Research Institute of Organic Agriculture

Biological soil quality as a factor of efficient resource utilization in organic farming systems

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FiBL

Biological soil quality – a factor of efficient resource utilization

- The „green“ revolution and its impact on agriculture and the environment
- Efficiency of production in farming systems of the DOK long-term trial in Switzerland
- The role of soil quality in sustainable farming systems

The “Green” Revolution

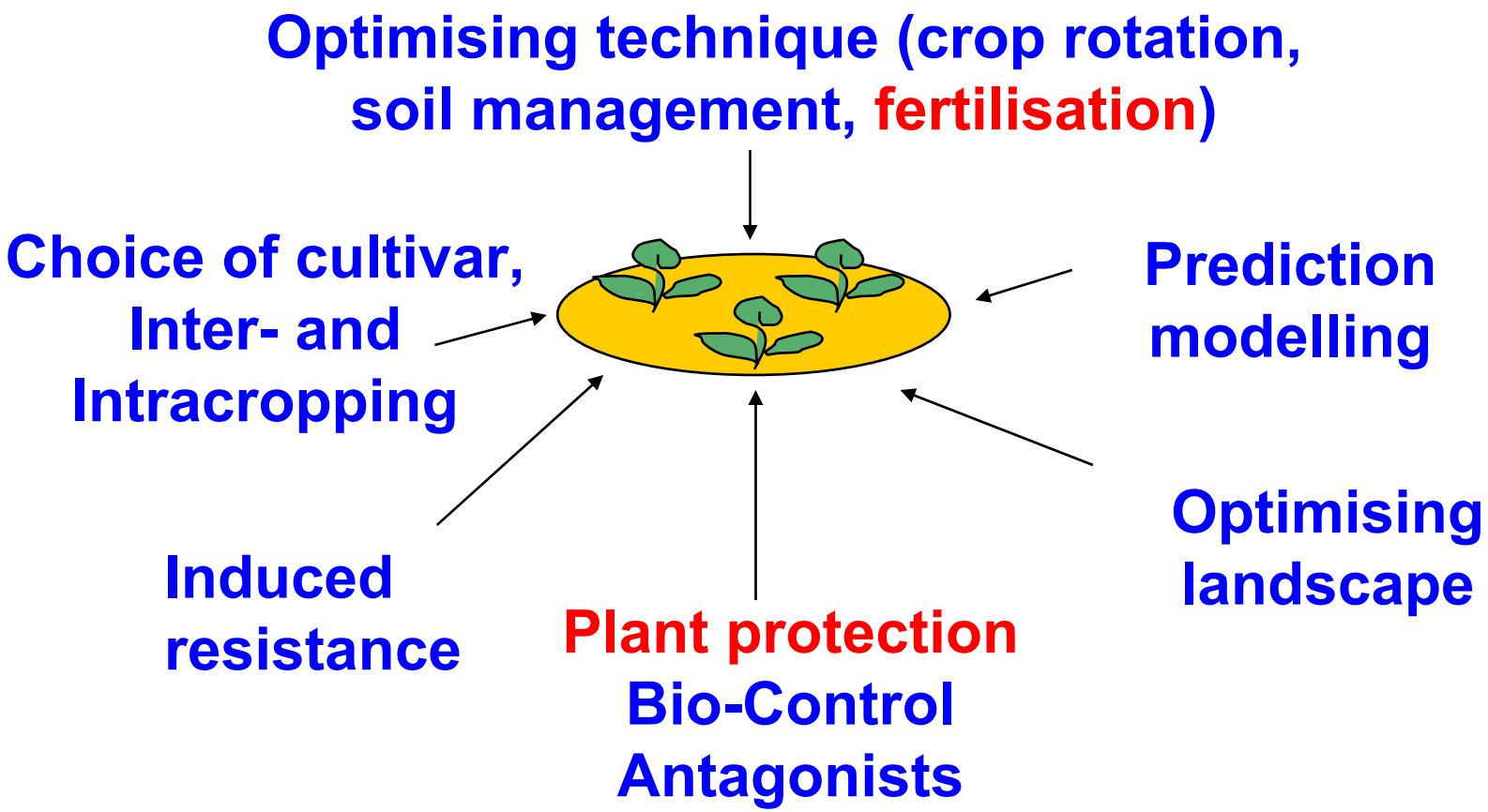
PROGRESS:

- Crop Yield increase
- Fertilizer Input
- Pesticide Input
- Weed Control
- Breeding and GMO
- Heavy Machinery
- Larger Fields
- Specialization…

