“Ecological precision farming” - reintegrating spatial crop diversity and ecological principles in agricultural cropping systems

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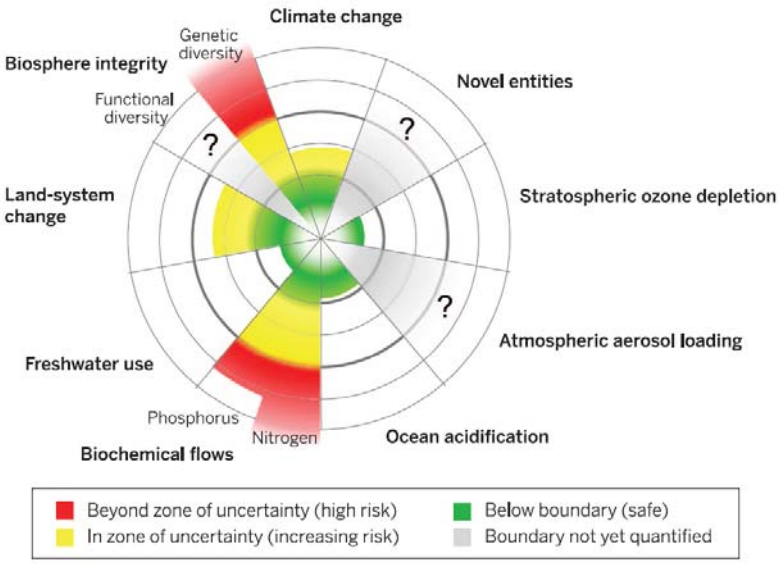
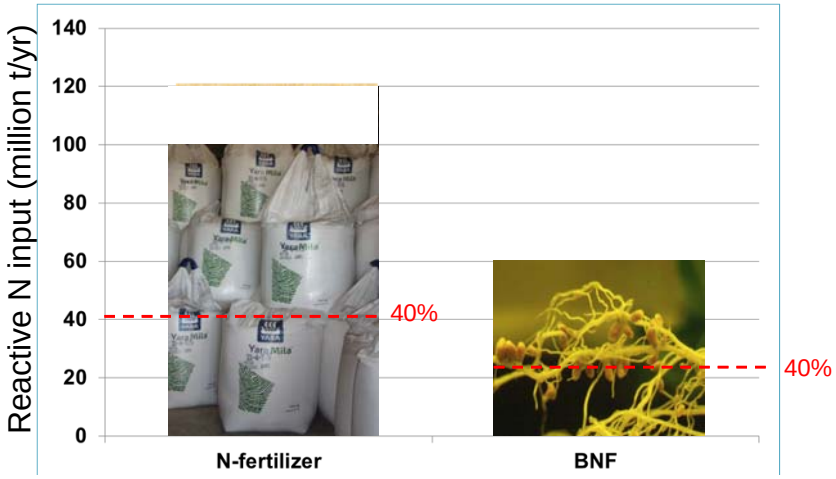
5th International ECOSUMMIT, Ecological sustainability. Montpellier, 29 Aug. – 1 Sept 2016. Session 40: Increasing species richness and genetic diversity in agriculture

Planetary boundaries



Steffens et al. 2015. Planetary boundaries: Guiding human development on a changing planet. Science 347, 736-746

Global reactive N input from fertilizers and anthropogenic mediated biological N_2 fixation



Galloway, J. N. et al. 2008. Transformation of the N cycle. Recent trends, questions and potential solutions. *Science* **320**, 889; Herridge, D.F, Peoples, M.B, and Boddey, R.M. 2008.Global inputs of biological N2 fixation in agricultural systems. Plant and Soil, 311, 1-18

