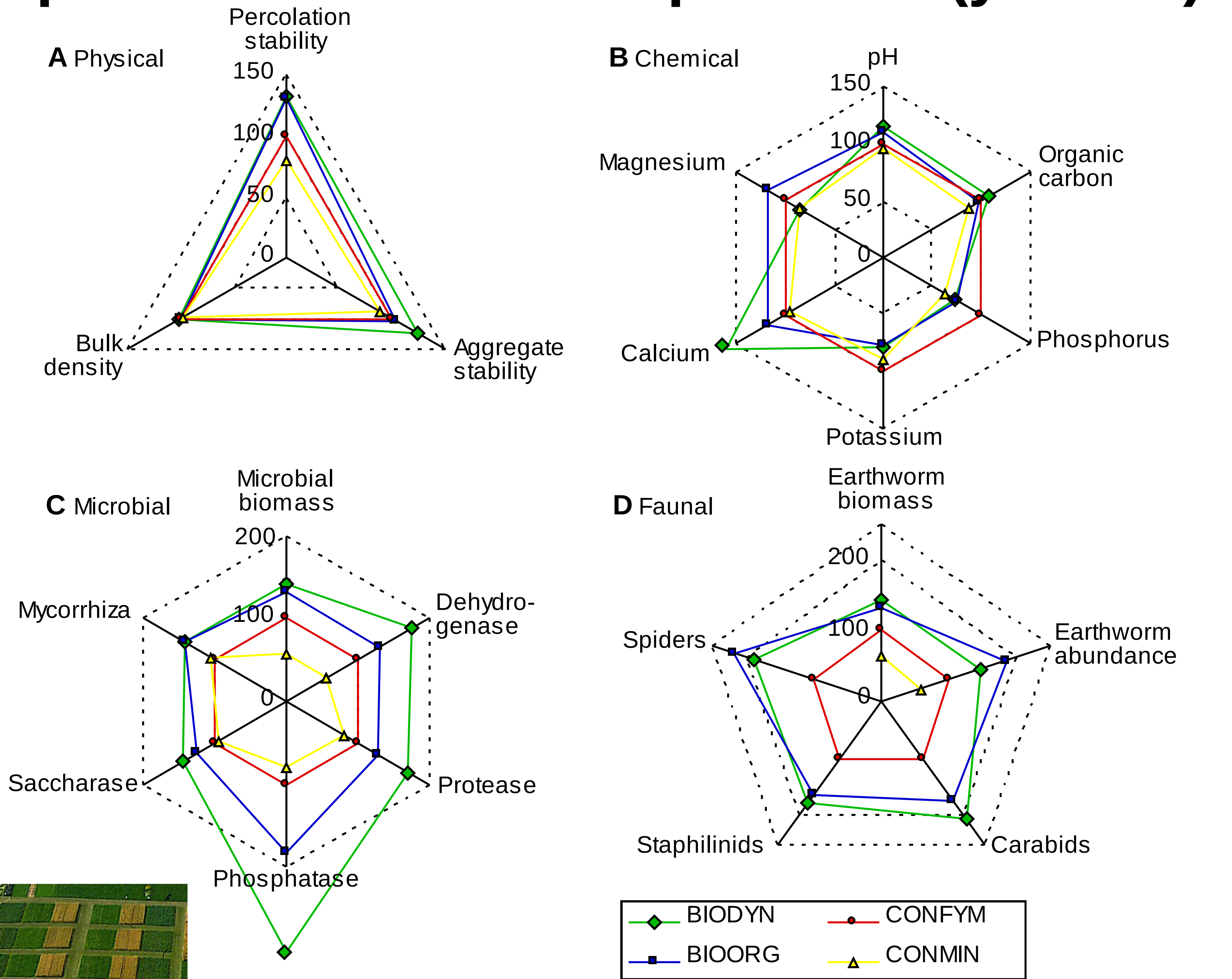
- Improved technologies like minimum/ no tillage or GMO crops.
- Integrated Production (IP, IPM).
- Low Input Agriculture (LIA) or Precision Farming.
- Low External Input Sustainable Agriculture (LEISA).
- Organic Farming.
- Organic Farming & reduced tillage.
- Organic (successional) agroforestry systems.