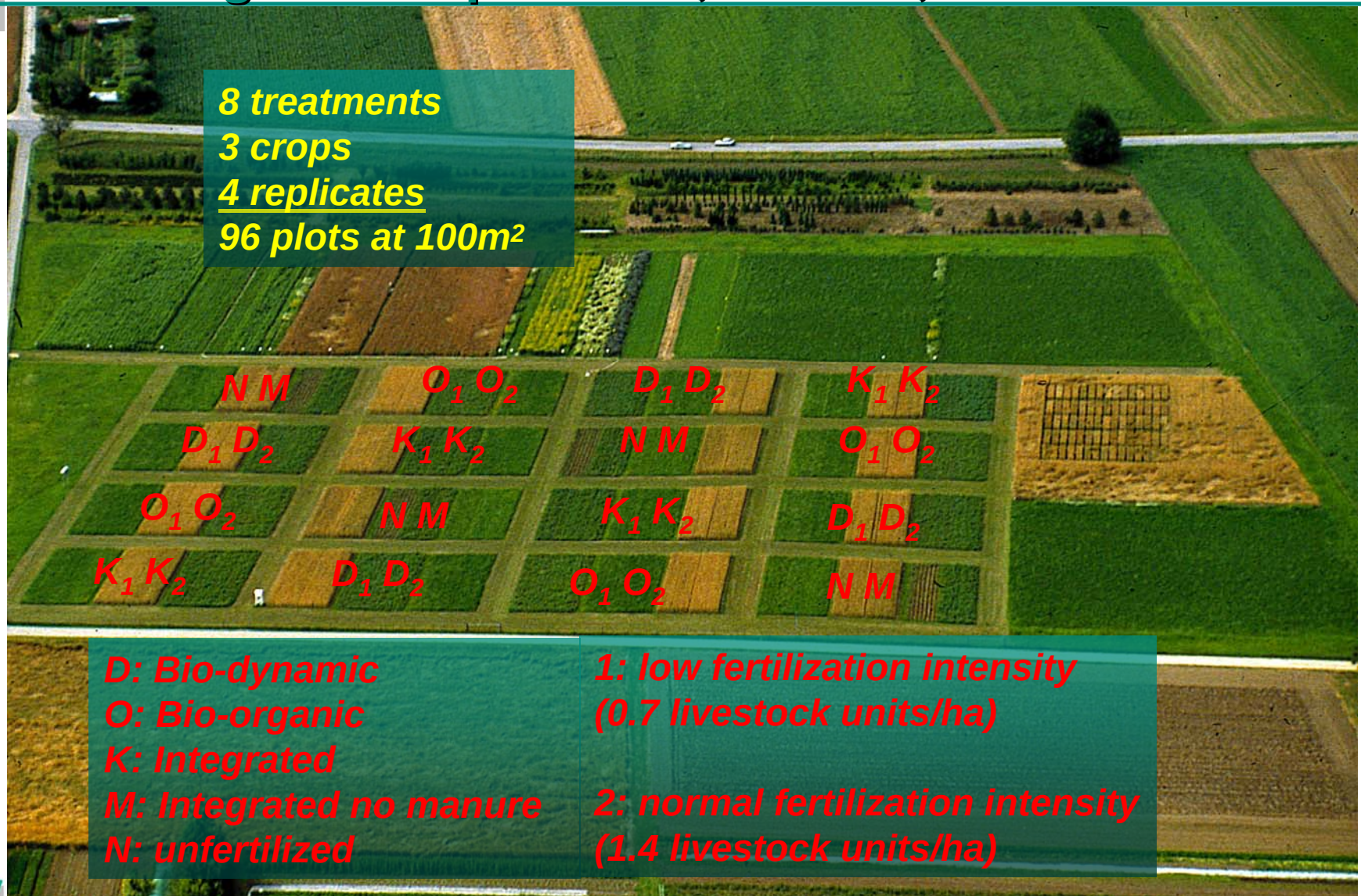
REACTION:

- Monocultures
- Nutrient loss
- Residues, Leachates
- Loss in Diversity
- Loss in Varieties
- Compaction
- Erosion
- Mixed farming: internal cycling of nutrients…

Strategy of organic farming: Package of actions



How sustainable is organic farming?
DOK long-term experiment, Therwil, Switzerland



DOK trial - the farming systems

	Organic		Conventional (integrated)	
N	**bio-Dynamic**	**bio-Organic**	**Konventional**	**Mineral**
	composted FYM	*rotted FYM*	*mixed FYM*	*Mineral*
	and slurry	*and slurry*	*and slurry*	
		rockdust	*NPK*	*NPK*
	Mechanical weed control		*Herbicides (thresholds)*	
	Indirect disease control		*Fungicides (thresholds)*	
	Biocontrol for pests	*Insecticides (thresholds)*		
	Biodynamic	*copper-*	*plant growth regulators*	
	preparations	*sulphate*		

