Second International Conference on

Organic Food Quality and Health Research

June 5-7, 2013
Warzaw, Poland

Researching links between sustainable and healthy organic systems

Niels Halberg

International Centre for Research in Organic Food Systems

ICROFS

Sustainable agriculture – the way forward

BASF
The Chemical Company

Sustainability in agriculture means achieving higher yields from less land with less water and energy...

…while ensuring the profitability of farming,...

…caring for the environment...

…and meeting the expectations of society.

➔ **We make progress in sustainability through innovations at all levels!**

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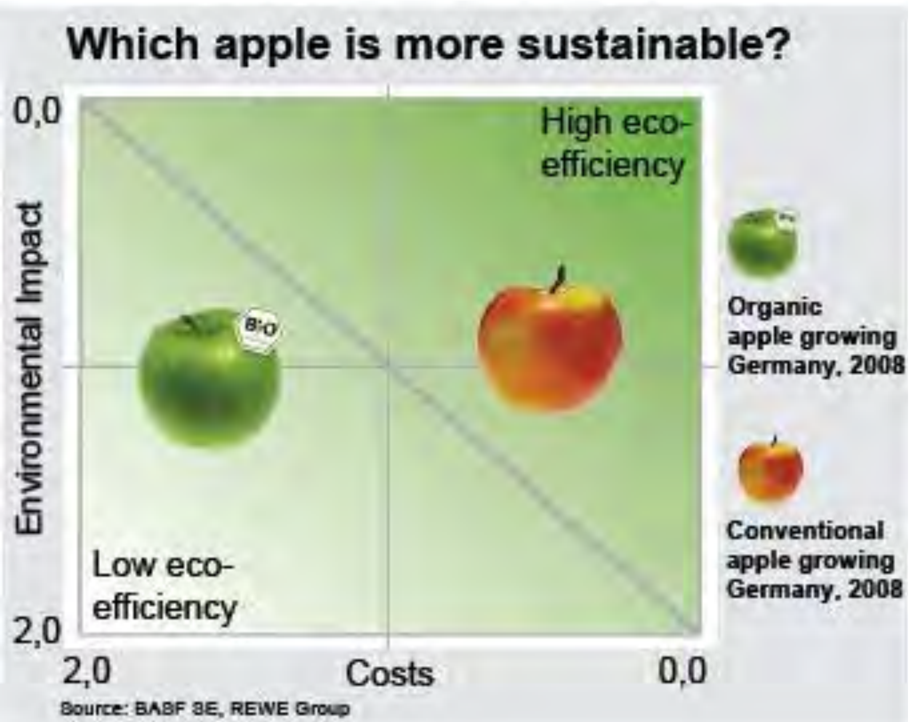
Eco-efficiency analysis in apple growing – Organic vs. Conventional?



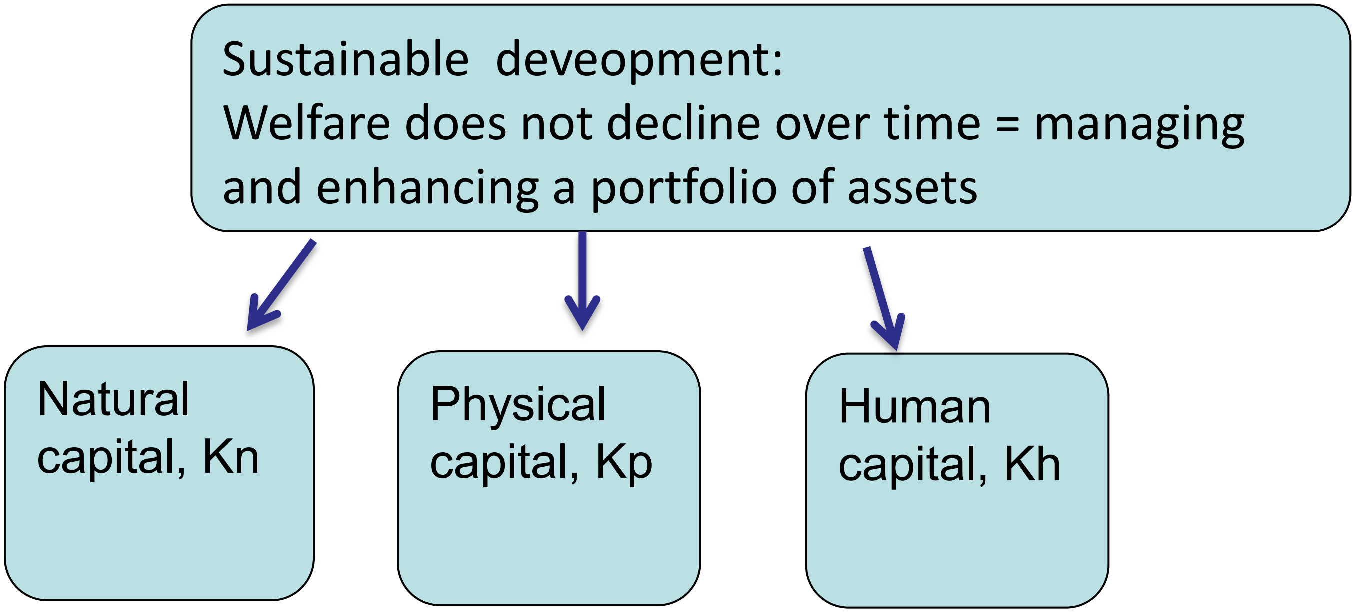
- No surprise: cost of organic is higher
- Surprise: conventional apple has a slightly better ecological profile
- Organic causes less waste water and consumers less energy form fertilizer and pesticide production
- But overall energy consumption, CO_2 emission and land use is higher
- The drivers are
  - ➔ Higher use of machinery (+70%)
  - ➔ Lower yield (-30%)

➔ Sustainability can be quantified by a comprehensive eco-efficiency analysis

FAO/OECD Expert Meeting: IMPROVING FOOD SYSTEMS FOR SUSTAINABLE DIETS IN A GREEN ECONOMY. -September 2011

- FAO defines sustainable diets as
  - “those diets with low environmental impacts
  - that contribute to food and nutrition security and to healthy lives
  - for present and future generations.
- Sustainable diets are
- protective and respectful of biodiversity and ecosystems,
- culturally acceptable, accessible, economically fair and affordable,
- nutritionally adequate, safe and healthy,
- while optimizing natural and human resources” (FAO, 2010c).

Sustainability as maintaining and enhancing critical capital



Can Kp and Kn substitute for erosion of Kn?

Weak S: Yes, All Kn are non-essential
Strong S: No, Some Kn are essential

- What is the critical capital for ecosystem services?
- Which capital assets can resp. cannot be substituted by other types of capital?

