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# Enhanced yields in arable organic farming – a role for eco-functional intensification?

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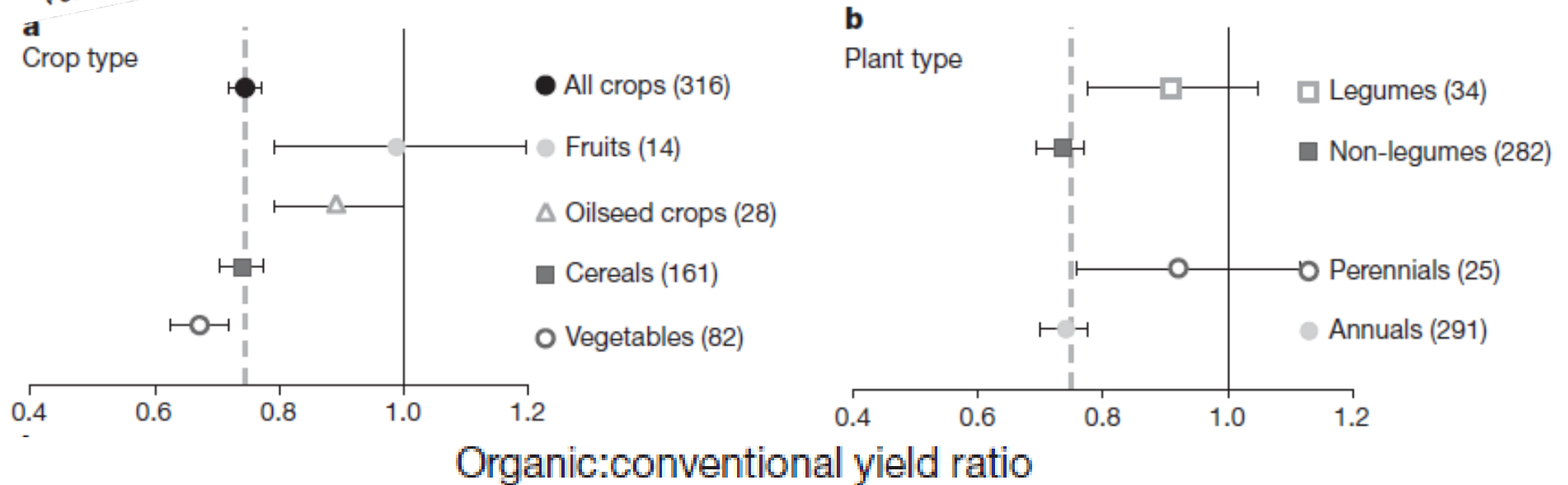




# Comparing the yields of organic and conventional agriculture

10 MAY 2012 | VOL 485 | NATURE | 229

Verena Seufert<sup>1</sup>, Navin Ramankutty<sup>1</sup> & Jonathan A. Foley<sup>2</sup>





## Yield, ecosystem services and environmental impacts

- Crop yields are only part of a range of ecosystem, social and economic services delivered by farming systems
- Comparing commodities in ton/ha without considering externalities, product quality and net margins is an incomplete exercise,
- but,
- Environmental impacts, in term of per kg of commodity, may not be very different between organic and conventional production, e.g. GHGs, thus yield improvements will improve environmental performance
- Decisions makers often base their decisions on simple yield comparisons and environmental impact assessments relative to conventional systems
- Increased food production and accessibility for the future





# Eco-functional intensification - some essential components

- Using agroecological methods for:
  - intensifying agroecosystem functions via **enhanced agrobiodiversity**, and
  - the health of soils, crops and live-stock
- Using the biological elements of the ecosystem in a structured, organized and more efficient way
- Using the knowledge of stakeholders and rely on powerful information and decision-making tools.



# Did we forget to re-design for planned spatial crop diversity in arable OF systems?



**Pre-“fossilization”  
of arable cropping**



**Conventional fertilizer/  
pesticide-based  
arable cropping**



**Organic farming  
arable cropping?**

# The challenge

Can annual crop yields, N use efficiency and other ecosystem services be enhanced by eco-functional intensification using planned spatial crop diversity?