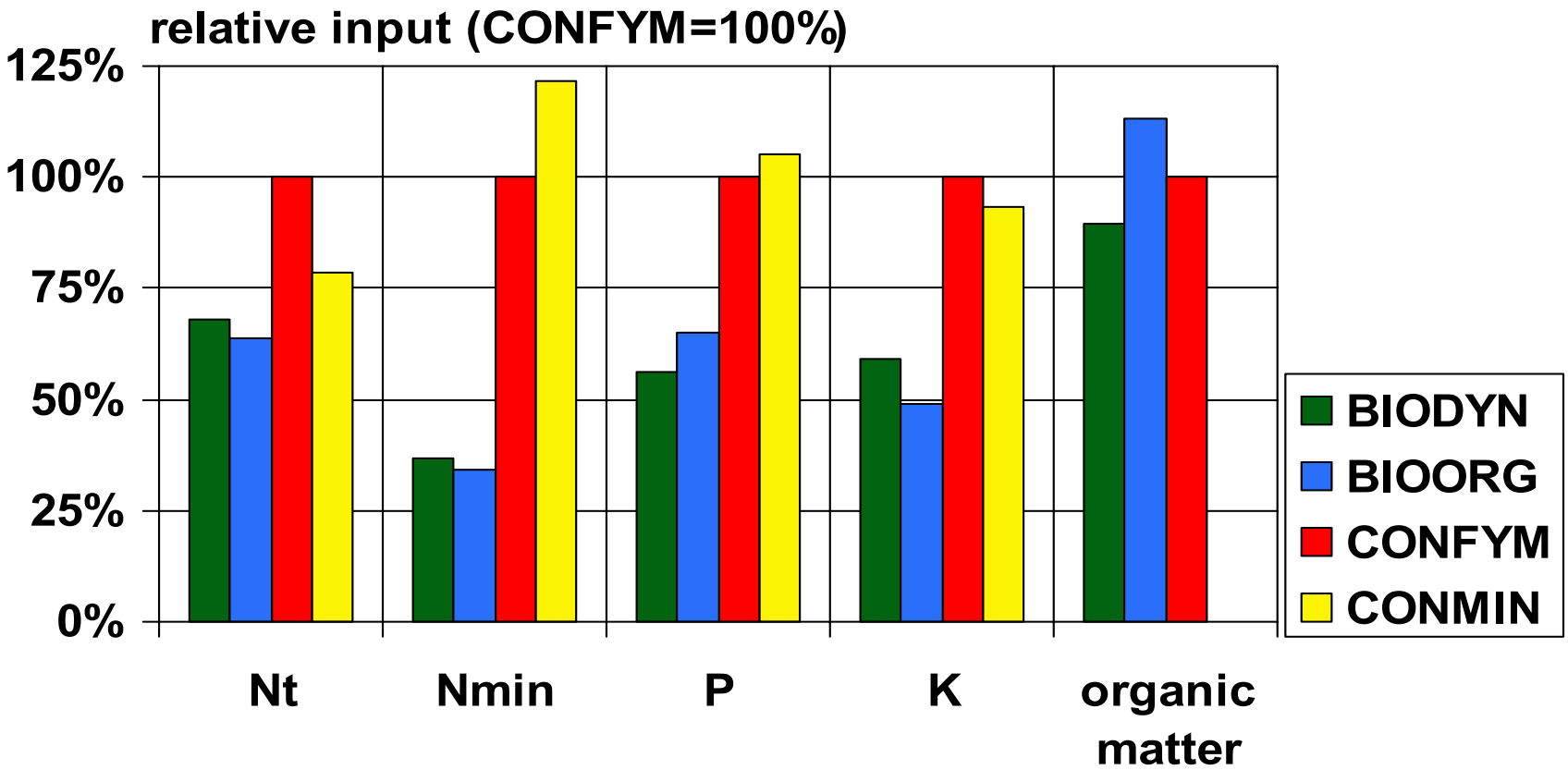

Farmers and Researchers
work hand in hand

DOK-trial: Crop rotation

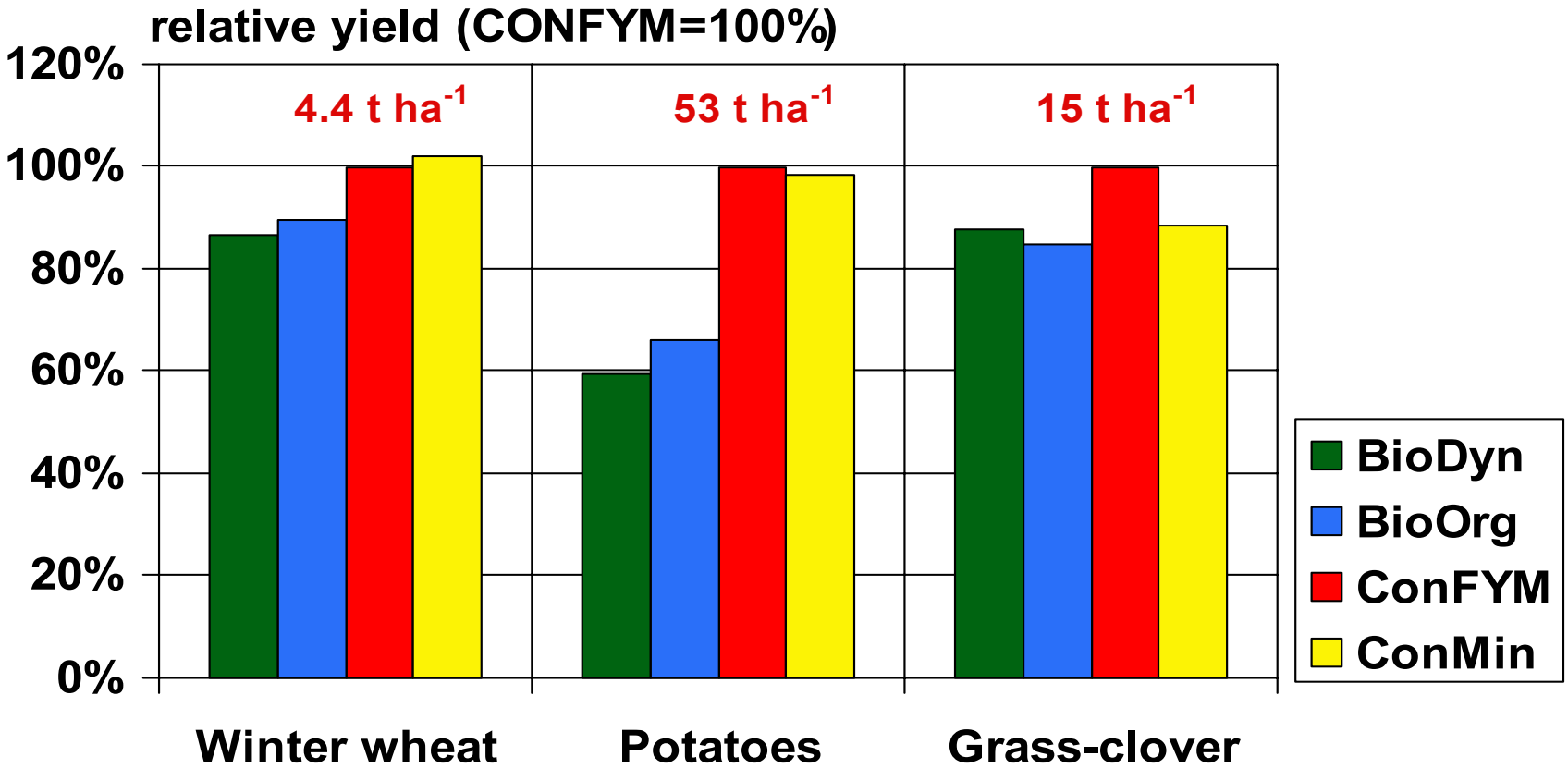
- Potatoes
- Winterwheat (catch crop)
- Soybeans (catch crop)
- Maize
- Winterwheat
- Grassclover
- Grassclover