Barbier & Marcandia, 2013:
A new Blueprint for a Green Economy

The classical 3 dominant visions of agricultural sustainability

- Food sufficiency
  - Agriculture as instrument for feeding people
- Stewardship
  - Ecological balance and bio physical limits
- Community
  - Agrees with stewardship but also focus on:
  - Vital, coherent rural cultures

G. Douglass, 1984

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The meaning of sustainability:
Assessment with a long term perspective

Thompson, 1995, after Douglass, 1984

- ***Resource sufficiency***

(food sufficiency):

- Efficient food production
- Foreseeable use of resources,
- Fulfilment of present and future needs: Capacity to produce
- Substitutability among resources
- Nature is robust – a resource for humans

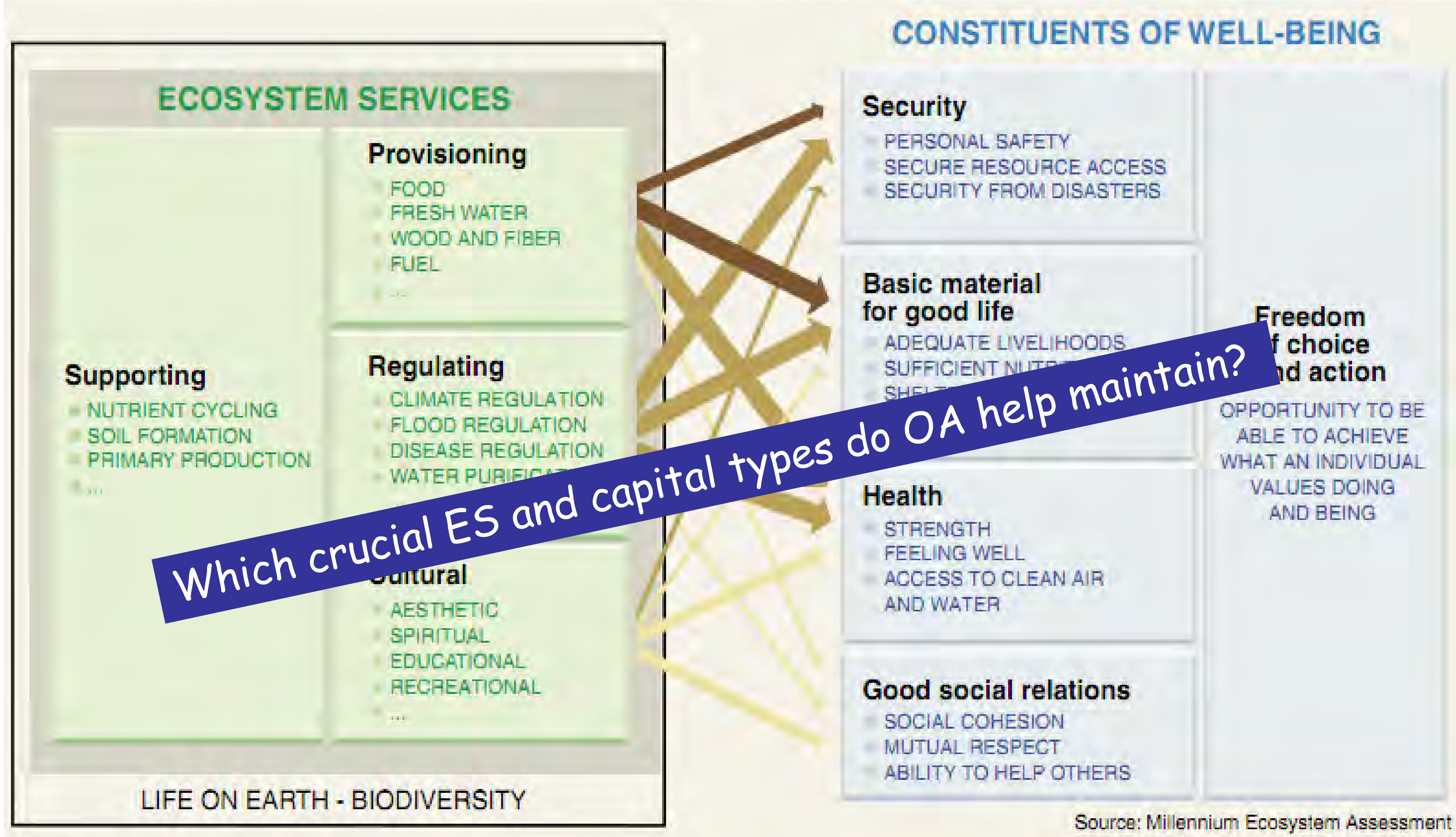
- ***Functional integrity***

(Stewardship & Community):

- Availability and regeneration of critical renewable resource base
- Resilience and avoidance of irreversible changes of complex agro-ecological and social systems
- Build institutions to support moral obligations
- Nature is "vulnerable" – we are an integrated part
- Systemic approach, link to health

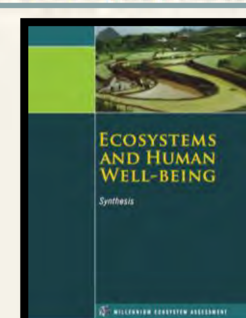
What may Organic Farming offer in relation to goals for sustainability?

Which crucial ES and capital types do OA help maintain?



Source: Millennium Ecosystem Assessment

Ecosystem services



The four basic principles of organic agriculture

Endorsed by IFOAM, September 2005

	Health	Ecology	Fairness	Care
Principle[1)]	Agriculture sustain and enhance health of soil, plant, ani...	Agriculture based on living ecological systems a...	Relationship ... ...d to common environment and life opportunities	... and ...sponsible management in light of future generations and environment
Keywords and concepts	**Immunity, resilience, regeneration** **Healthy soil** **Healthy crops** **Healthy livestock** **(Healthy people?)**	**Recycling, efficient resource use, ecological balance, genetic and agricultural diversity, habitats**	**Ecologically just use of natural resources and environment**	**Technology assessment, and risk aversion, acknowledge of limited understanding of ecosystems, respect for practical experience and indigenous knowledge**

Which "sustainability concept" apply to each principle?


PRINCIPLES of ORGANIC AGRICULTURE

Principle of **HEALTH**
Organic Agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible.

Principle of **ECOLOGY**
Organic Agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.

Principle of **FAIRNESS**
Organic Agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities.

Principle of **CARE**
Organic Agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment.

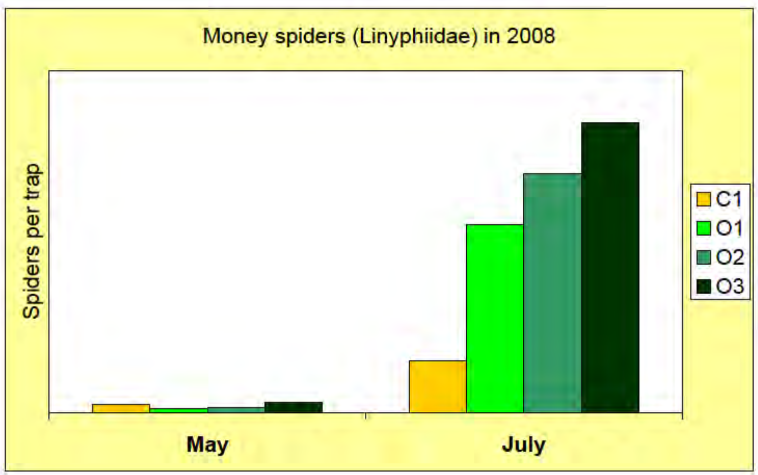
OA is good for biodiversity and biodiversity is good for OA (…?!)