Since arable OF systems are often N-limited, it is essential to include crop species with complementary functional traits for N acquisition, such as cereals and grain legumes



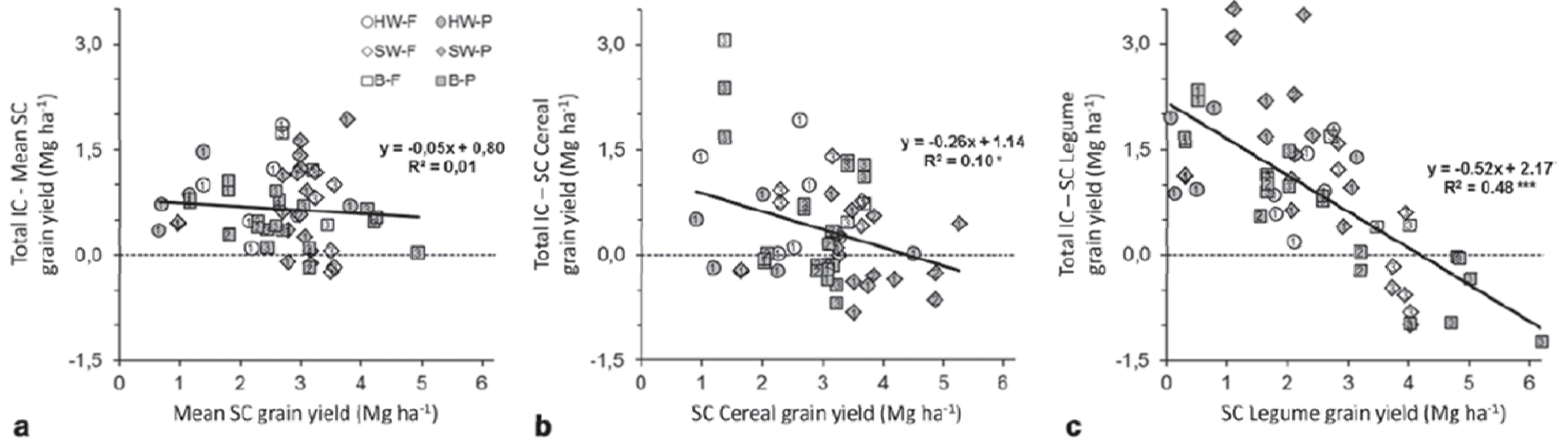


**Intercropping** – planned spatial crop diversity - the simultaneous cultivation of several species on a field, at least part of the growing season





# Grain legume-cereal intercrops out-yield sole crops, especially when sole crop yields are low



Bedoussac, L., Journet, E-P., Hauggaard-Nielsen, H., Naudin, C., Corre-Hellou, G., Prieur, L. Jensen, E.S. and Justes, E. 2014. Eco-Functional Intensification by Cereal-Grain Legume Intercropping in Organic Farming Systems for Increased Yields, Reduced Weeds and Improved Grain Protein Concentration. In: "Organic farming, prototype for sustainable agricultures" Ed. Bellon, S. Chapter 3. pp. 46-64. Springer