- Soil tillage and chosen varieties are identical.
- In last years seeds of varieties are chosen that are available in organic (untreated) and conventional (treated with fungicides and insecticides) form.

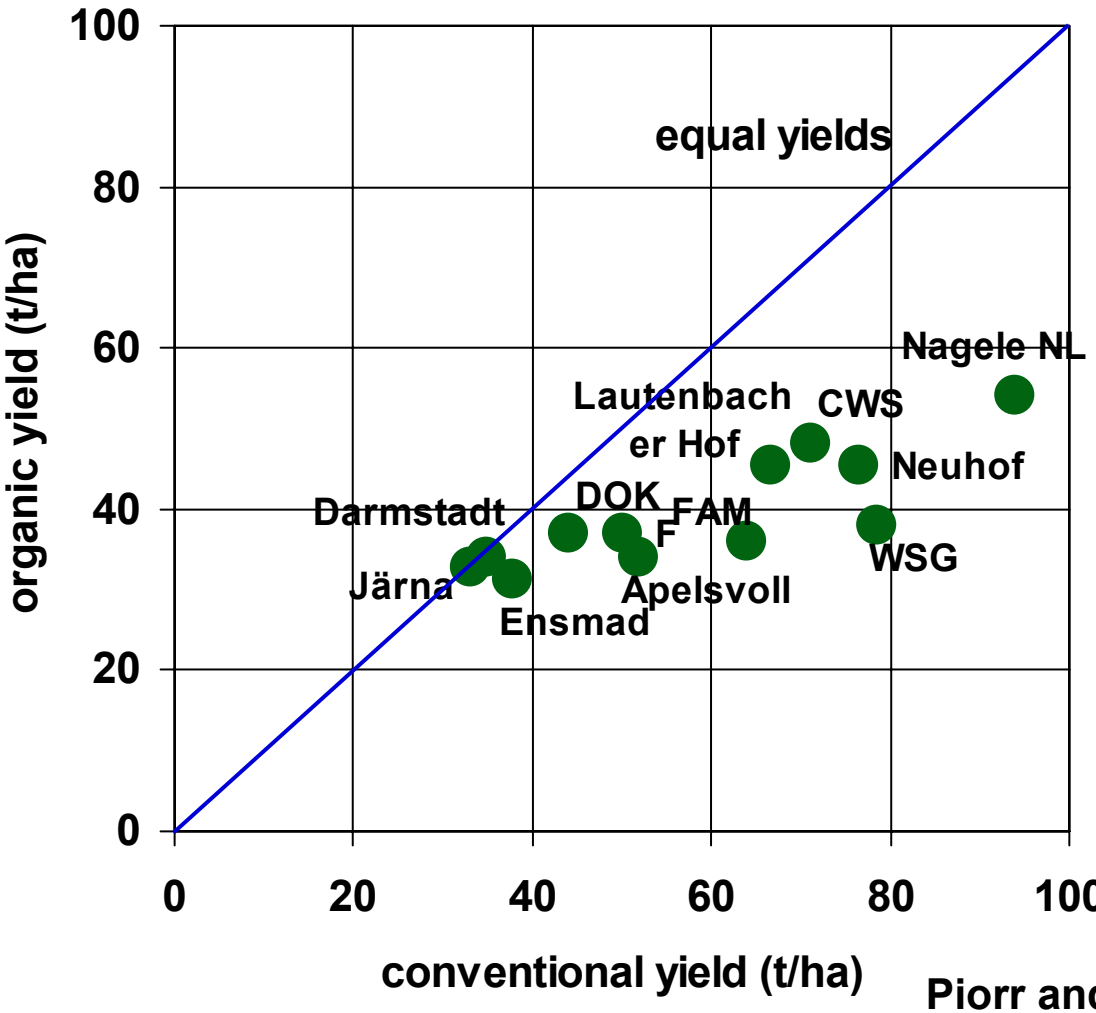
DOK trial - Input of nutrients



DOK trial – Yield (1978-1998)



Intensity: Cereal yields in organic and conventional



Piorr and Werner (1998) extended

Life cycle assessment for a whole crop rotation – BIOORG *vs.* CONFYM

	pota-toes	winter wheat	red beets	winter wheat	barley	grass-clover	grass-clover	average 1985-91
Resource use	○	+	+	+	○	+	+	○
waste	○	○	○	○	○	○	+	○
land use	○	+	+	+	○	○	○	+
GWP	○	+	○	+	○	○	○	○
acidification	○	–	○	–	–	○	○	○
eutrophication	○	+	○	+	+	○	○	+
soil toxicity	+	++	++	++	++	+	+	++

yield diff. (%)	-34	-19	-25	-19	-26	-6	-15	-19

Alföldi *et al.*, Ökologie & Landbau 118 (2001)