Organic farmers use more *Agro-ecological methods*:

- Mixed crop rotations, intercropping, …
- Grasslands and green manure,
- Habitats and non-farmed areas
- Non-chemical pest management

Promoting *functional diversity* means enhancing and benefitting from *Ecological service functions*:

- Pollination
- Pest and disease prevention
- Biodiversity preservation,
- Soil quality
- Resilience
- In situ conservation of genes



Growing carrots in rows between grass-legume mixtures for enhanced pest control and nutrient recycling in Danish horticulture crop rotation experiment "Vegqure", ww.vegqure.elr.dk/uk
(Source: ICROFS)

Soil degradation and food security

Soil as a provisioning ecosystem service

- Soil degradation
  - Erosion
  - Compaction
  - Crusting and salinization
  - Nutrient mining
  - Loss of soil organic matter

→

- Food security
  - Yield reduction
  - Efficiency of input use reduced
  - Micro nutrient deficiency

Need for paradigm shift in land husbandry and Principles and practices for soil management

R. Lal, Food Security journal, 2009

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Solutions for soil and food quality improvements

- Improve soil structure and quality
- Adoption of diversified cropping systems,
- Agro-forestry and mixed farming
- No-till agriculture
- On-farm experimentation and adaptation
- Adoption of diversified cropping systems, indigenous foods, GMO's high in nutrients

- Mulching and recycling organic residues
- Inoculating soils for improved Biological Nitrogen Fixation
- Microbial processes to increase P-uptake
- Water conservation and water use efficiency

R. Lal, 2009; Okalebo et al., 2006

With adoption of proven management options, global soil resources are adequate to meet food and nutritional needs of the present and future population

Organic Agriculture and soil quality

Results from different long term experiments:

- The organically treated soils were
  - physically more stable,
  - contained smaller amounts of soluble nutrients and
  - biologically more active than conventional

  (DOK trials, Mäder et al., 2002)
- Under organic farming the soil organic matter
  - captures and retains more water in the crop root zone
- Water capture in organic fields can be 100% higher than in conventional fields during torrential rains *(Rodale Institute, 2008)*

Soils as "regulating ecosystem services"

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Carbon sequestration in long term experiments

Field trial	Components compared	Carbon gains (+) or losses (–) kg ha⁻¹ yr⁻¹	Relative yields of the respective crop rotations
DOK Experiment, CH (Mäder, et al., 2002; Fließbach, et al. 2007) Running since 1977	Organic, FYM composted	42	83 %
	Organic, FYM fresh	–123	84 %
	IP, FYM fresh, mineral fertilizer	–84	100 %
	IP, mineral fertilizer	–207	99 %
SADP, USA (Teasdale, et al., 2007) Running 1994 to 2002	Organic, reduced till	+ 819 to + 1738	83 %
	Conventional, no till	0	100 %
Rodale FST, USA, (Hepperly, et al., 2006; Pimentel, et al., 2005) Running since 1981	Organic, FYM	1 218	97 %
	Organic, legume based	857	92 %
	Conventional	217	100 %
Frick Reduced Tillage Experiment, CH (Berner, et al., 2008) Running since 2002	Organic, ploughing	0	100 %
	Organic, reduced tillage	879	112 %
Scheyern Experimental Farm, D [illegible] Running since 1990	Organic	[illegible]0	57 %
	Conventional	–120	100 %

Soils as "regulating ecosystem services"

Niggli et al., 2009, FAO brochure

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Rodale FST, [illegible] (Hepperly, e[illegible] Pimentel, et[illegible] Running sin[illegible]	[illegible]	[illegible]	7 %
	[illegible]	[illegible]	2 %
	[illegible]	[illegible]	0 %
Frick Reduc[illegible] Experiment, CH (Berner, et al., 2008) Running since 2002	[illegible]	[illegible]	0 %
	Organic, reduced tillage	879	112 %
Scheyern Experimental Farm, D (Rühling, et al. 2005), Running since 1990	Organic	180	57 %
	Conventional	–120	100 %

Average difference between the best organic and the conventional treatments: 590 kg carbon (2.2 t CO_2) per hectare and year.

Niggli et al., 2009, FAO brochure

Do we simplify ES too much?

Richard B. Norgaard *(Ecol. Econ. 2010)*:

Ecosystem services:

From Eye-opening metaphor

to complexity blinder

- Stock and flow models, remuneration of simple ES

Vs.

- Accepting complexity, limitations to understanding of ecosystems

Is there a specific role for organic agriculture in the second approach?
Or, is the focus on functional biodiversity in OA part of first approach?

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Challenges for organic farming in light of the globalisation process

- Global procurement systems and Increased supermarket sales
- Long distance transport (food miles, energy use),
- Harmonisation and supply-on-demand favours
  - Large-scale production and trade
  - specialisation
- Increased global competition means
  - pressure on organic principles and
  - commodification of common goods
- Transperancy, trust, nearness…?
- Local ownership and control of certification
- Local embedment of Organic principles
- Fair trade, partition of price premium

(Hall & Mogyorody, 2001; Woodward et al., 2002; Rundgren, 2003; Schwartz, 2002; Milestad & Darnhofer, 2003; Raynolds, 2004; Alrøe et al, 2006)

IFOAM 2011
General Assembly
Motion 57

IFOAM shall position Organic Agriculture better in its own and the public perception as a holistic, sustainable farming system that is committed to further develop its practices to meet traditional and new challenges. To

ORGANIC MOVEMENT LAUNCHES A NEW SUSTAINABILITY INITIATIVE:

THE SUSTAINABLE ORGANIC AGRICULTURE ACTION NETWORK (SOAAN)

The Sustainable Organic Agriculture Action Network (SOAAN) exists to develop activities that positions organic agriculture and its related supply chains as a holistic, sustainable approach to agricultural production for all of human society. Working together as an alliance of

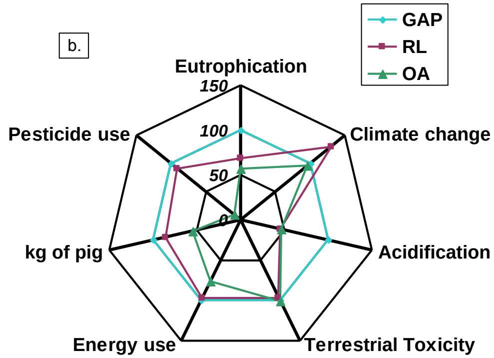
The relation between principles for organic agriculture, sustainability perspectives and indicators for benchmarking of organic farms

	Health	Ecology	Fairness	Care
Sustainability concept	**Functional integrity**	***Resource sufficiency*[5)]** **Functional integrity**	**Functional integrity**	**Functional integrity**
Practice based indicators (examples)	Soil fertility building; Diversification of crop rotation and intercropping Functional diversity Avoid soil compaction Livestock health management	*N cycling on farm* *Production and use of renewable energy* *Reduction of GHG emissions* P recycling Use of traditional breeds and diverse varieties. Maintenance of biotopes and permanent grassland	Good working conditions Recruitment Animal housing and access to outdoor areas.	Participatory innovation and technology risk assessment (biotechno-logies, molecular -omics and nano-technologies)

	Health	Ecology	Fairness	Care
Sustainability concept	**Functional integrity**	***Resource sufficiency***[5)] **Functional integrity**	***Resource sufficiency*** **Functional integrity**	**Functional integrity**
Results based indicators (examples)	Animal health and welfare indicators Soil quality indicators - changes in soil organic matter - biological soil indicators % area treated with pesticides (Cu, pyretrum etc.)	*% imported manure,* *N surplus, kg* ha^{-1} *Energy use (MJ kg* $product^{-1}$*)* *% renewable energy use* P Surplus, kg ha^{-1} % non-cultivated habitats of total farm area.	(see ecology) *Global warming impact (g* CO_2*-eq kg* $product^{-1}$*)* *Ammonia emission* Accidents to farm workers $years^{-1}$ Social conditions	New technologies implemented based on careful risk and benefit assessments Technologies avoided from a risk aversion principle

Indicators should:

- Describe relevant aspects of a food or farming systems,
- Be meaningful to the farmer and to other parties,
- Be scientifically valid and reproducible,
- Be possible to register and calculate by farmers or local advisors at reasonable costs,
- Be sensitive to changed management practice and be able to show changes over time,
- Be predictable and suitable for strategic (multi-objective) decision making.