Ecological or eco-functional intensification

Increasing complexity of measure

➔ Improving sustainability and resilience

Soil properties in the DOC experiment (year 24)



Mäder, Fliessbach, Niggli (2002), Science 296

DOK trial in CH, since 1977: Organic yields 83 %, excellent input/output ratio

	Parameter	Unit	Organic farming	Integrated farming (IP) with FYM	Organic in % of IP
Input	Nutrient input	kg N_{total} ha^{-1} yr^{-1}	101	157	64 %
		kg N_{min} ha^{-1} yr^{-1}	34	112	30 %
		kg P ha^{-1} yr^{-1}	25	40	62 %
		kg K ha^{-1} yr^{-1}	162	254	64 %
	Pesticides applied	kg ha^{-1} yr^{-1}	1.5	42	4 %
	Fuel use	L ha^{-1} yr^{-1}	808	924	87 %
Output	Total yield output for 28 years	%	83	100	83 %
	Soil microbial biomass as „output“	tons ha^{-1}	40	24	167 %

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Mäder, Fliessbach,..., Niggli (2002), Science 296

Yields: state-of-the-art of literature

- Temperate zones: The organic yields are between 75 and 80 % of conventional yields (intensive farms):
  - Seufert, V.; N. Ramankutty and J.A. Foley 2012: Comparing the yields of organic and conventional agriculture. Nature 485, 229-232.
  - De Ponti, T.; B. Rijk and M.K. van Ittersum 2012: The crop yield gap between organic and conventional agriculture. Agricultural Systems 108, p 1-9.

- Entire crop rotations: The DOK trial running in permanence in Switzerland since 1977 (5 x 7 year rotation): 83 % organic/conventional.
  - Mäder, P.; A. Fließbach; D. Dubois; L. Gunst; P. Fried and U. Niggli 2002: Soil fertility and biodiversity in organic farming. Science 296, 1694-1697.

Yields: state-of-the-art of literature

- Sub-Saharan Africa: Organic farming increased yields by 116 % compared with subsistence farming.
  - UNCTAD and UNEP (2008). 'Organic Agriculture and Food Security in Africa', New York, Geneva, United Nations Conference on Trade and Development, United Nations Environment Programme.
- An older meta-analyses of global data: the average yield ratio "organic/conventional" was slightly < 100 % for studies in the developed world and > 100 for studies in the developing world.
  - Badgley, C., Moghtader, J., Quinterio, E., Zakem, E., Chappell, M.J., Avilés-Vázquez, K., Samulon, A. and Perfecto, I. (2006). 'Organic agriculture and the global food supply'. Renewable Agriculture and Food Systems 22: 2, pp. 86-108.