On-farm Research

Soil - a complex living system

a Ants

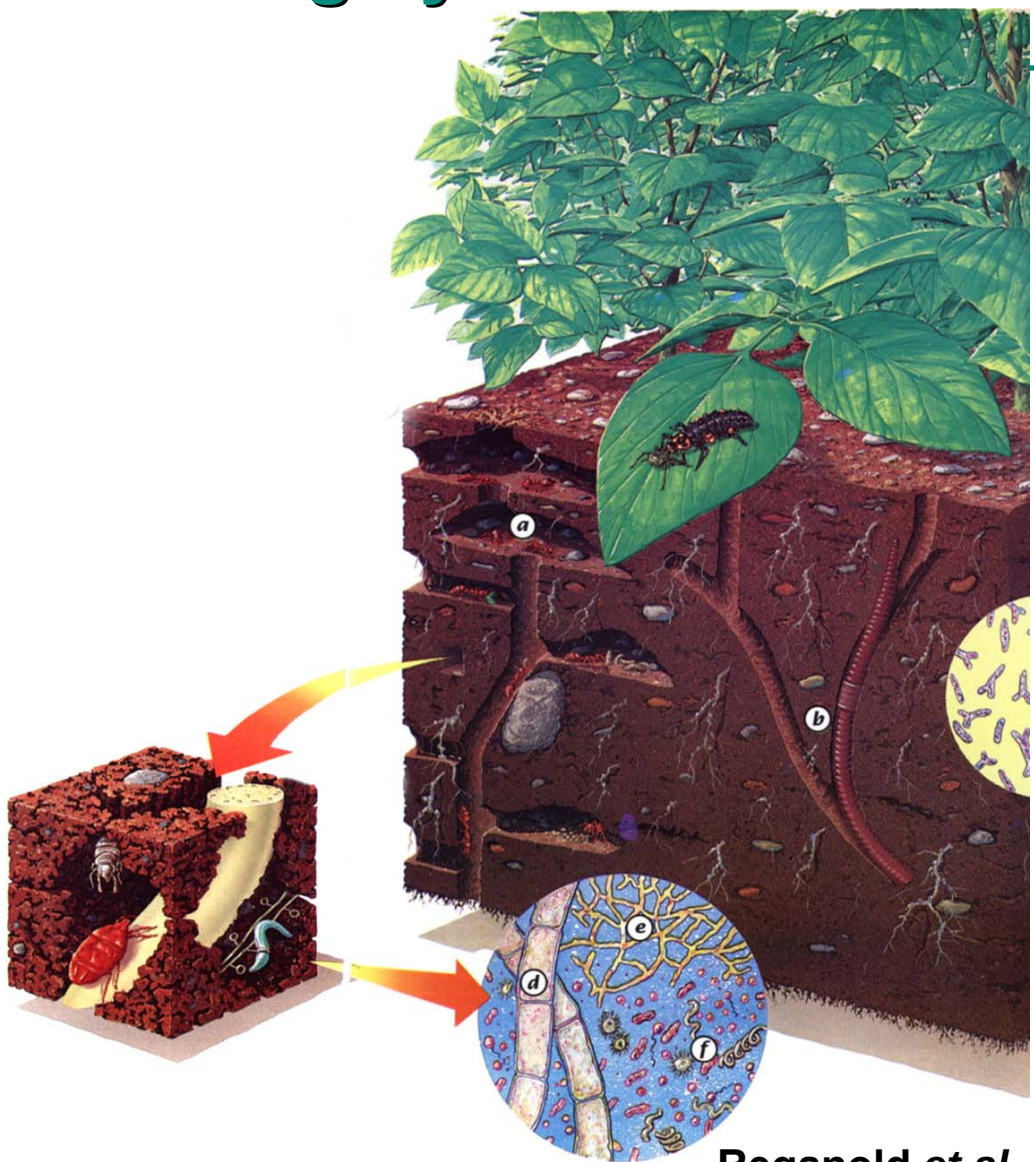
b Earthworms

c Rhizobia

d Fungi

