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How agricultural practices can better contribute to increasing future yields in a sustainable way

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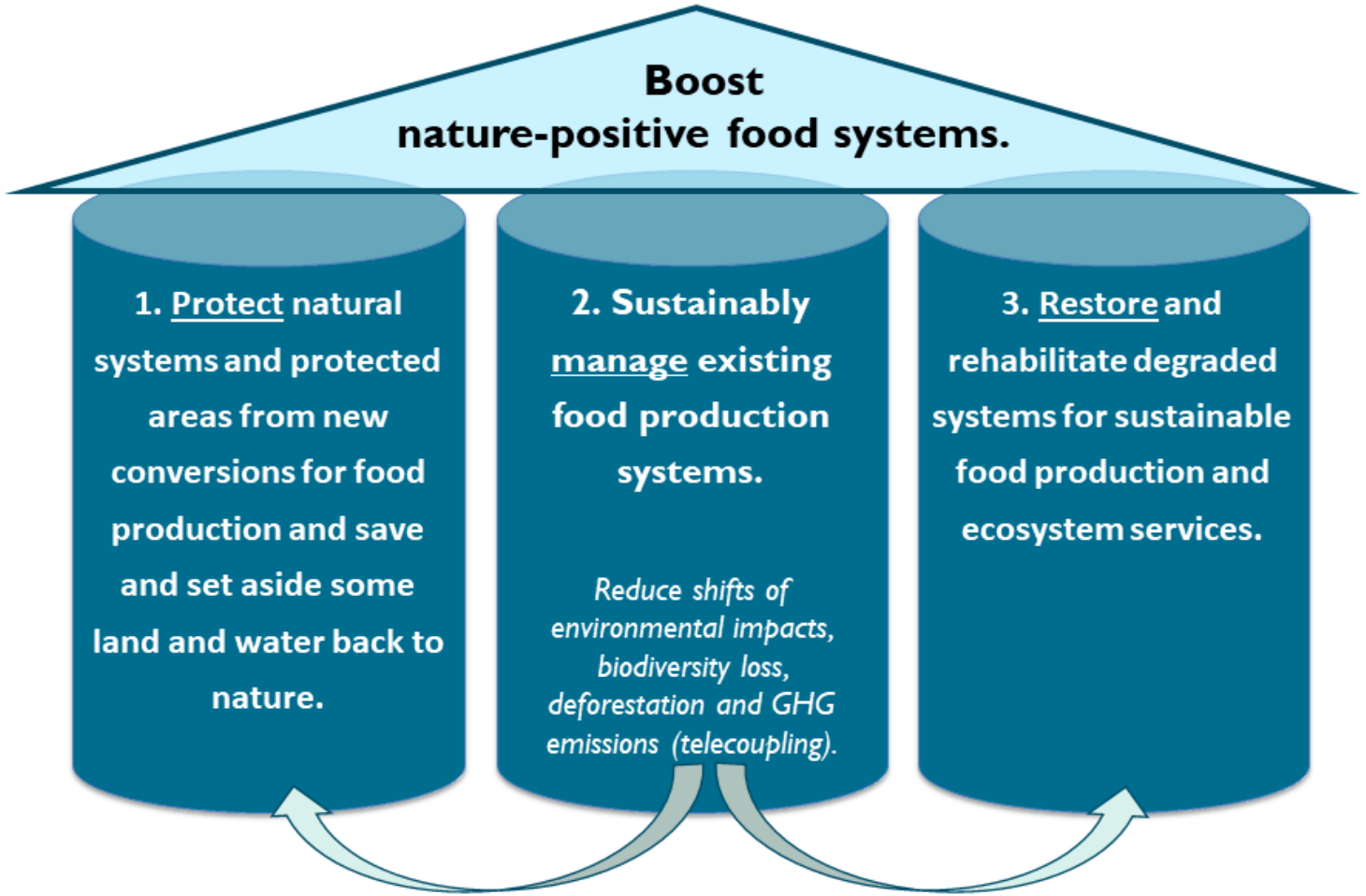
Content

- Productivity or/and sustainability?
- The role of diversification
- Management options
- Conclusions

Recommendations of the Scientific Group of the UNFSS 2021:



- Manage existing food production systems in a sustainable and productive way.
- Reduce shifts (or exports) of environmental impacts, biodiversity loss, deforestations and GHG emissions.

