Enhanced yields in organic crop production through crop diversification intensifying the role of eco-functionality

Eric-Steen Jensen, Georg Carlsson, Laurent Bedoussac, Etienne-Pascal Journet, Eric Justes, Henrik Hauggaard-Nielsen

SLU
Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

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

Erik Steen Jensen

G. Carlsson, SLU,Sweden | **L. Bedoussac ENFA, France** | **E-P. Journet CNRS, France** | **E. Justes INRA, France** | **H. Hauggaard-Nielsen, RUC, DK**

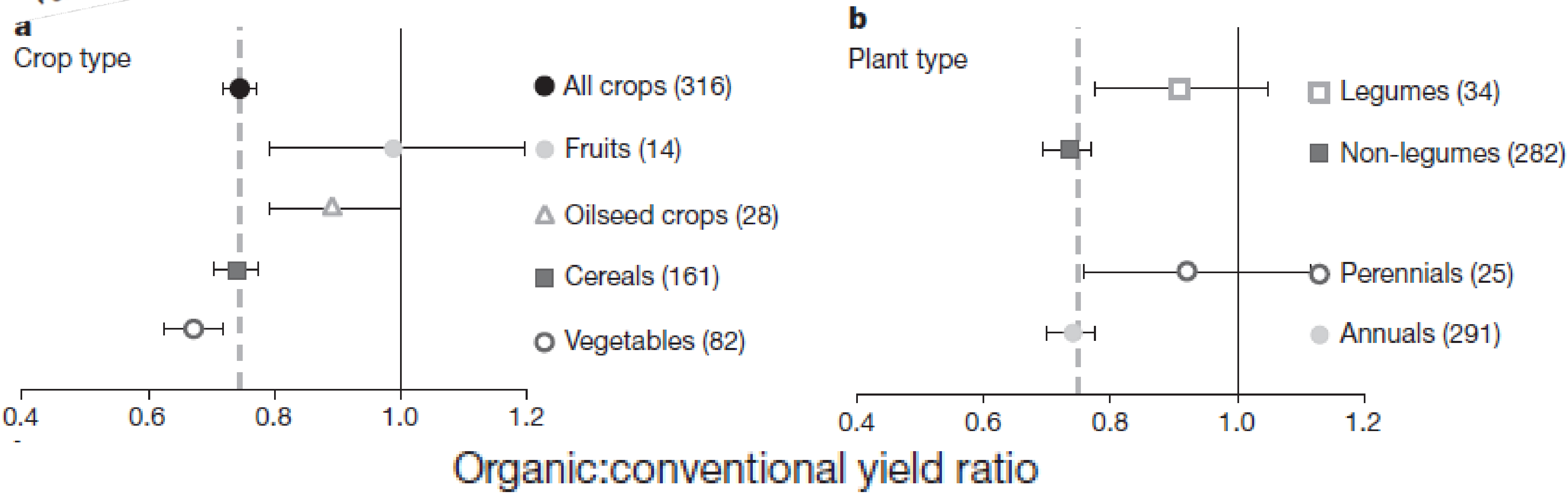




Comparing the yields of organic and conventional agriculture

Verena Seufert[1], Navin Ramankutty[1] & Jonathan A. Foley[2]

10 MAY 2012 | VOL 485 | NATURE | 229



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.

Niggli, U., Slabe, A., Schmid, O., Halberg, N,and Schluter, M. 2008 Vision for an Organic Food and Farming Research Agenda to 2025 Organic Knowledge for the Future, TPOrganics..