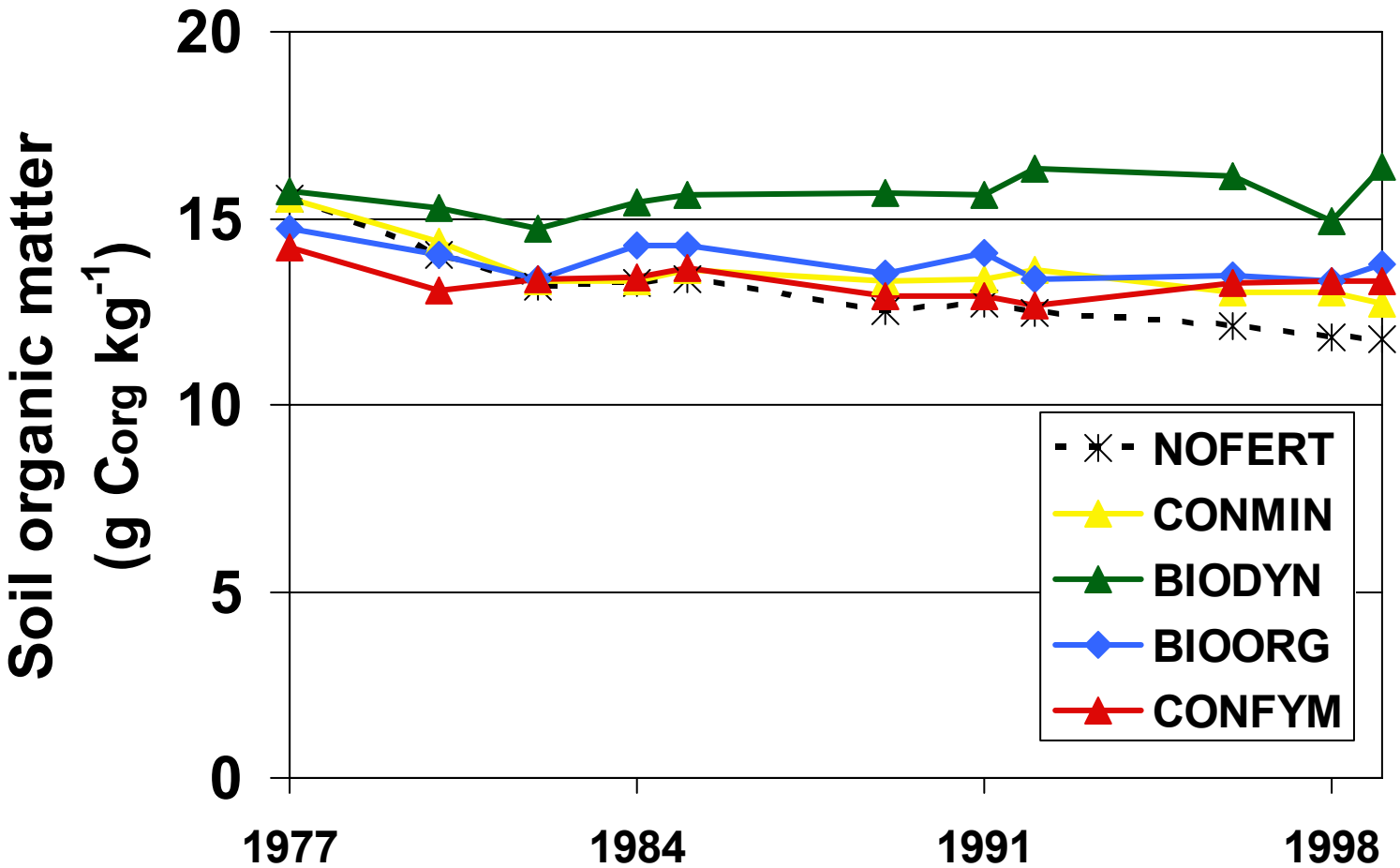
e Actinomycetes

f Bacteria

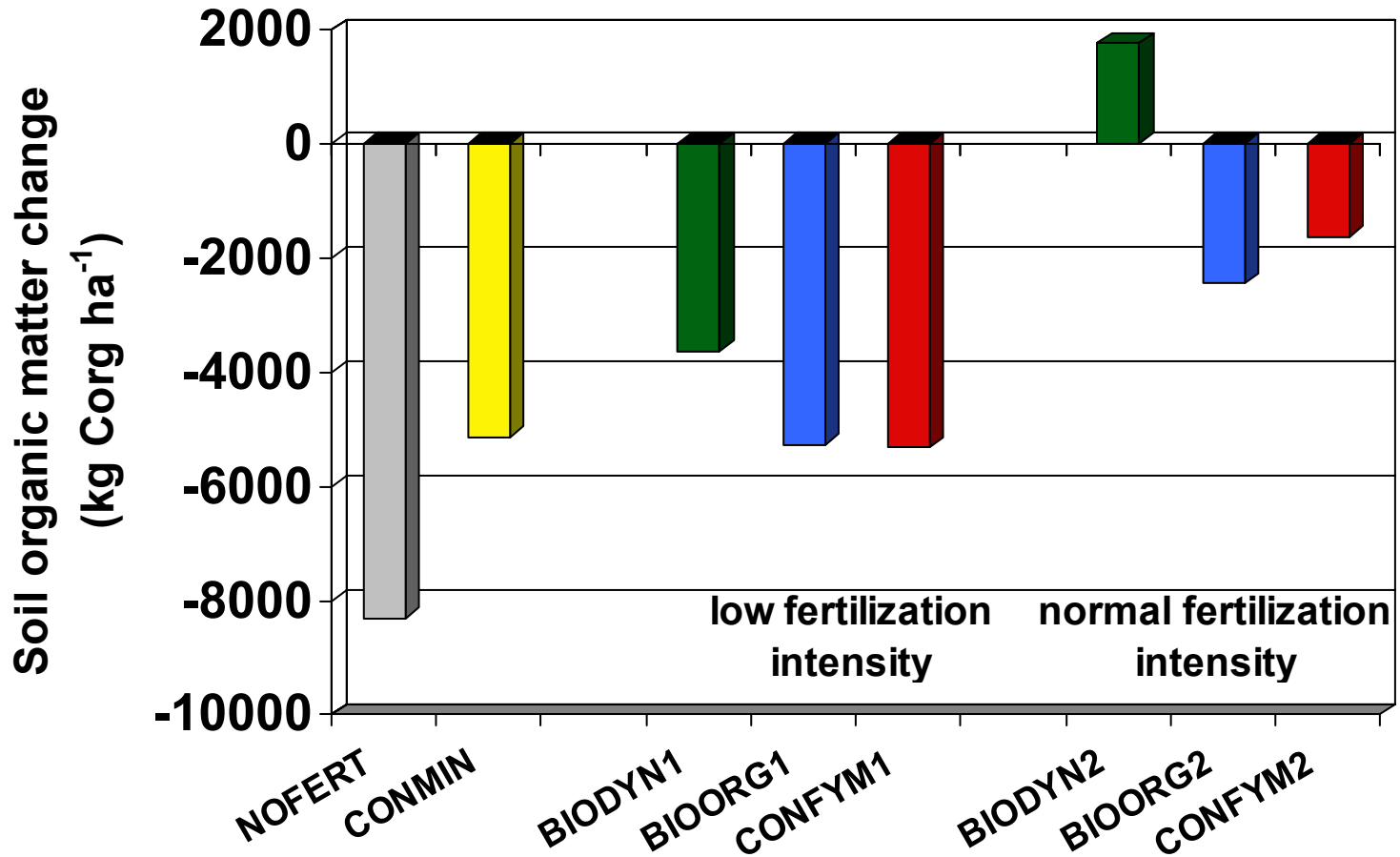


Reganold *et al*., (1990)