Dargie, G., Lewis, S., Lawson, I. *et al. K* (2017). Age, extent and carbon storage of the central Congo Basin peatland complex. *Nature* **542,** 86-90. https://doi.org/10.1038/nature21048

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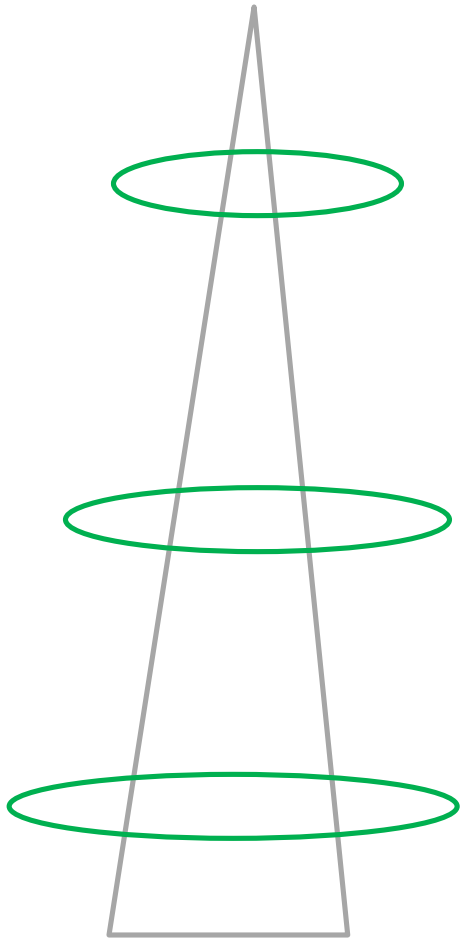
Starting point of my presentation:

There is scientific evidence that agricultural diversification positively correlates productivity with both ecosystem and natural resource maintenance, thus reduces trade-offs.

***Meta-Analyses** (excerpt):*

- Tamburini, G et al. (2020) Agricultural diversification promotes multiple ecosystems services without compromising yield. *Science Advances 6*.
- Agroecological transformation for sustainable food systems. Insight on France-CGIAR Research. Number 26, September 2021. www.agropolis.org/publications/thematic-files-_agropolis.php
- Niggli U, Sonnevelt M and Kummer S (2021) Pathways to advance agroecology for a successful transformation to sustainable food systems. Scientific Brief UNFSS, June 2021. https://sc-_fss2021.org/wp-content/uploads/2021/06/FSS_Brief_Agroecology.pdf
- Muller, Adrian; Leippert, Fabio; Darmaun, Maryline; Mpheshea, Molefi; Nesper, Maike; Herren, Martin; Bellon, Stéphane; Bezner Kerr, Rachel; DePorras, Miguel, Grovermann, Christian; Smith, Pete; Stöckli, Sibylle; Bernoux, Martia: Agroecology's potential to adapt to climate change (in preparation).

Diversification is the key element of sustainable intensification



Field: fertilization, variety choice, pest, disease and weed control, soil tillage

Farm: Crop diversity, crop rotation, mixed farming, diversity of value chains

Landscape: Land use diversity, landscape structure, temporal and spatial heterogeneity

EU agriculture: actions needed!

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Farming systems implementing diversifications strategies in a holistic way can be summarised under the term “agroecological farming”

- (Successional) agroforestry systems (in temperate zones e.g. alley cropping).
- Silvo-pastoral systems and sustainable pastoralism.
- Organic farming: system-based practices, traditional knowledge, and basic constraints on inputs and techniques. Focus on social, environmental and, to some extent, technological innovation.
- Regenerative cropping systems, integrated production systems with greatly reduced input use, application of diversified crop rotations, recycling of organic matter, intercropping and mixed cropping, relay intercropping of legume cover crops, alley cropping.
- Agroecological farming: smart combination of system-based practices and scientific-technological innovation (e.g. precision farming, digitalisation).*

* Lambertus AP Lotz , Clemens CM van de Wiel and Marinus JM Smulders (2020) Genetic engineering at the heart of agroecology. Outlook on Agriculture 2020,Vol. 49(1) 21–28. DOI: 10.1177/0030727020907619