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Types of Agri-environmental indicators

-linking farmer practices to environmental impacts

1. Farmers practise
2. Resource & Input use
3. Input-output account
4. Emission estimates
5. Environmental Impact, (aggregation over food chain in categories)

1. Fertiliser plan made?, harvest interval respected?
2. Amounts of Feed, Fertiliser, Energy, Pesticides,
3. Nutrient surplus per ha, Fossil energy per kg, Feed efficiency
4. Nitrate loss, Exo-tox (pesticides)
5. Acidification, Global Warming Potential, per kg product

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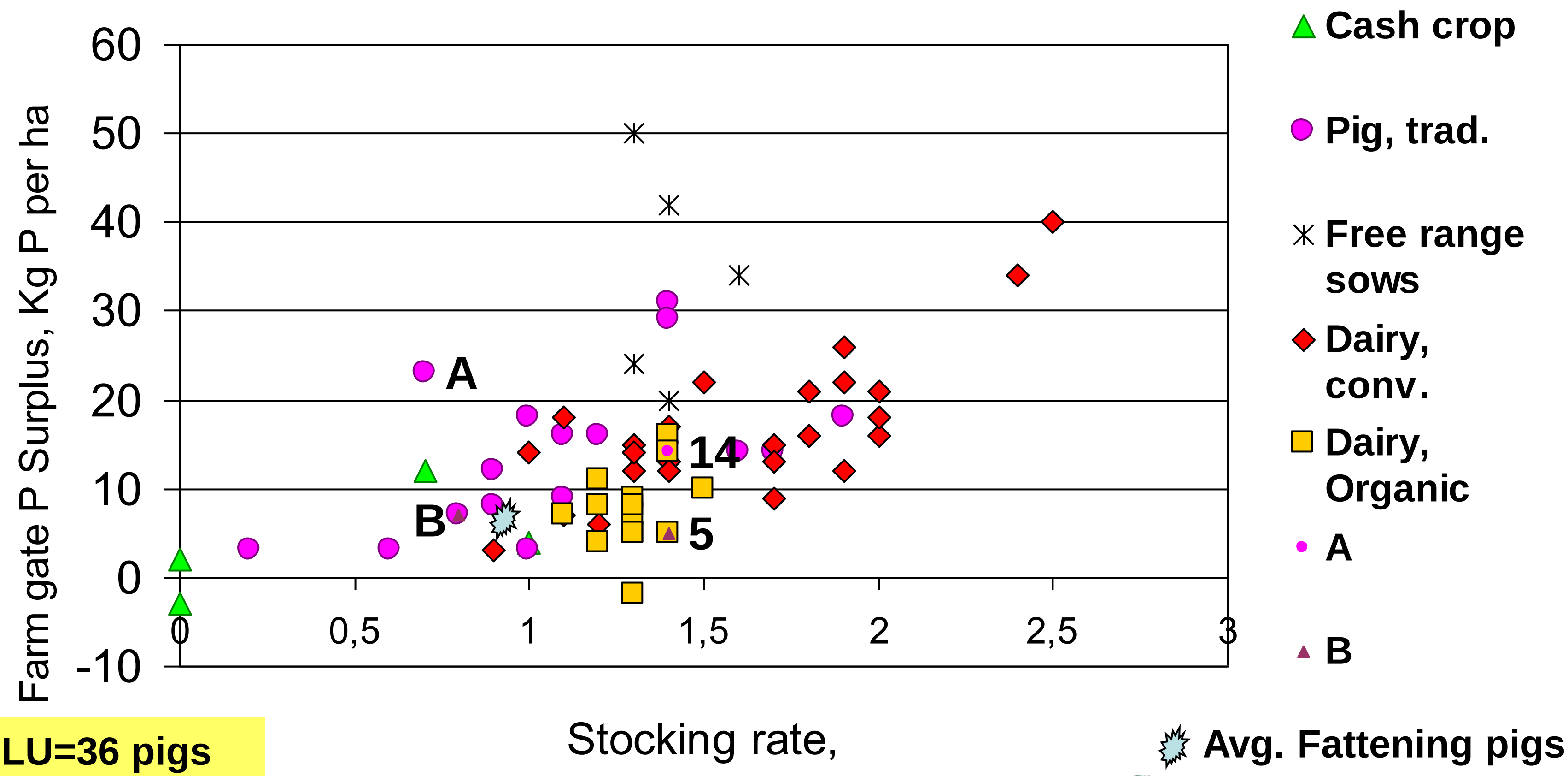
Reference values for benchmarking:

Farmgate P surplus by farm type and manure P supply



Stocking rate,
livestock units per ha, after net manure sale

1 LU=36 pigs
30-102 kg

("Studielandbrug", Danish private farms, 2-6 year farm avrg., 1997-2002)

(Nielsen, 2004)