Intensification

Eco-functional

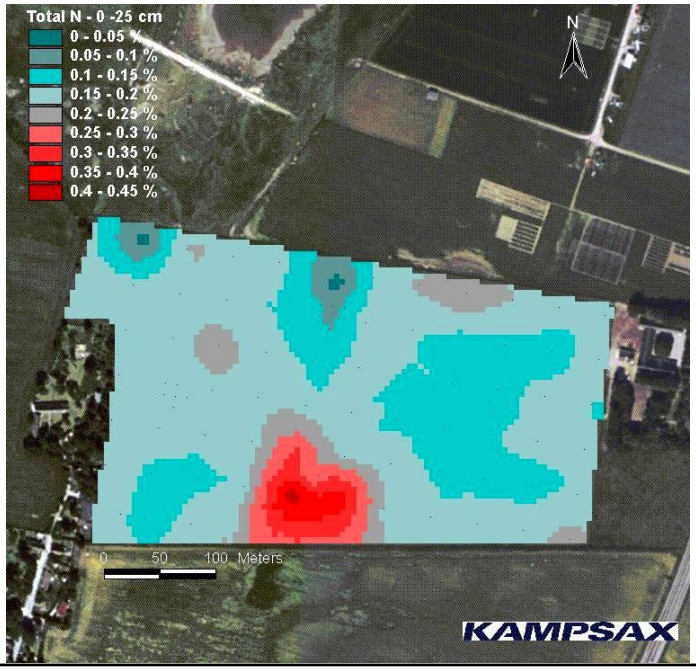
Ecological

Sustainable

- Farmer involvement in developing sustainable systems
- Increased yields with reduced use of external inputs
- Use of ecological principles and ecosystem services
- Agroecological practices
- Intentionally use functional agrobiodiversity at multiple and spatial scales

Pretty, J. N. 1998. The sustainable intensification of agriculture. Nat. Res. Forum, 21, 247-256. Cassman KG 1999 Ecological intensification of cereal production systems: Yield potential, soil quality and precision agriculture. PNAS 96, 5952-5959
Niggli, U. 2008 Vision for an Organic Food and Farming Research Agenda to 2025 , TPOrganics.

Variability in soil N (0-25 cm) within a 10 ha field



SLU

Diversification of agroecosystems

Agroecosystem Design/redesign

Planned diversity

Promotes

Agroecosystem function (e.g. productivity, regulation of pests and nutrient cycling)

Creates conditions which promotes

Promotes

Associated biodiversity

Biodiversity in the surrounding ecosystems

Vandermeer, J et al 1998 Global change and multi-species agroecosystems: Concepts and issues. Agric. Ecosys. Envir. 67, 1-22.

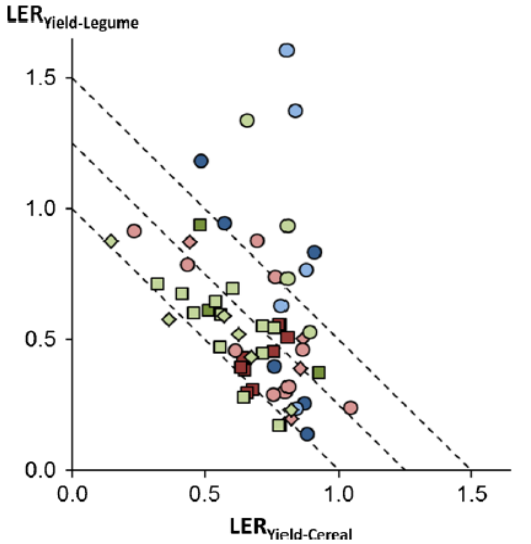
Intercropping

We know from small plot experiments that:

- differential canopy architectures, rooting depths, growth patterns in time and space of species mixtures/intercrops better match the availability of light, water and nutrient sources and enhance their use efficiencies as compared to sole crops

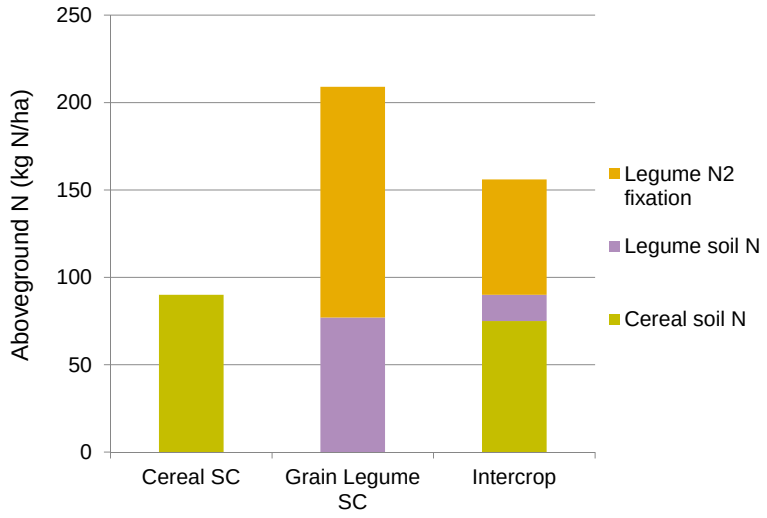
Intercropping of grain legumes and cereals in European organic farming