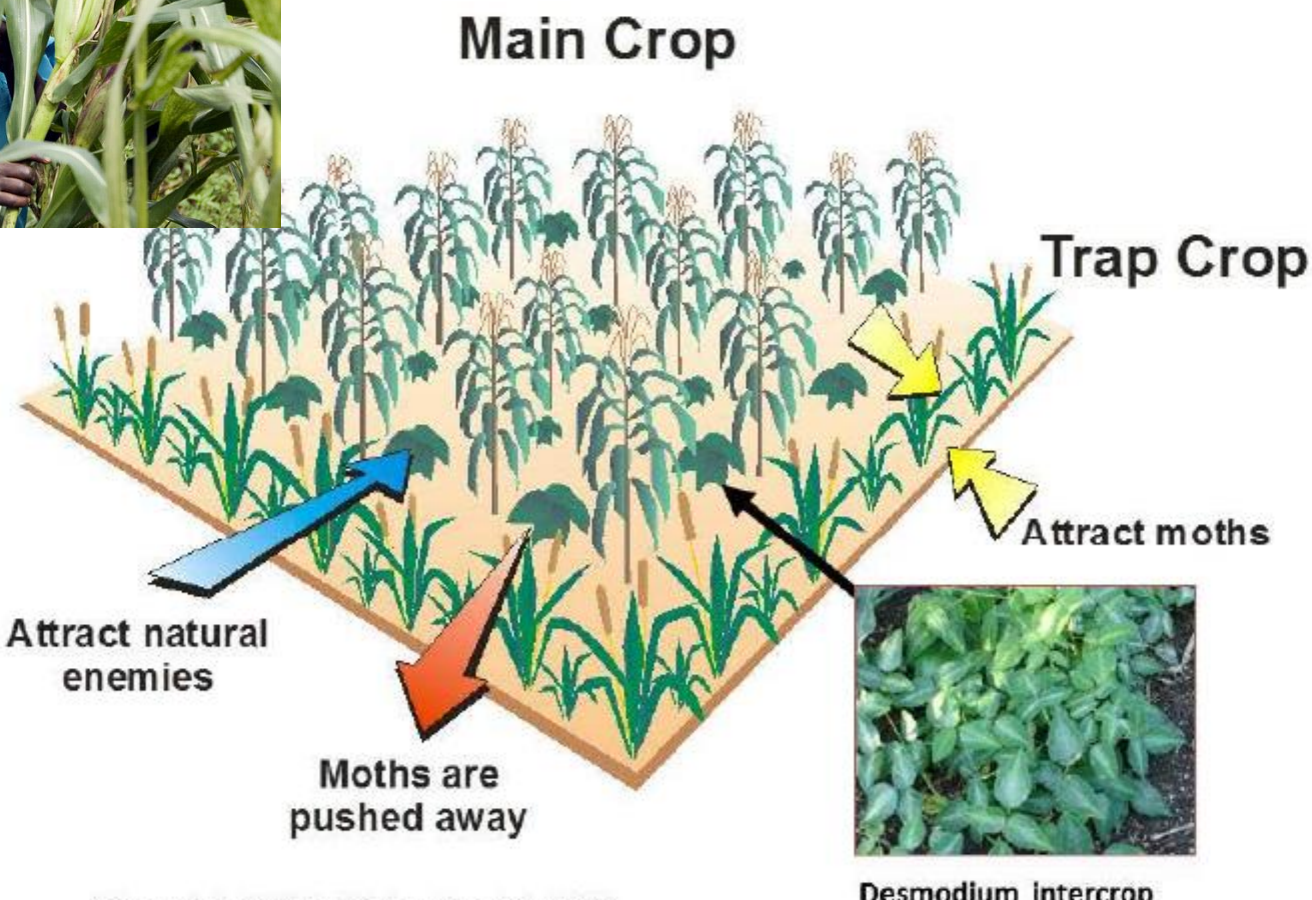
Causes in the case of the Pretty study

- Improved supporting and regulating ecosystem services (esp. soil fertility, water supply, flood control, waste recycling, biodiversity) – 93 % of all cases (**nature capital**).
- Benefits to community, cooperation and partnership (**social capital**).
- Improvement to infrastructure and markets.
- Increase in education, skills and health (**human capital**).

- Increase in farmer and household income (less costs and debts, more surplus produce to sell, higher prices in export and domestic markets).

*UNEP-UNCTAD CBTF (2008).

Example ‘push & pull’ of the team of Hans Herren



Khan et al. (2010) *J. Exp. Bot.* 61: 4185

Example for ‘functional biodiversity’