Crop rotation: Effects on spring wheat yields

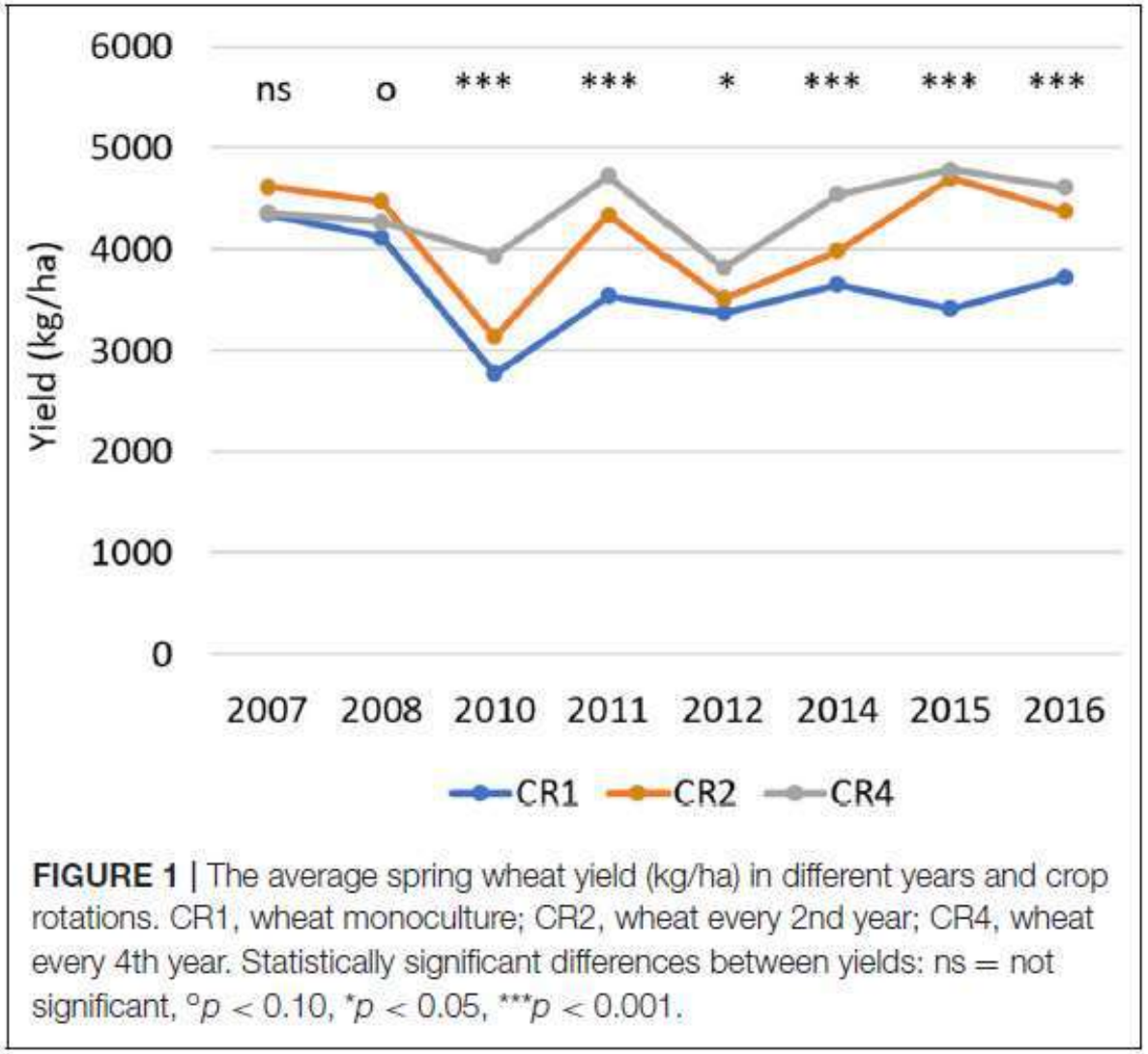
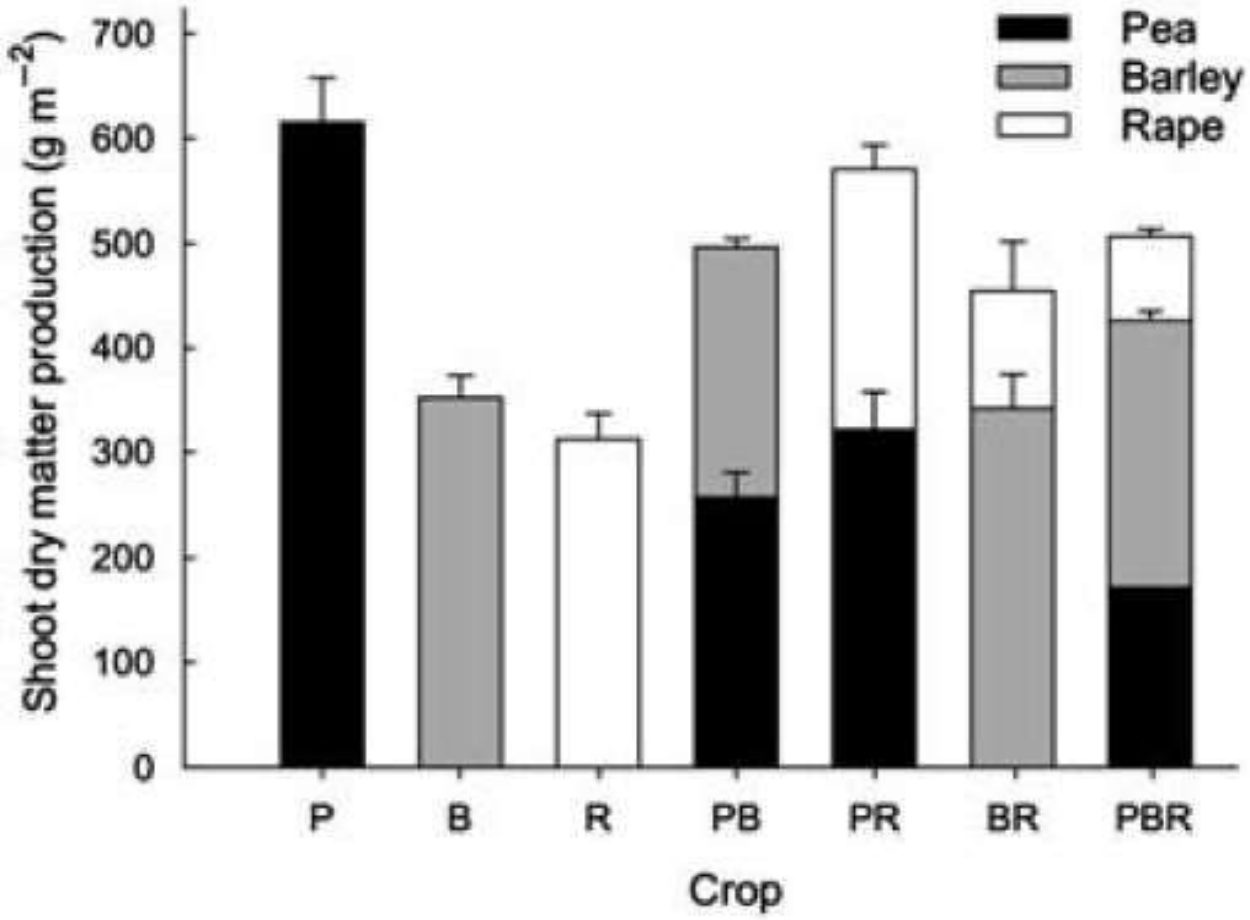