Yield land equivalent ratio for legume and cereal



Bedoussac, L. et al. 2015. Ecological principles underlying the increase of productivity achieved by cereal-grain legume intercrops in organic farming. A review. Agronomy for Sustainable Development 35(3), 911-935

Analysis of complementary in N use based on ^{15}N in 9 published studies of intercropping of cereals and grain legumes



Jensen, E.S. and Haugaaard-Nielsen, H. 2013. Intercropping: crop management for reduced inputs of reactive nitrogen and related GHG emissions? - prospects for a sustainable and climate smart agriculture. The Second Climate Smart Agriculture Global Science Conference UC Davis and World Bank, 22 April 2013 (unpublished)

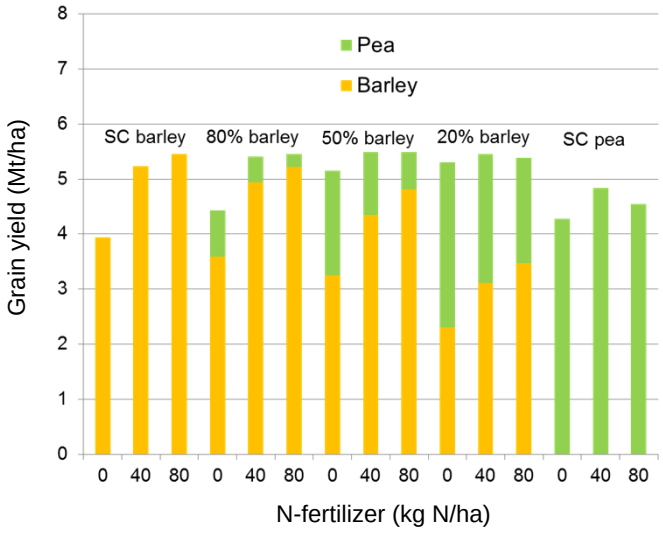
We propose the concept:
Ecological precision farming

The variability of abiotic and biotic factors in a field determines the composition of a mixed crop/intercrop, due to competition, complementarity, facilitation and compensation between species, resulting in improved use of resources and greater/more stable yields as compared to sole crops.

- **Example: N use by cereal-grain legume intercrops (low input)**
  - In parts of a field with more available soil N the cereal is more competitive and will use efficiently the available soil N
  - In parts with less available soil N, the legume will be more competitive and thrive to fix more N and add more residue N to this specific part of the field

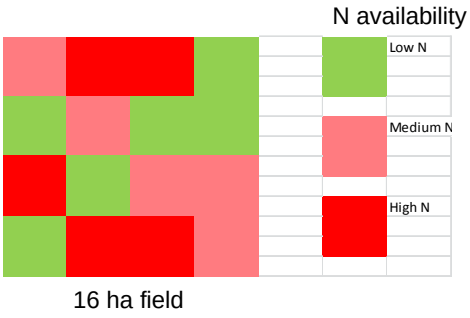
Jensen, E.S., Bedoussac, L, Carlsson, C., Journet, E-P., Justes, E. and Hauggaard-Nielsen, H. 2015. Enhancing Yields in Organic Crop Production by Eco-Functional Intensification. Sustainable Agriculture Research 4, 42-50

Grain yield of SC and IC of pea an barley as influenced by N-fertilizer and IC design



Jensen, E. S. Unpublished . Data are means of three years of experimentation. Replacement design.

Theoretical example of outcome of pea-barley IC as compared to sole cropping in a 16 ha field with variable soil N availability



	Pea SC	IC:20%B-80%P	IC:50%B-50%P	IC: 80%B-20%P	Barley SC
Total grain (Mt/16 ha)	73	86	85	81	77
LER		1.14	1.12	1.06	

Calculation based on data from pea-barley IC experiment (Jensen, unpublished)

Conclusions

- Inter-/mixed cropping of grain legumes and cereals increase resource use efficiency, and
- delivers other services, e.g. weed and disease regulation, enhanced protein conc. of cereals, ...
- Ecological precision farming (EPF) may be a method for eco-functional intensification on heterogeneous land, to make the most efficient use of resources and enhance and stabilize yields.
- The EPF concept should be validated in empirical experiments and modelling including several growth factors.