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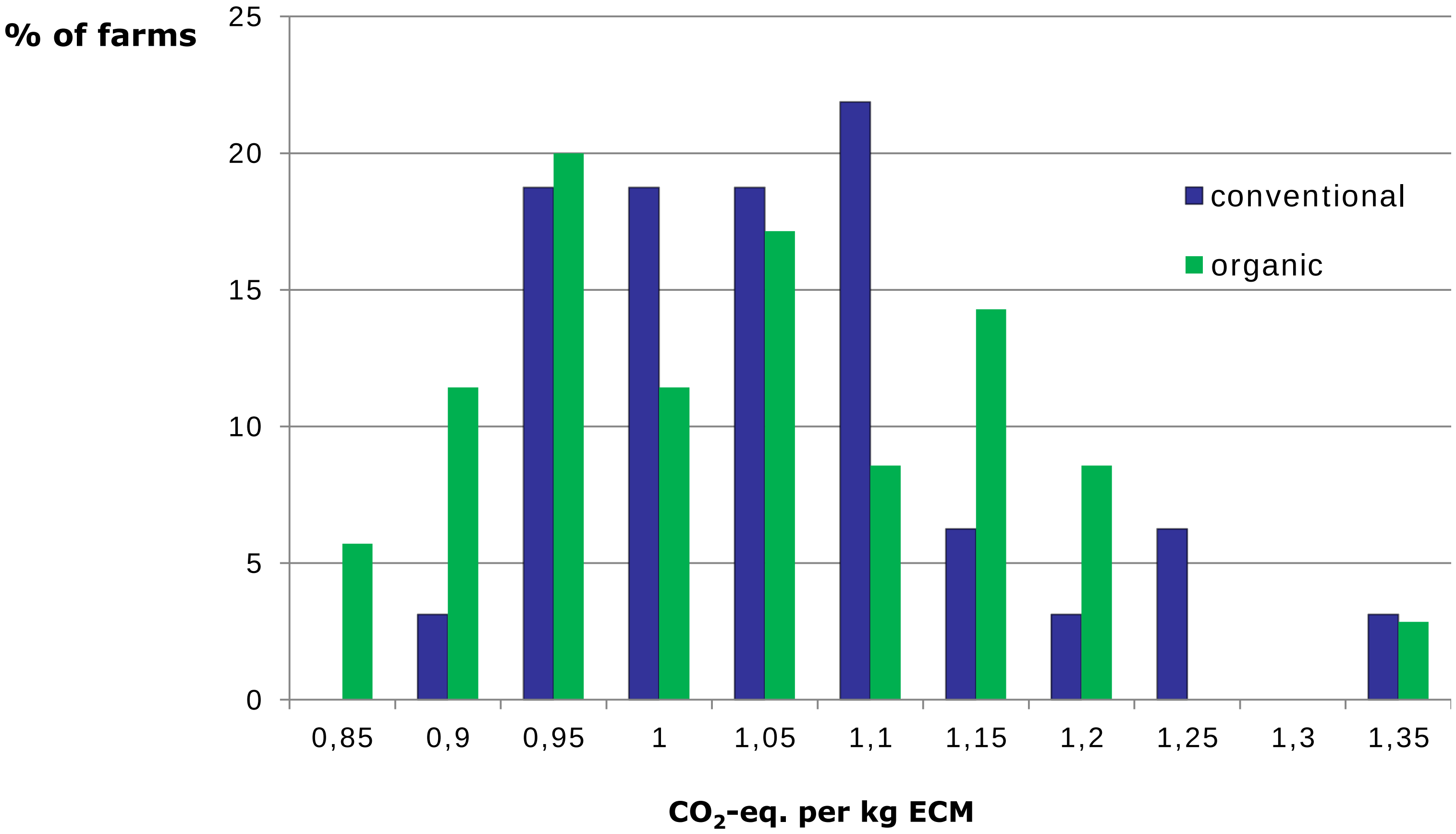
Variation in CF of milk between farms



Kristensen et al, 2011

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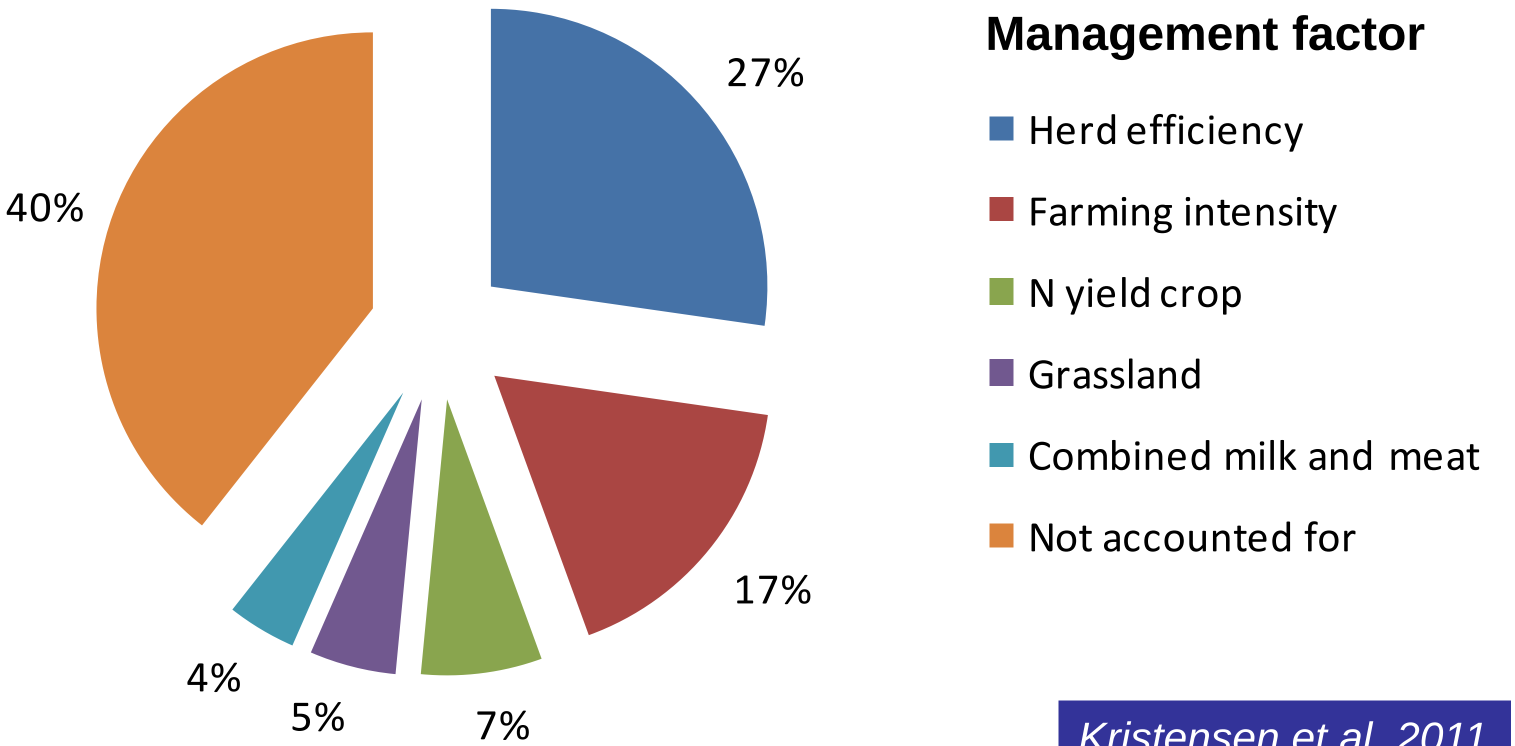
Variation in CF of milk explained by different management factors