# How to add apples and bananas?



## The Land Equivalent Ratio (LER)

$$LER_{AB} = \frac{Y_{AB}}{Y_{AA}} + \frac{Y_{BA}}{Y_{BB}}$$

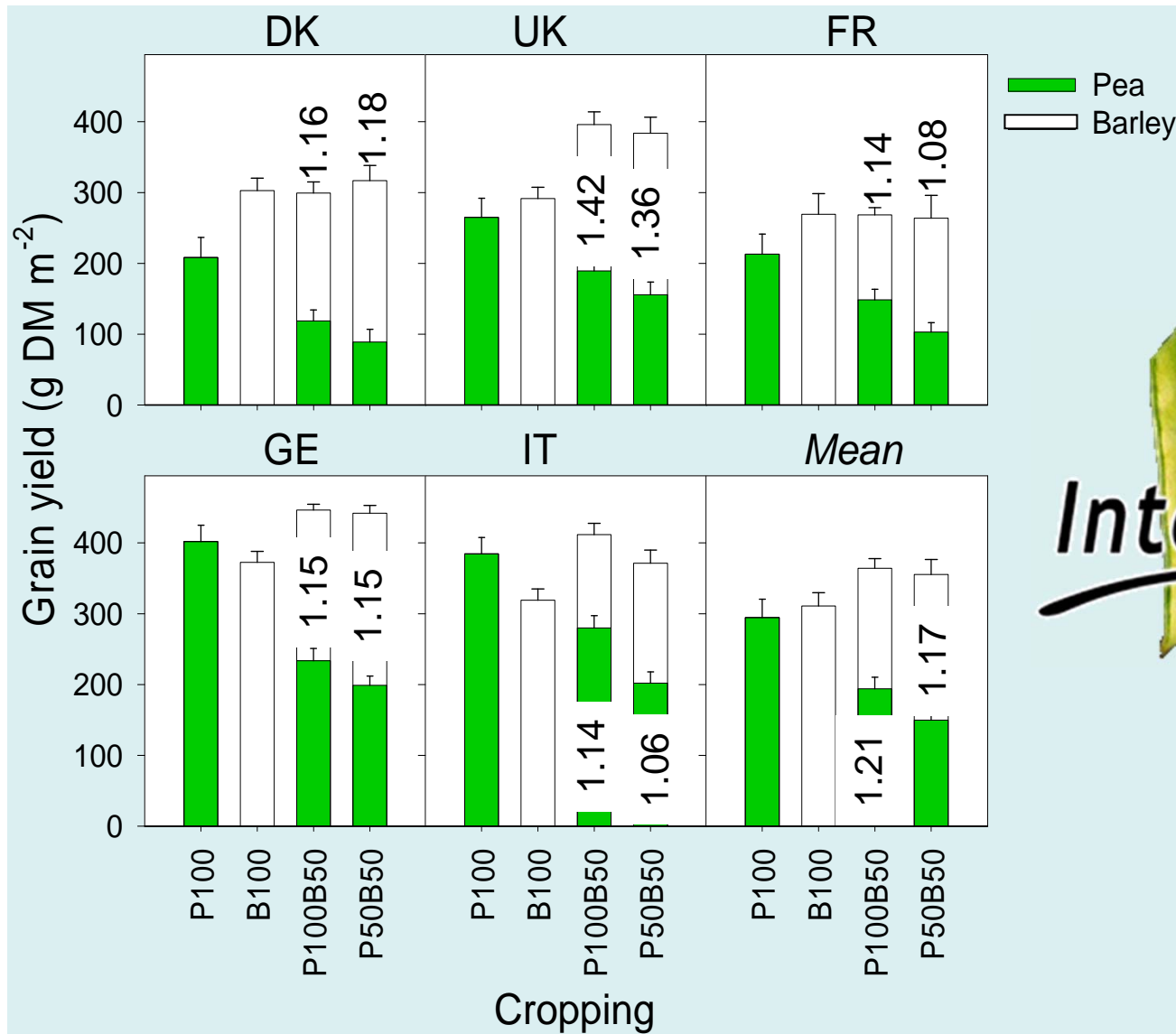
*LER > 1: Advantage from intercropping*

*LER < 1: Advantage from sole cropping*





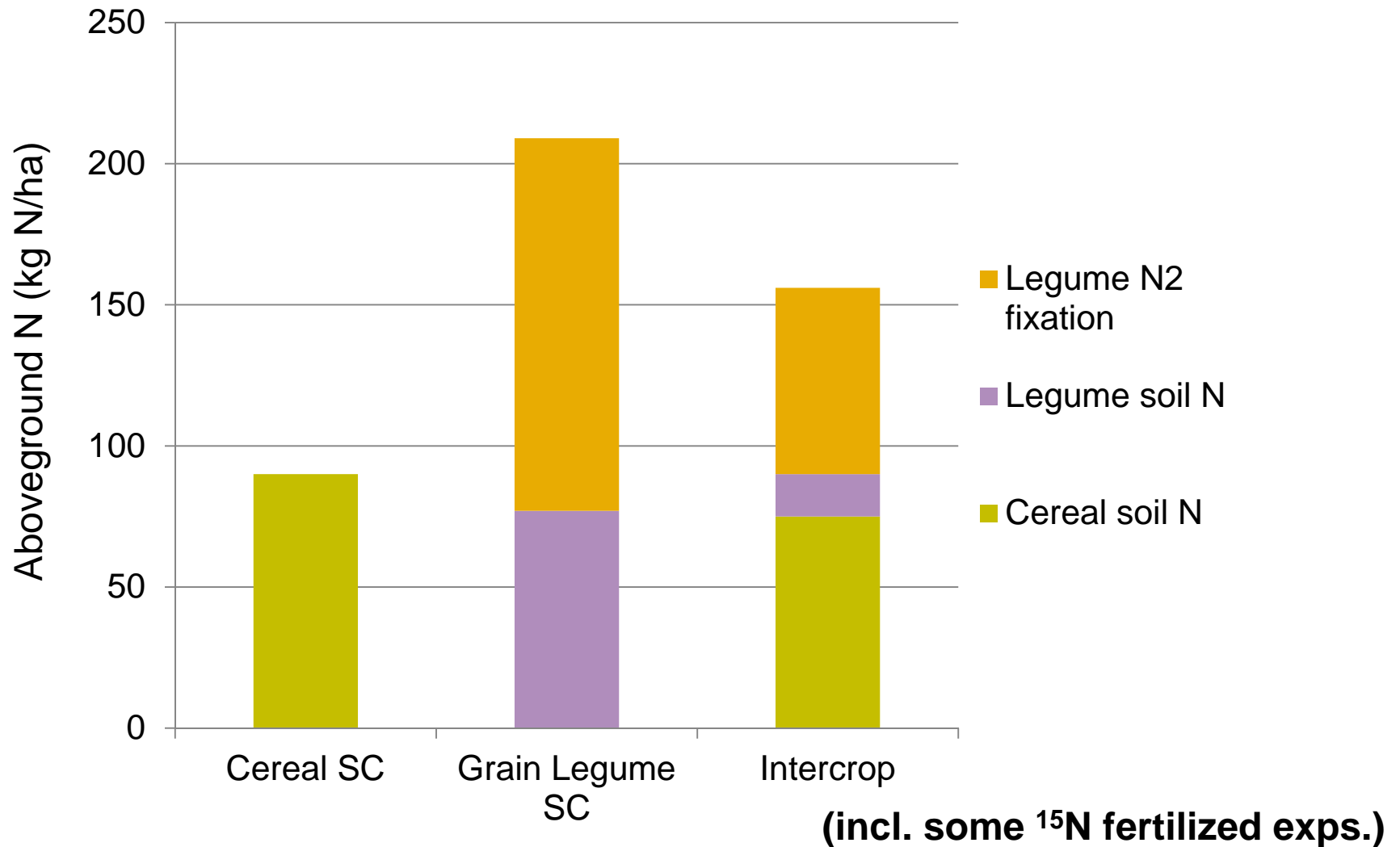
# Agronomic performance of pea-barley organic intercrops in five European countries. Avg. 3 yrs