FIGURE 1 | The average spring wheat yield (kg/ha) in different years and crop rotations. CR1, wheat monoculture; CR2, wheat every 2nd year; CR4, wheat every 4th year. Statistically significant differences between yields: ns = not significant, °$p < 0.10$, *$p < 0.05$, ***$p < 0.001$.

Conclusion: «A diversified crop rotation improved spring wheat yield by up to 30% in no-tillage and by 13% under plowing compared with monoculture»

Jalli M, Huusela E, Jalli H, Kauppi K, Niemi M, Himanen S and Jauhiainen L (2021) Effects of Crop Rotation on Spring Wheat Yield and Pest Occurrence in Different Tillage Systems: A Multi-Year Experiment in Finnish Growing Conditions. Front. Sustain. Food Syst. 5:647335. doi: 10.3389/fsufs.2021.647335

Intercropping



Competitive dynamics in two- and three-component intercrops
METTE KLINDT ANDERSEN,HENRIK HAUGGAARD-NIELSEN, JACOB WEINER and ERIK STEEN JENSEN (2007) *Journal of Applied Ecology* **44**, 545–551

Fig. 2. Total above-ground dry matter yields of pea (P, black), barley (B, grey) and rape (R, white) grown as sole crops (SC) and in dual- and tri-component intercrops (IC). Values are means (n = 4) ± SE.