Kristensen et al, 2011

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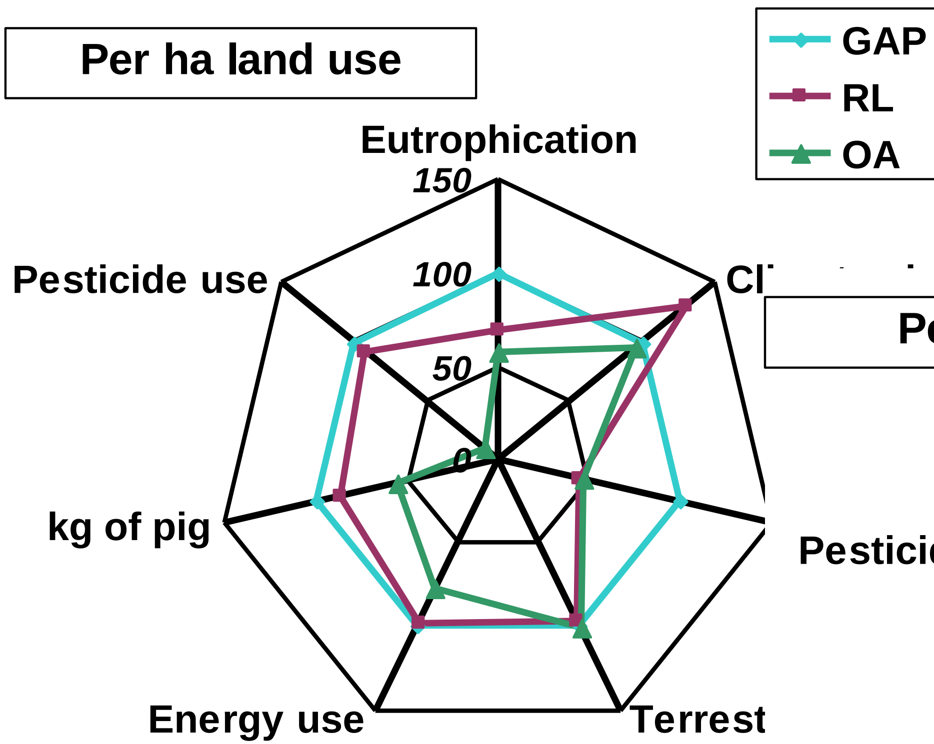
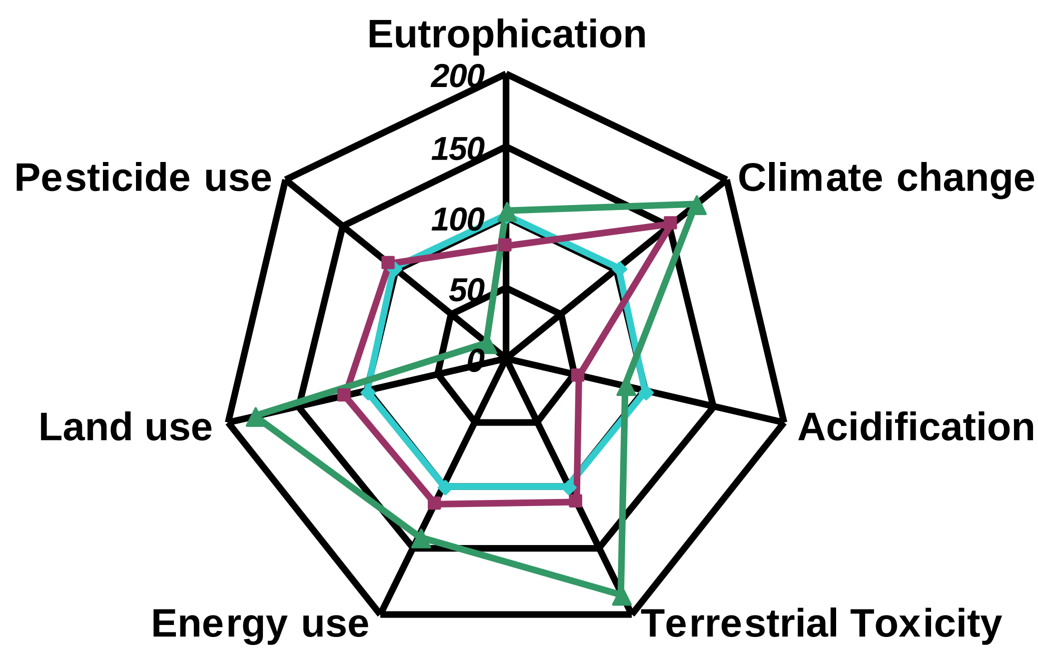
Areabased indicators vs. Product oriented
Comparison of pig production systems

Per ha land use



Per kg pig



(Basset-Mens and van der Werf, in press)

An overall objective:
Eco-functional intensification

Intensification of land use and agriculture by means of

- *improved knowledge and application of biological principles and agro-ecological methods*
- *increased cooperation and synergy between different components of agro-eco systems and food systems,*

with the aim of enhancing the health and productivity, adaptability and resilience of all its components.

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Icrofs research and development strategy 2012: Primary themes

Growth

Credibility

Resilient systems

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Focus area 4: Microbial interactions in soil, plants, animals, fodder and food

Little knowledge!

Decisive role!

Microbes, soil, plants, animals, fodder and food

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BioConval – Conversion of manure to high value poultry feed in large scale egg production systems