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

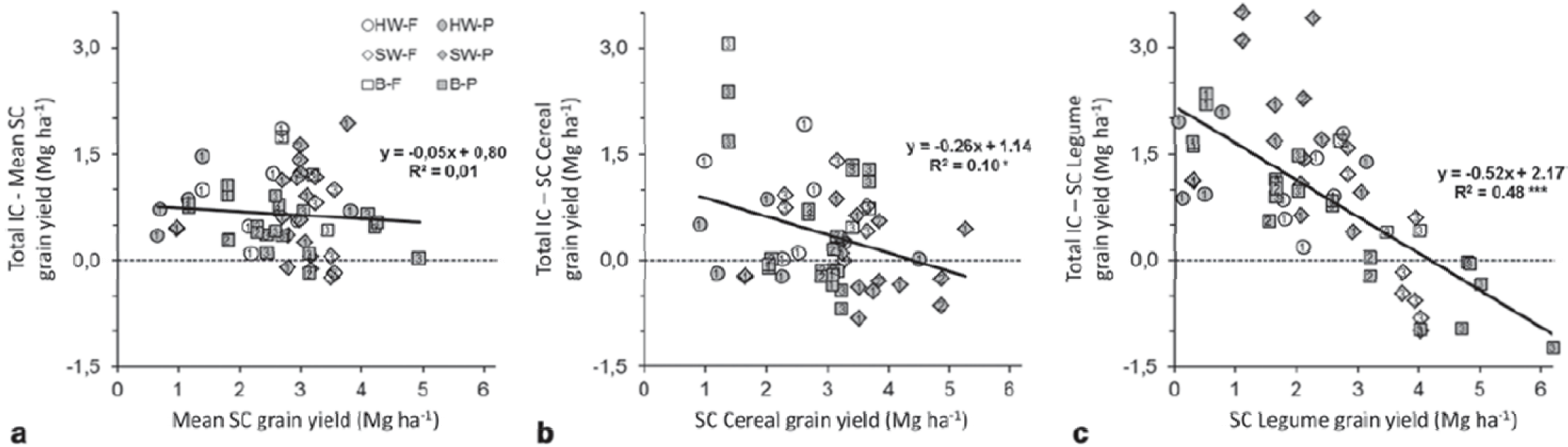
Can annual crop yields, N use efficiency and other ecosystem services be enhanced by eco-functional intensification using planned spatial crop diversity?

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

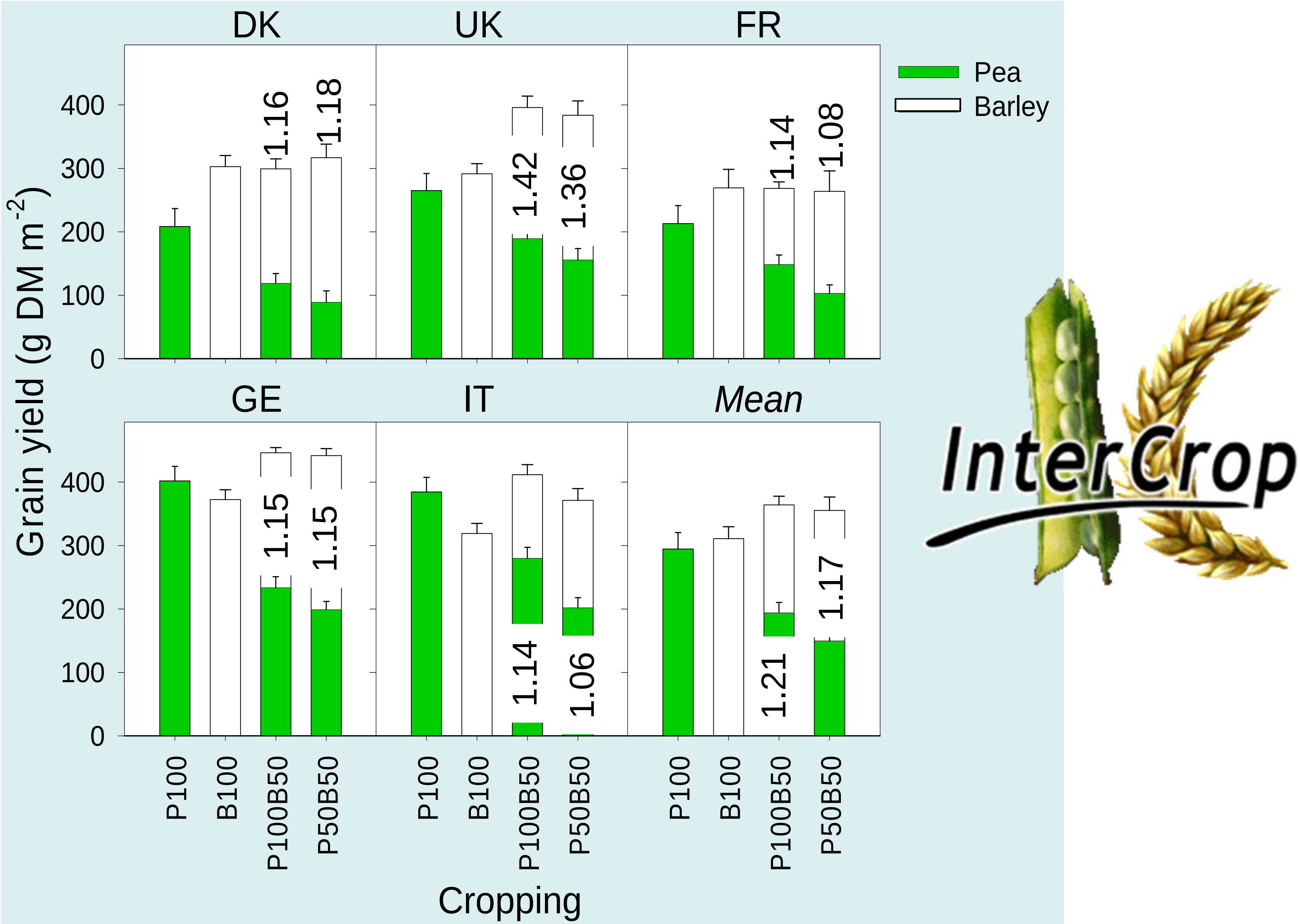
How to add apples and bananas?