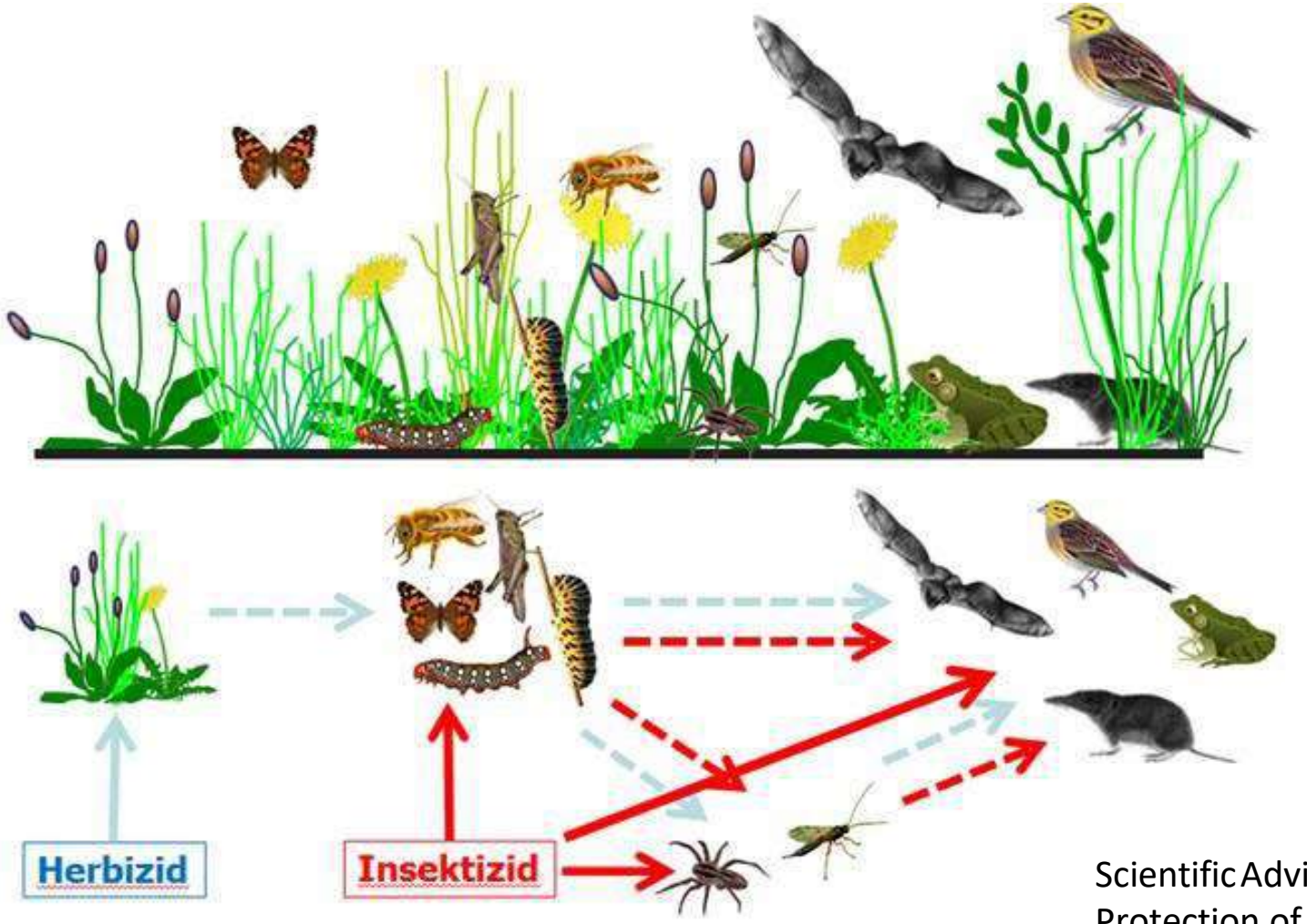
Use of digitization for system diversification while maintaining yields