Steen Nordentoft

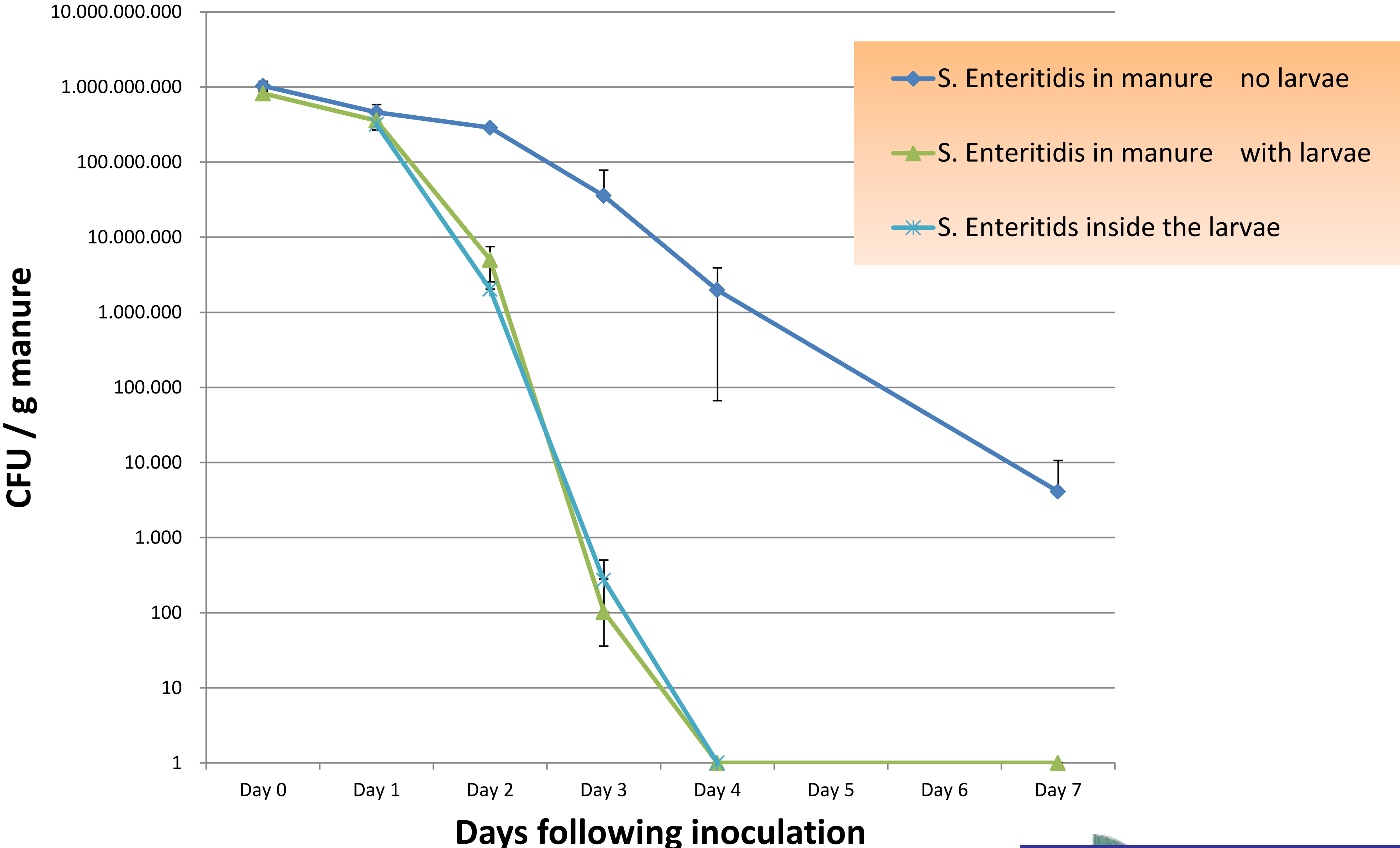
ICROFS

Challenges in the organic egg production

- **Composition of the feed**
  - Balanced feed containing all necessary nutrients and being organic
- **Animal welfare**
  - Cannibalism
  - Lower production, if undersupplied in essential nutrients
- **Improved utilization of the manure**
  - Conversion of nitrogen to high value protein
  - Improved value of the compost
  - Fresh insects are a part of organic hens diet
  - However, are larva grown on manure safe to use as fresh feed?

Steen Nordentoft ,DTU/FOOD

Degradation of *Salmonella* Enteritidis in poultry manure



Steen Nordentoft ,DTU/FOOD

Focus area 6: Animal and human health

Prevention

Health promoting qualities

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CORE organic II

Introduction

ProPIG

Farm specific strategies to reduce environmental impact by improving health, welfare and nutrition of organic pigs

C. Leeb

Amsterdam, 15th May, 2013

2nd CORE Organic II research seminar

Three Systems

75 farms in 8 countries

To identify

- animal - environment interactions in three systems

Hypothesis

- all systems are able to ensure good welfare and low environmental impact
- when well managed

Indoor with concrete outside run

=?

Partly outdoors

=?

Outdoors

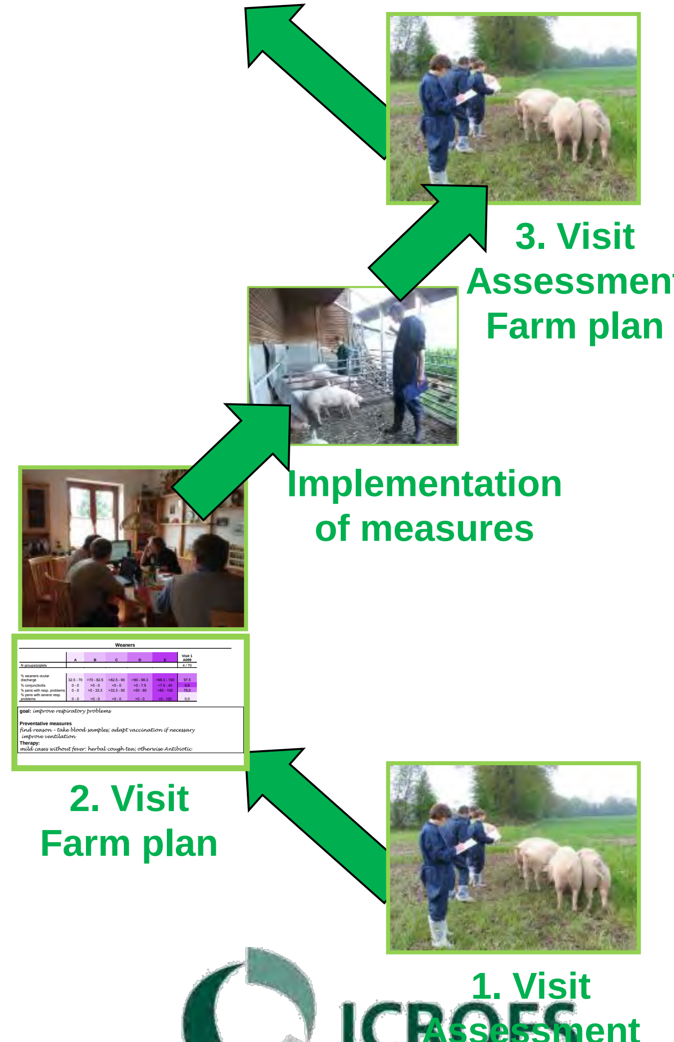
Farm specific strategies for improvement

To develop and implement

- **Farm specific strategies** to:
  - reduce environmental impacts
  - by improving health, welfare, nutrition and management of organic pigs



- To **disseminate knowledge** to national advisory bodies and farmers



Sustainable intensification

A productive agriculture that conserves and enhances natural resources.

- uses an ecosystem approach that draws on nature's contribution to crop growth
  - – soil organic matter, water flow regulation, pollination and natural predation of pest
  - – and applies appropriate external inputs at the right time, in the right amount

  CPI represents a major shift from the homogeneous model of crop production to knowledge-intensive, often location-specific, faming systems.

FAO, 2011

Is there a paradigm shift undergoing?

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Focus Area 2: New organic production systems

New integrated systems

Intensification

Integration

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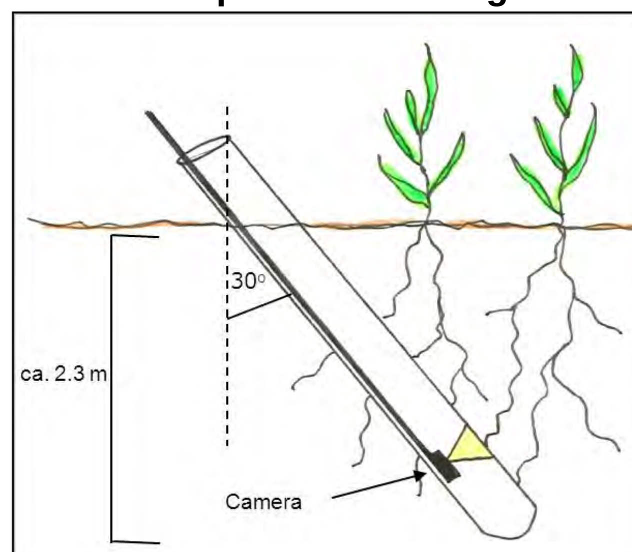
Field studies of root growth

Wheat plots in the field with 3 m long rhizotrons for root observation installed.