The Land Equivalent Ratio (LER)

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

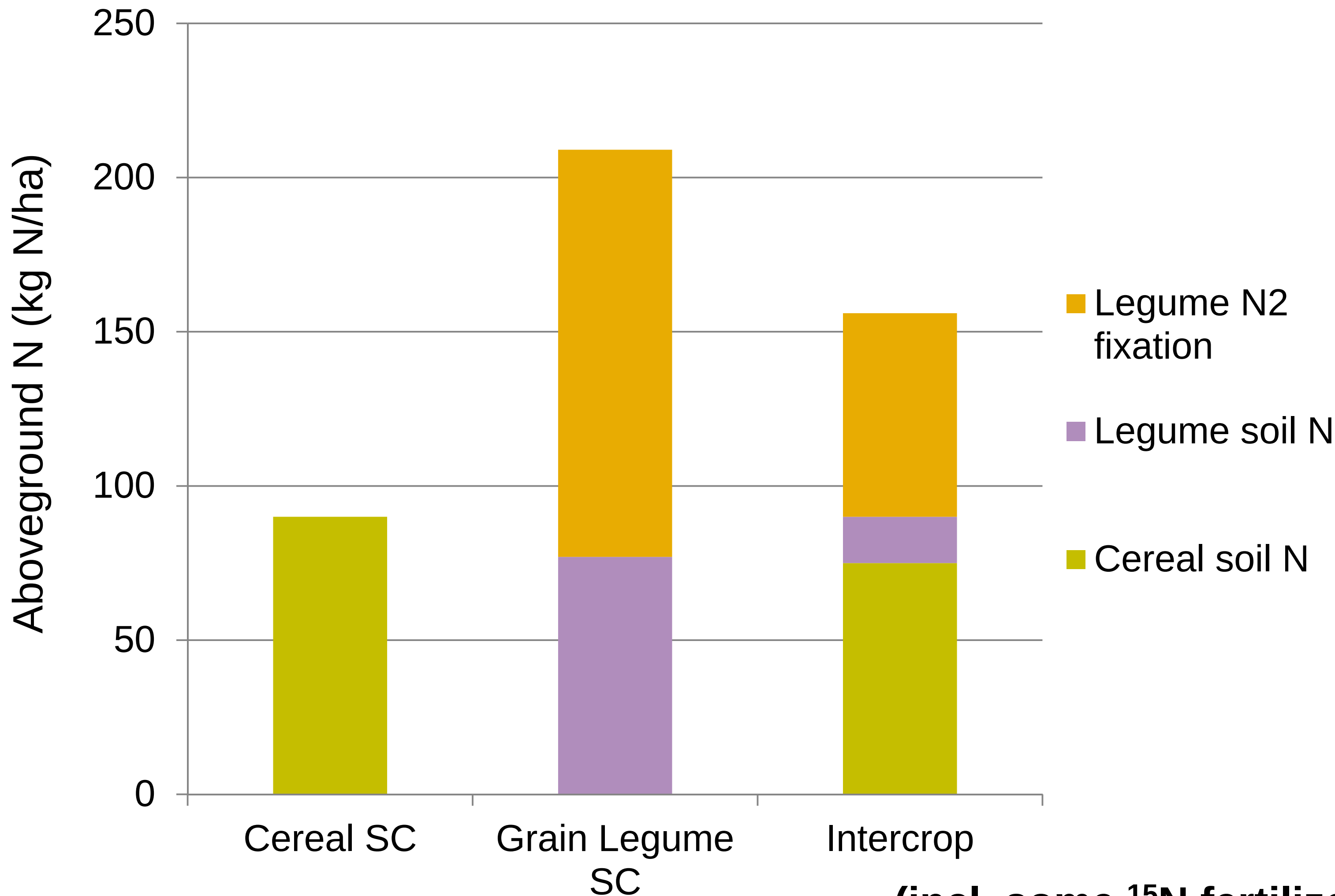
LER > 1: Advantage from intercropping
LER < 1: Advantage from sole cropping

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}N in 9 studies of intercropping of cereals and grain legumes