Strip and contour farming (3000 ha organic Farm Laguna Blanca in Argentina).
(Photo: Tompkins Conservation Foundation)

Precision farming
for clever people
…. for "dummies"

Photo: PantherMedia

Digitalization reduces chemical pesticide treatments by 50 to 80 % and has an additional positive effects on biodiversity and natural food chains

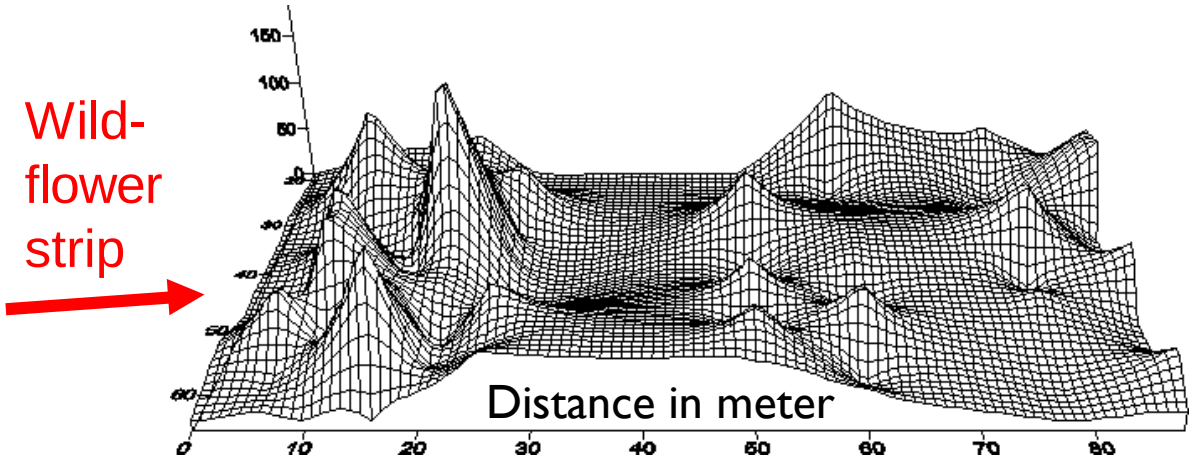


Alternatives:

- Preventive methods
- Physical methods
- BioControl & Botanicals
- Biostimulants

Scientific Advisory Board of the National Action Plan for Plant Protection of the Federal Ministry of Food and Agriculturein Germany (Niggli et al. 2018).

Functional biodiversity: Spatial effect of a wildflower strip against vegetable pests



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Parasitisation of cabbage moth (Mamestra brassicae) eggs with Trichogramma wasp and Telonomus sp.

Pfiffner et al. 2003

Reduced tillage: Positive effects on abundance and biomass of earthworms (g/m²)

Treatment	All		Juvenile		Cocons
	Weight	Number	Weight	Number	Number
Plough	56.1	156.5	11.2	103.8	21
Reduced	83.3	261.8	18.8	187.0	113
Reduced/Plough	+48%	+67%	+68%	+80%	+438%

Both organic

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Berner et al. 2008: Soil & Tillage Research
Krauss et al., 2010: Soil Use & Management

Agroecological transformation of farms (and society)

Level 1: Increasing efficiency

Level 2: Replacing industrial/conventional inputs and practices with alternative practices.

Level 3: Transforming the agroecosystem so that it becomes self-regulating, regenerative, and resilient.

Level 4: Restoring farmer-consumer exchanges and creating shorter value chains.

Level 5: Societal paradigm shift in terms of consumption, policy and trade.

Gliessmann (https://www.tandfonline.com/doi/full/10.1080/21683565.2015.1130765.)

Biodiversity is also a question of risk management!

Conclusions:

- Diversification is the key to sustainably increasing yields.
- The most effective on-farm measures are diversified crop rotations, alley cropping, and to a lesser extent intercropping and mixed cropping.
- Digitization offers techniques for diversifying cropping systems and landscapes and reducing pesticides and fertilizers.
- Agroecological agriculture offers a holistic innovation strategy with *social, institutional, environmental, and technological* elements.