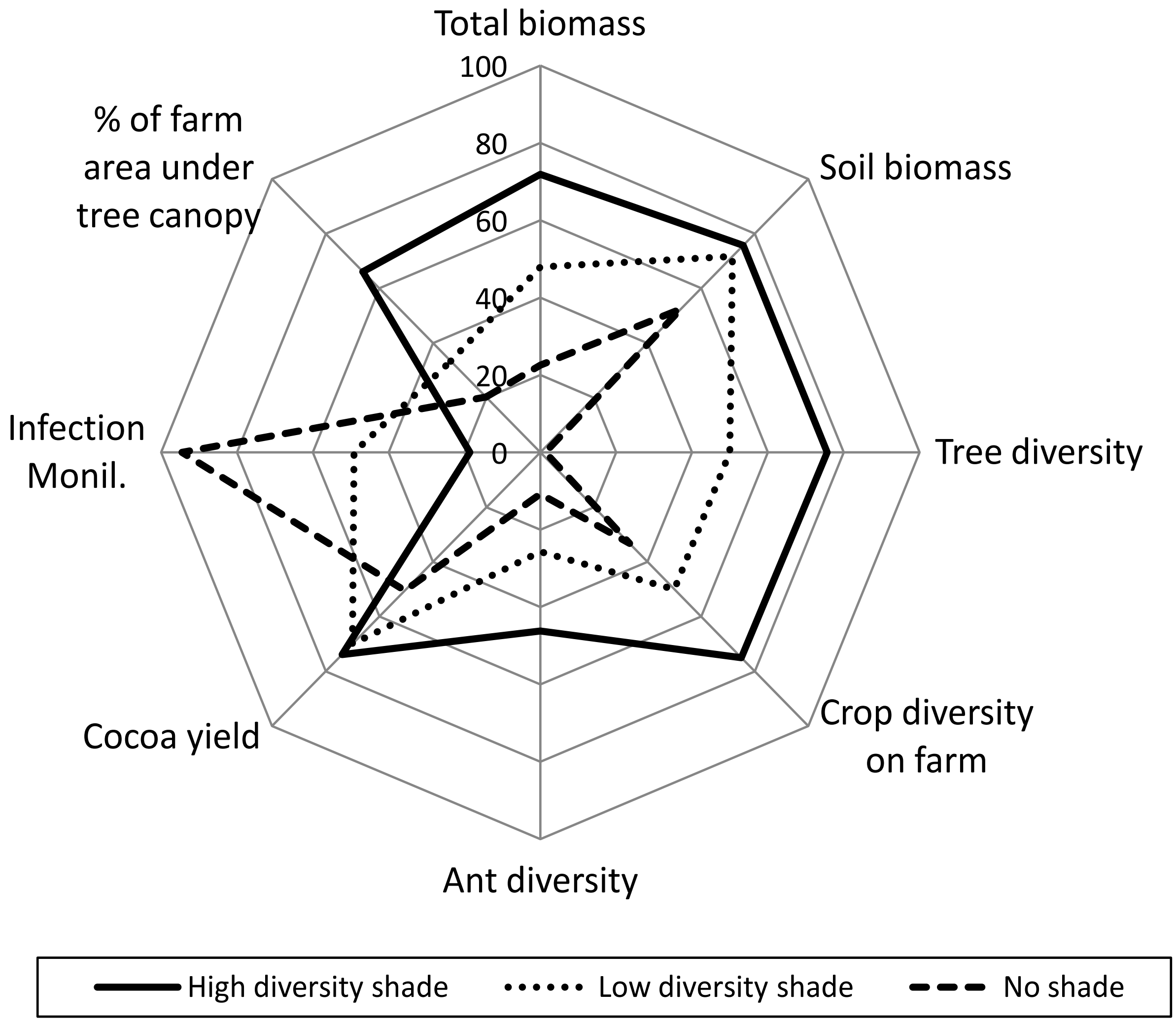
Parasitoids: from **2** day survival in cabbage (mono) to **20** days in cabbage + cornflower

Companion plants serve as food sources within the crop to enhance longevity and oviposition of parasitoids.

Most important pests: *Pieris rapae, Pieris brassicae, Mamestra brassicae, Plutella xylostella*

Géneau, 2010, FiBL

Increased buffer capacity by agroforestry in cocoa production (tree canopy)



Bolivia, Alto Beni

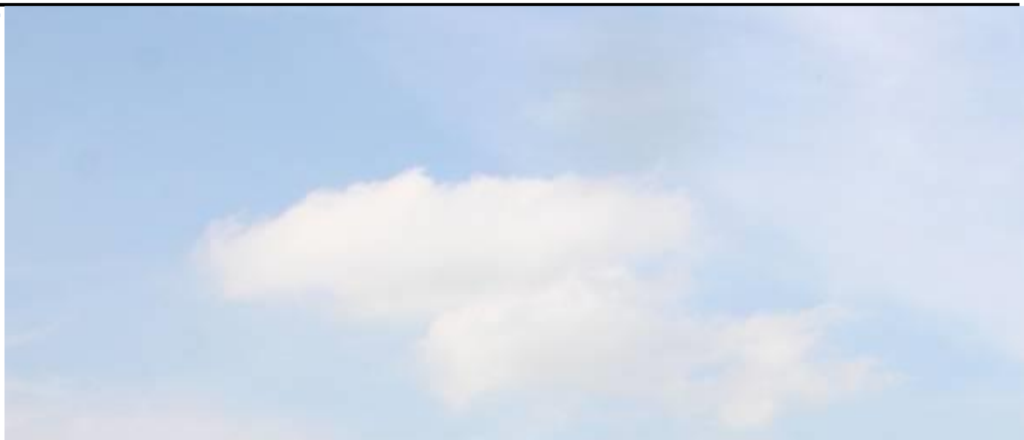
Johanna Jakobi, 2012/Diss/unpublished yet (FiBL & University of Berne)

Less N_2O from organically managed soils

	N_2O emissions per acreage (kg N_2O-N ha^{-1} a^{-1})					GWP [d] N_2O emissions per acreage (kg CO_2-eq. ha^{-1} a^{-1})				
land-use	MD [a]	CI [b]	p	studies	comp. [c]	MD [a]	CI [b]	p	studies	comp. [c]
all (annual) [f]	-1.04	0.41	0.00	12	70	-486	191	0.00	12	70
arable	-1.01	0.42	0.00	11	67	-472	195	0.00	11	67
grassland	-2.42	5.16	0.36	2	3	-1133	2416	0.36	2	3
rice-paddies	-1.39	2.22	0.22	1	3	-650	1038	0.22	1	3
overall [g]	-1.03	0.32	0.00	18	98	-482	150	0.00	18	98

Mean difference for all studies
0.5 t ha^{-1} yr^{-1} less CO_2 eq.
as nitrous oxide.