DOK: soil organic matter trend

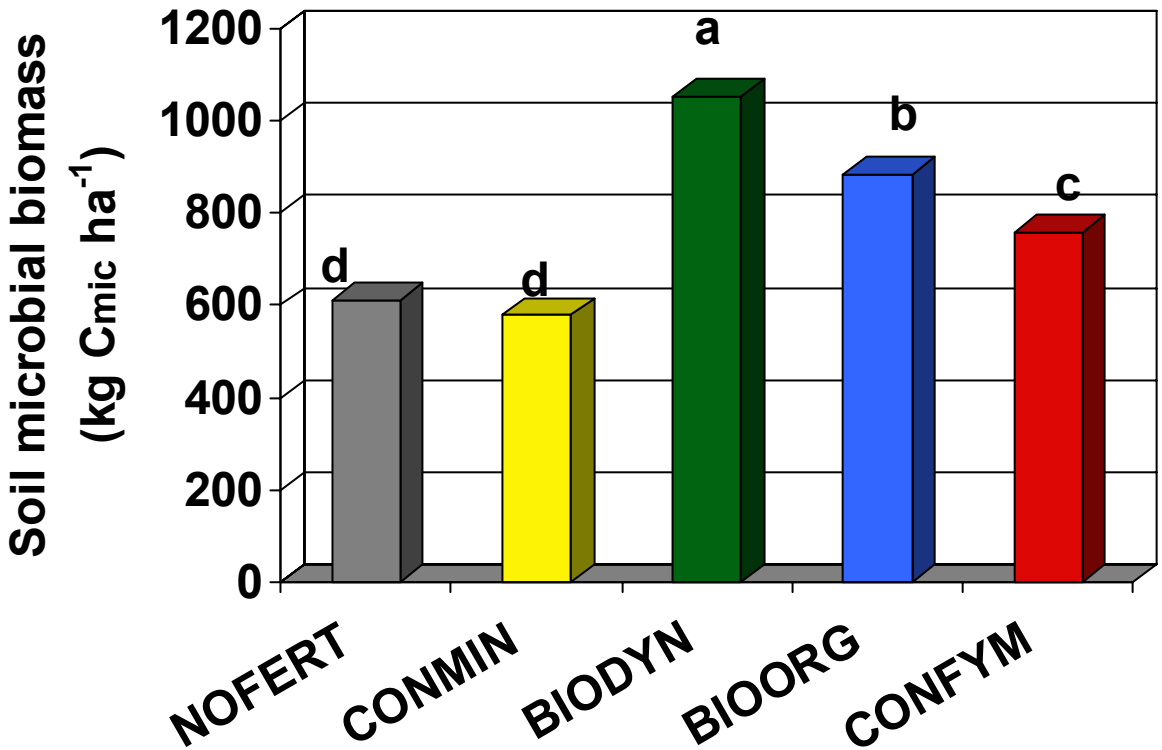


DOK: SOM change between 1978 and 1999



DOK: Soil microbial biomass carbon

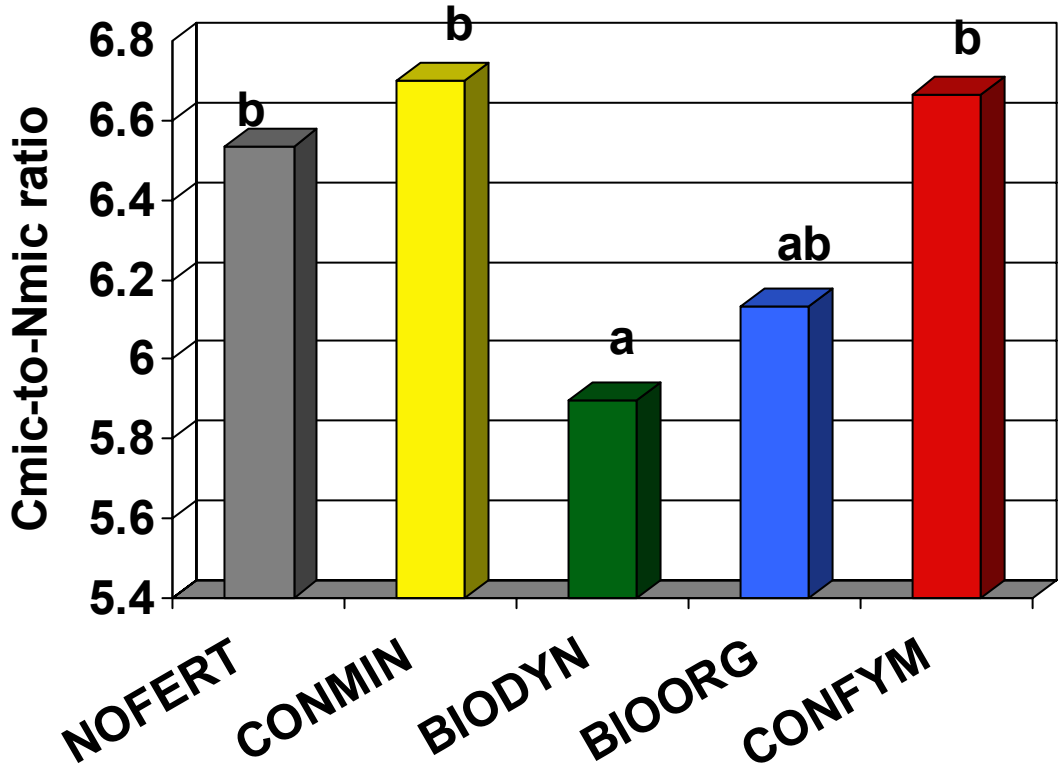
Long-term average (1995-2002)