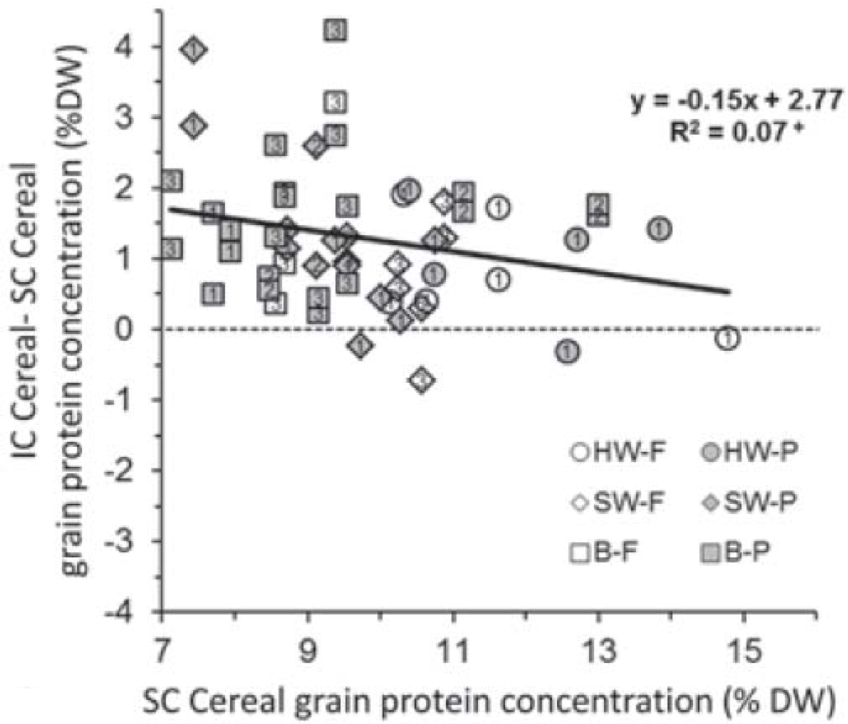


(incl. some ^{15}N fertilized exps.)

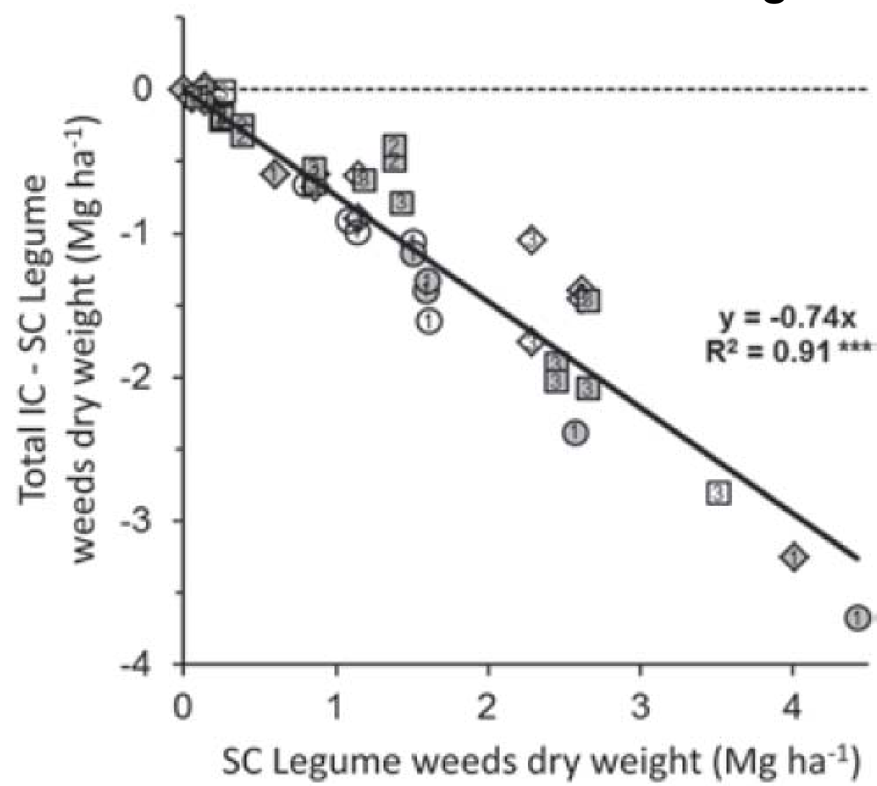
Jensen, E.S. and Haugaaard-Nielsen, H. 2013. Intercropping: crop management for reduced inputs of reactive nitrogen and related GHG emissions? - prospects for a sustainable and climate smart agriculture. The Second Climate Smart Agriculture Global Science Conference UC Davis and World Bank, 22 April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

SLU

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_2O 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 croppiung 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

Photo: Richard Hayes, CSIRO

SLU

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