Cut-off point: - 17 % yields

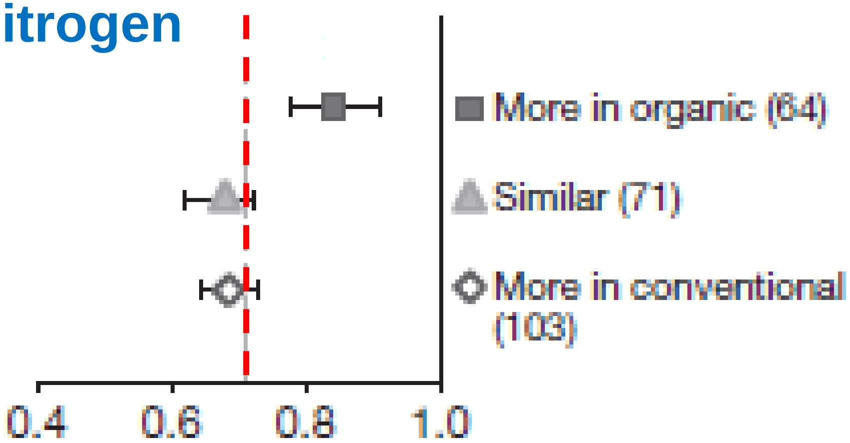


Skinner, C., Gattinger, A., Müller, A., Mäder, P., Fliessbach, A., Stolze, M., Ruser, R. and Niggli, U. (2014) Science of the Total Environment, pp. 553-563 DOI information: 10.1016/j.scitotenv.2013.08.098

Main factors limiting yields in organic farming

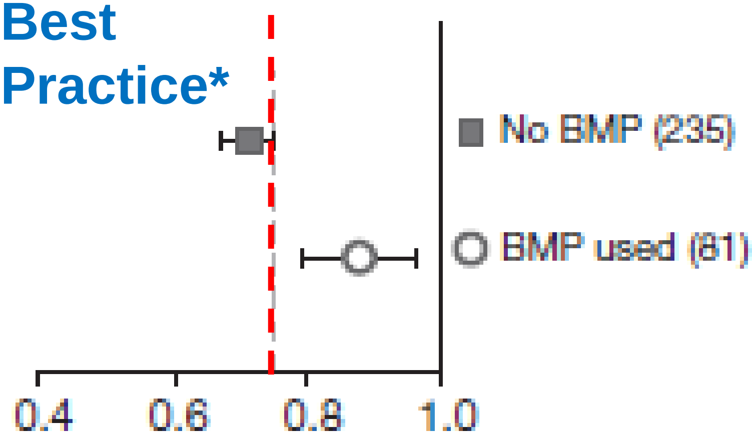
Ratio organic/conventional in the Seufert study: **0.75**