Jensen, E. S. et al 2006. Intercropping of cereals and grain legumes for increased production, weed control, improved product quality and prevention of N-losses in European organic farming systems. Final report EU-project INTERCROP, QLK5-CT-2002-02352

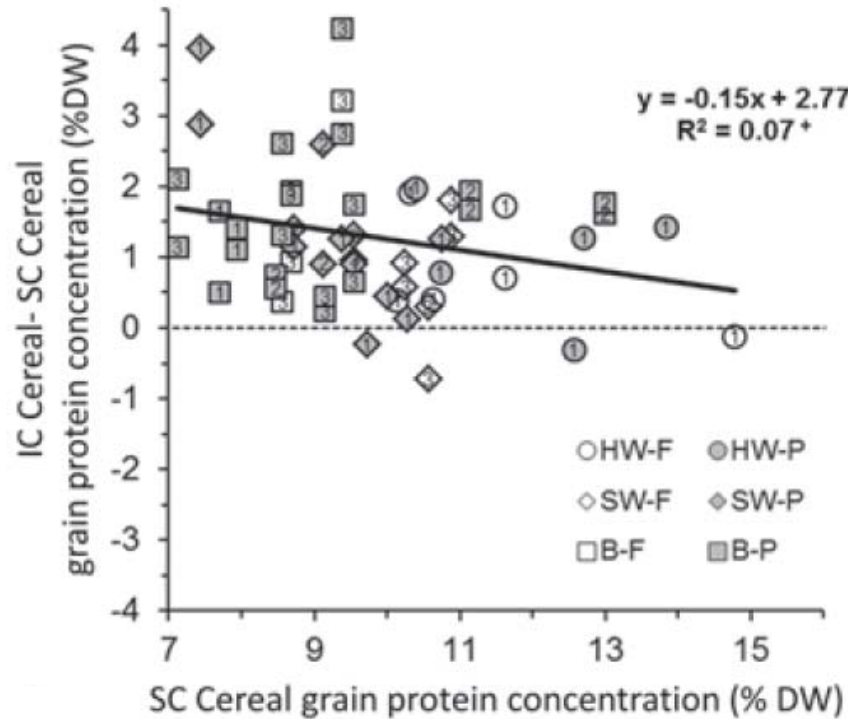


## Analysis of sharing and complementary N use based on $^{15}\text{N}$ in 9 studies of intercropping of cereals and grain legumes