Drilling equipment for insertionn of 3 m long minirhizotrons

Insertion of a minirhizotron

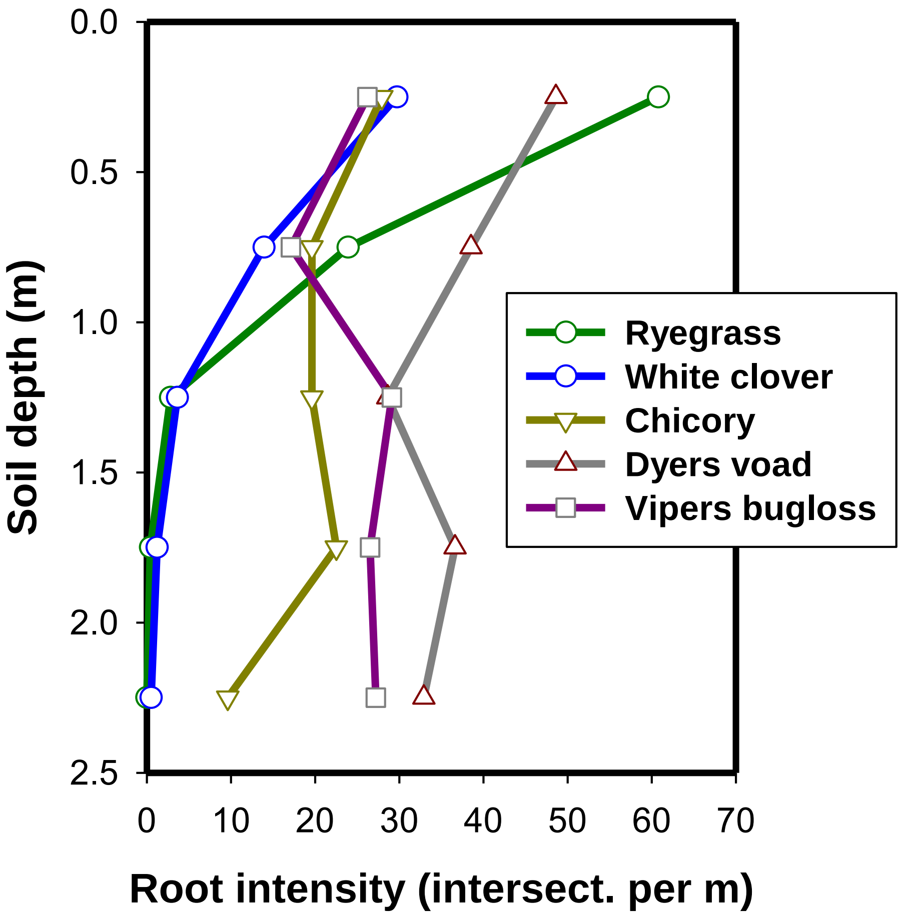
Camera inspection of root growth



Kristian Thorup-Kristensen, KU

Exploiting biodiversity:

- new species as cover crops



Kristian Thorup-Kristensen, KU

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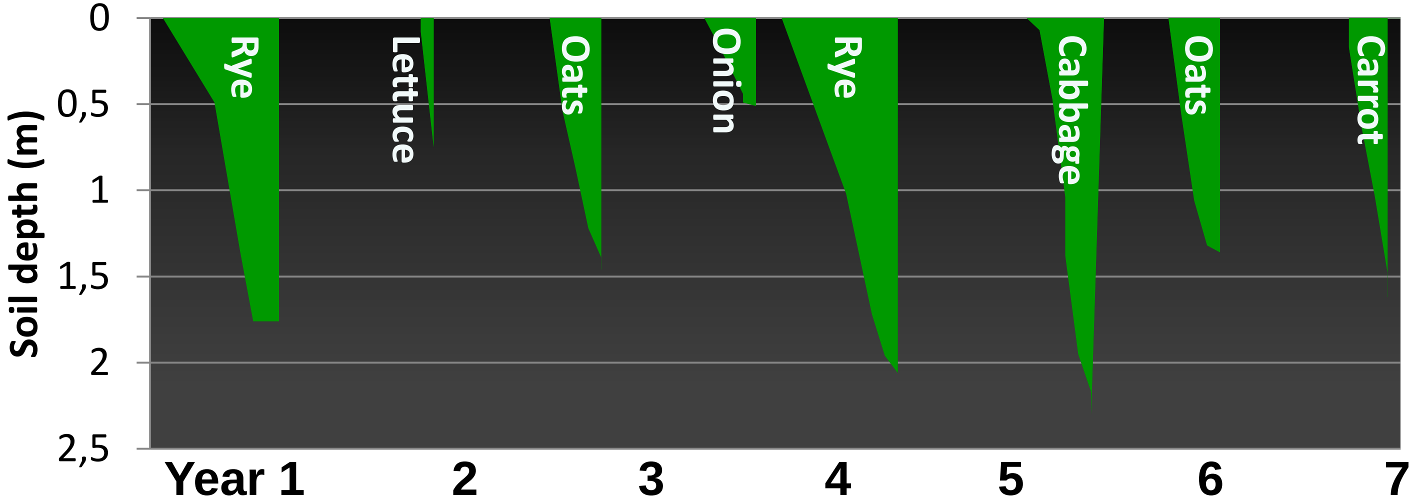
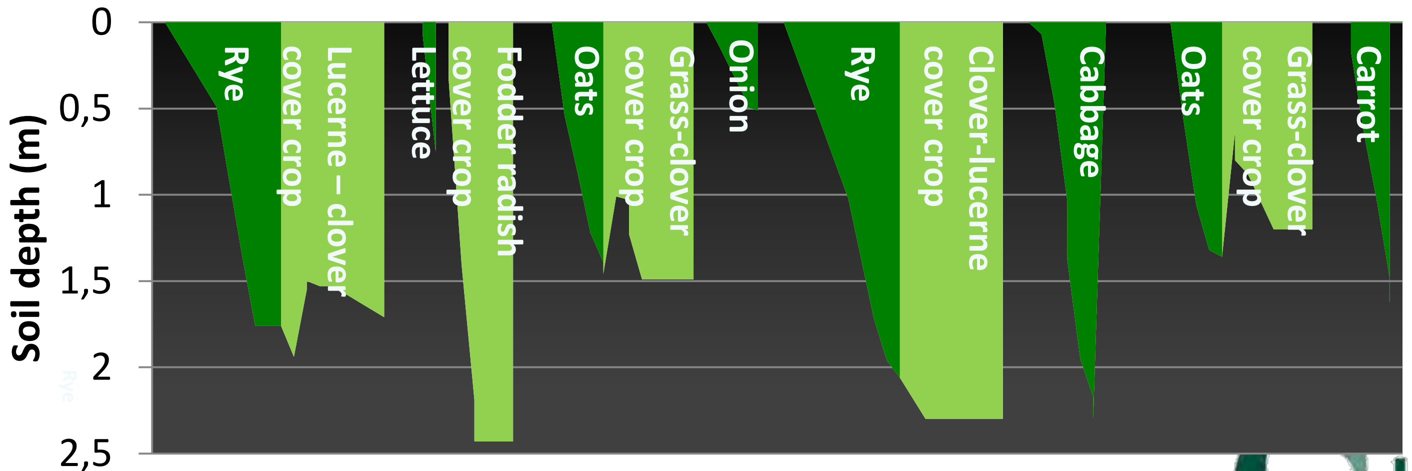
Root exploitation dynamics of rotation



Conventional mixed rotation

22% exploit.



Oranic rotation including cover crops

38% exploit.

Kristian Thorup-Kristensen, KU

FACCE – JPI Strategic Research Agenda

Core theme 2: Environmentally sustainable growth and intensification of agriculture
Core theme 3: Assessing and reducing trade-offs between food supply, biodiversity and ecosystem services