Nitrogen

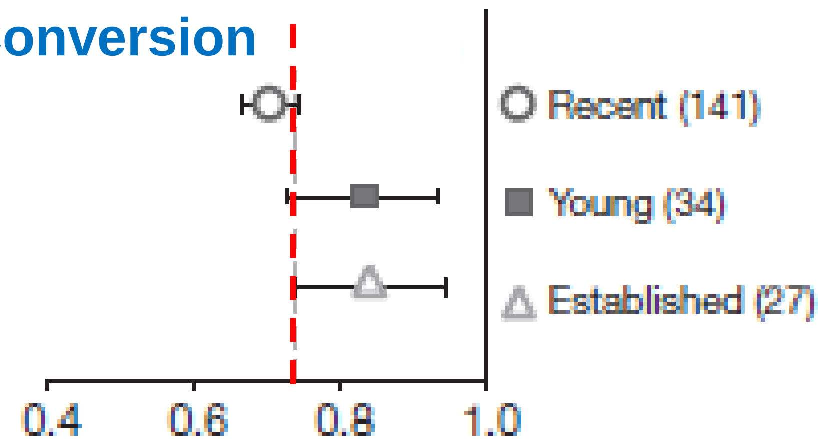


***Best Practice: mainly good disease, pest and weed control, adapted crop rotations and varieties.**

Best Practice*



Time of Conversion



Seufert, et al., 2012: Nature 485,

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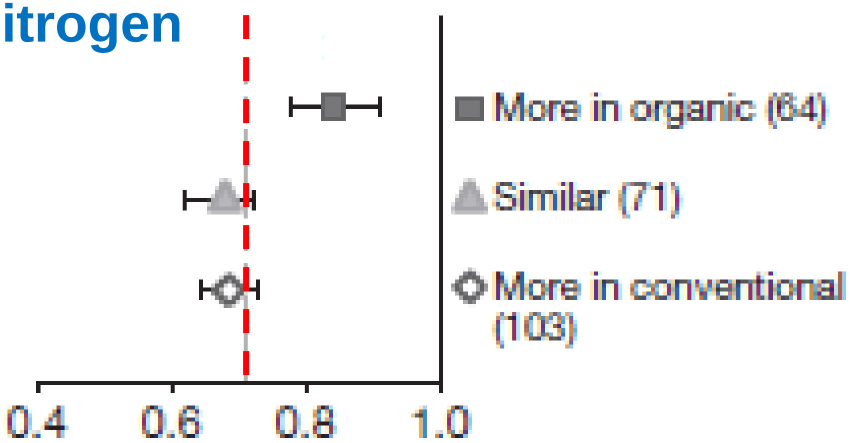

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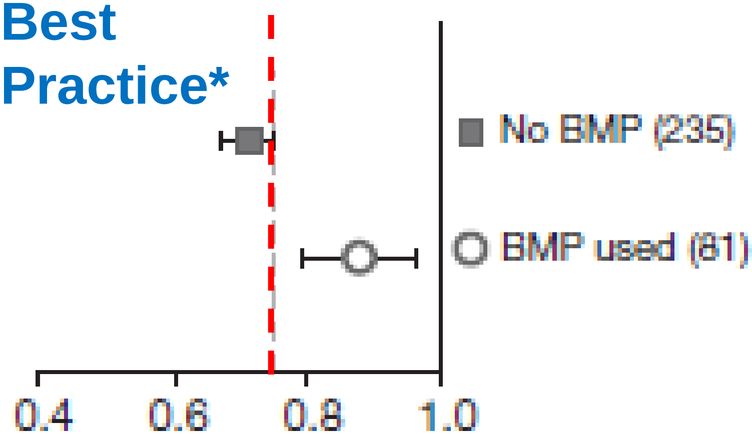

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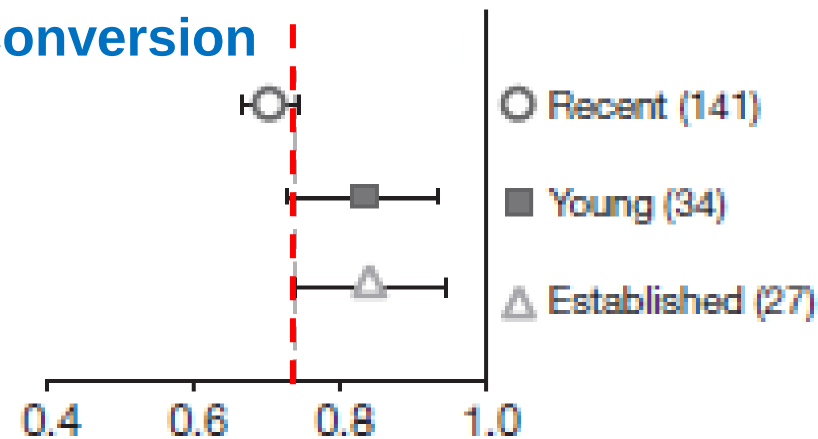

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Biocontrol and botanicals in agriculture

- Essential for further yield increase (“eco-functional intensification”) both in crop and livestock production.
- Improve the resilience and the yield stability in both crop and livestock production.
- Solve the problem of residues in food.
- One of the most challenging and exciting research activities.
- A combination of ecological, biological, molecular and nano-material sciences.


Conclusions

- The claim “higher yields improve food security” is an easy to understand message but will for sure not solve the problem.
- Agro-ecological and organic farming approaches will have priority in addressing food insecurity (and poverty of subsistence and small holder farmers).
- Biocontrol and botanicals are essential for eco-functional intensification of agriculture and will considerably increase yield stability.