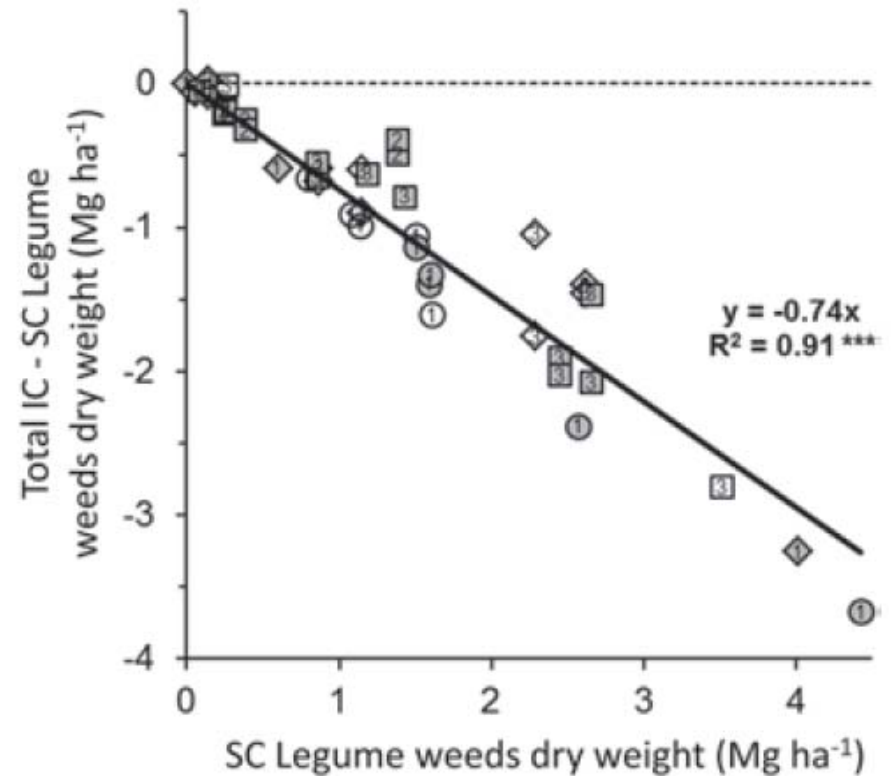


Jensen, E.S. and Haugaaard-Nielsen, H. 2013. Intercropping: crop management for reduced inputs of reactive nitrogen and related GHG emissions? - prospects for a sustainable and climate smart agriculture. The Second Climate Smart Agriculture Global Science Conference UC Davis and World Bank, 22 April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

## Protein concentration in cereal



## Weeds in IC versus SC legume



Bedoussac, L., Journet, E-P., Hauggaard-Nielsen, H., Naudin, C., Corre-Hellou, G., Prieur, L. Jensen, E.S. and Justes, E. 2014. Eco-Functional Intensification by Cereal-Grain Legume Intercropping in Organic Farming Systems for Increased Yields, Reduced Weeds and Improved Grain Protein Concentration. In: "Organic farming, prototype for sustainable agricultures" Ed. Bellon, S. Chapter 3. pp. 46-64. Springer



## Additional intercrop services

- Yield stability higher or intermediate
- Reduced grain legume lodging
- More efficient use of light, S, P, K...
- Improved plant health
- Residue C:N -> N synchrony
- Reduced N leaching rel. to GL SC
- Reduced N<sub>2</sub>O emissions



e.g. Hauggaard-Nielsen, H., Jørnsgaard, B., Kinane, J., and Jensen, E.S. 2008. Grain Legume – cereal intercropping: The practical application of diversity, competition and facilitation in arable and organic cropping systems. *Renewable Agriculture and Food Systems*: 23, 3-12.



## IC challenges

- Breeding and availability of cultivars suitable for IC
- Integration of IC in the rotation
- Attitudes and lock-in effects in food systems,
  - Considered old-fashion agriculture
  - Wholesalers and retailers not used to handle mixed grains – may restrict to on-farm use





Participatory action and learning research with farmers for prototyping and sustainability assessment of new intercrop designs and focus groups with farmers and other stakeholder in the food system to identify barriers and solutions





# Roadmap for R&D within eco-functional intensification by intercropping

- Attitudes and lock-in effects in the food system
- Breeding of suitable cultivars for IC, e.g. matching species cultivars for mature harvesting
- Simulation modelling of IC systems
- Integration of IC in the rotation
- “Ecological precision farming” - self-regulation at the field scale
- Long-term C/N dynamics, soil agrobiodiversity and GHG emissions?
- Multicriteria sustainability assessment
- Perennial grain intercrops

# The future?



**Perennial cereal (Kernza) - clover polyculture**



## Summary

- Eco-functional intensification by intercropping of annual grain legumes and cereals enhances significantly (often > 20%) the grain yield and N resource use,
- while simultaneously delivering other services
- A roadmap for R&D includes modelling approaches, research on rotational design, soil biodiversity and long-term soil C/N dynamics, GHGs and perennial ICs of cereals and legumes
- We suggest strengthening socio-technological innovation of intercropping systems via participatory action and learning research with farmers and other stakeholders to enhance adaption of IC in OF systems



**Thank you**