Calculated for 0-20cm at an average density of 1.4 g cm^{-3}

Cmic-to-Nmic ratio – microbial population

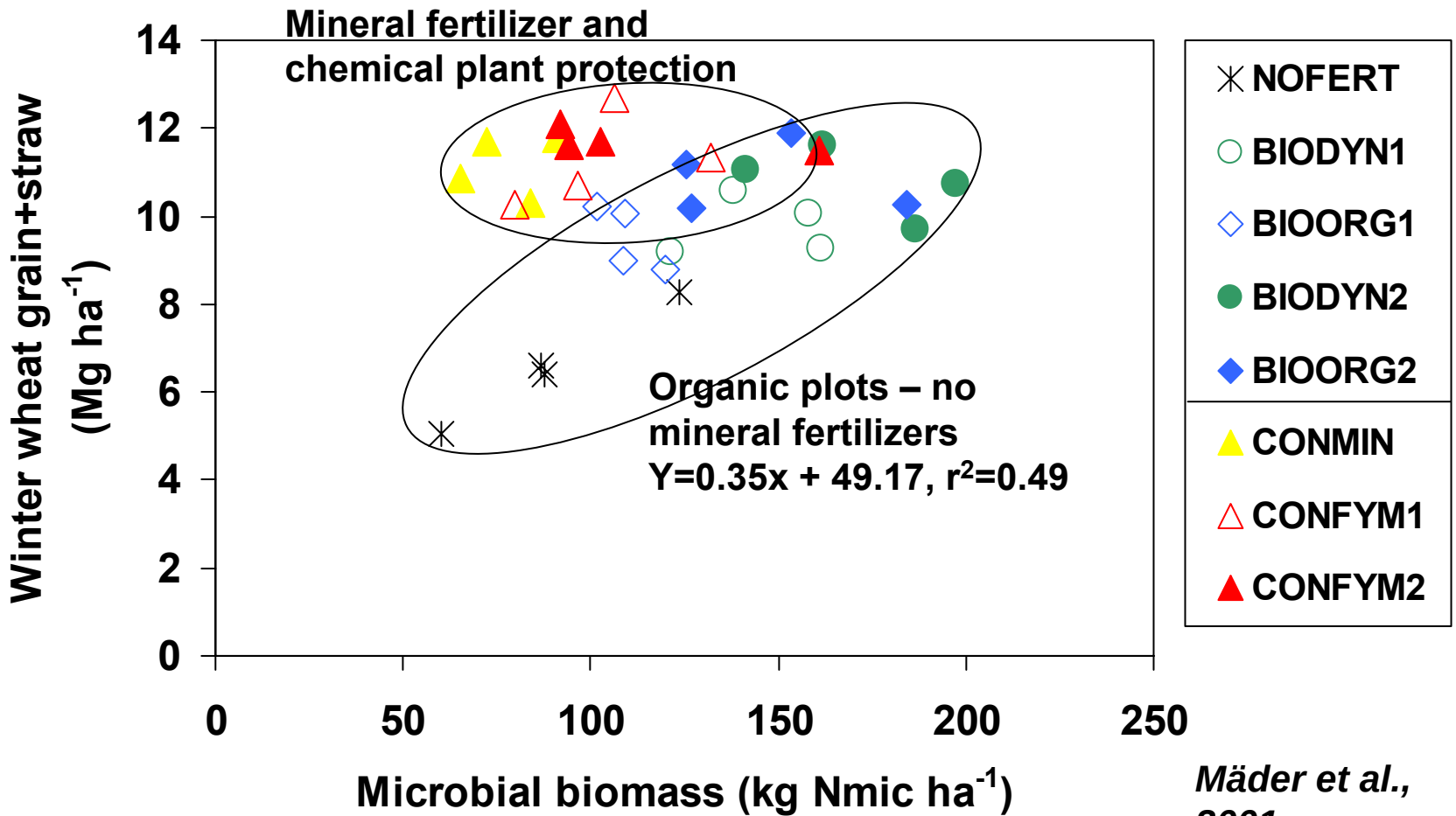
Older cells ☞ more fungi?



Younger cells ☞ more bacteria?

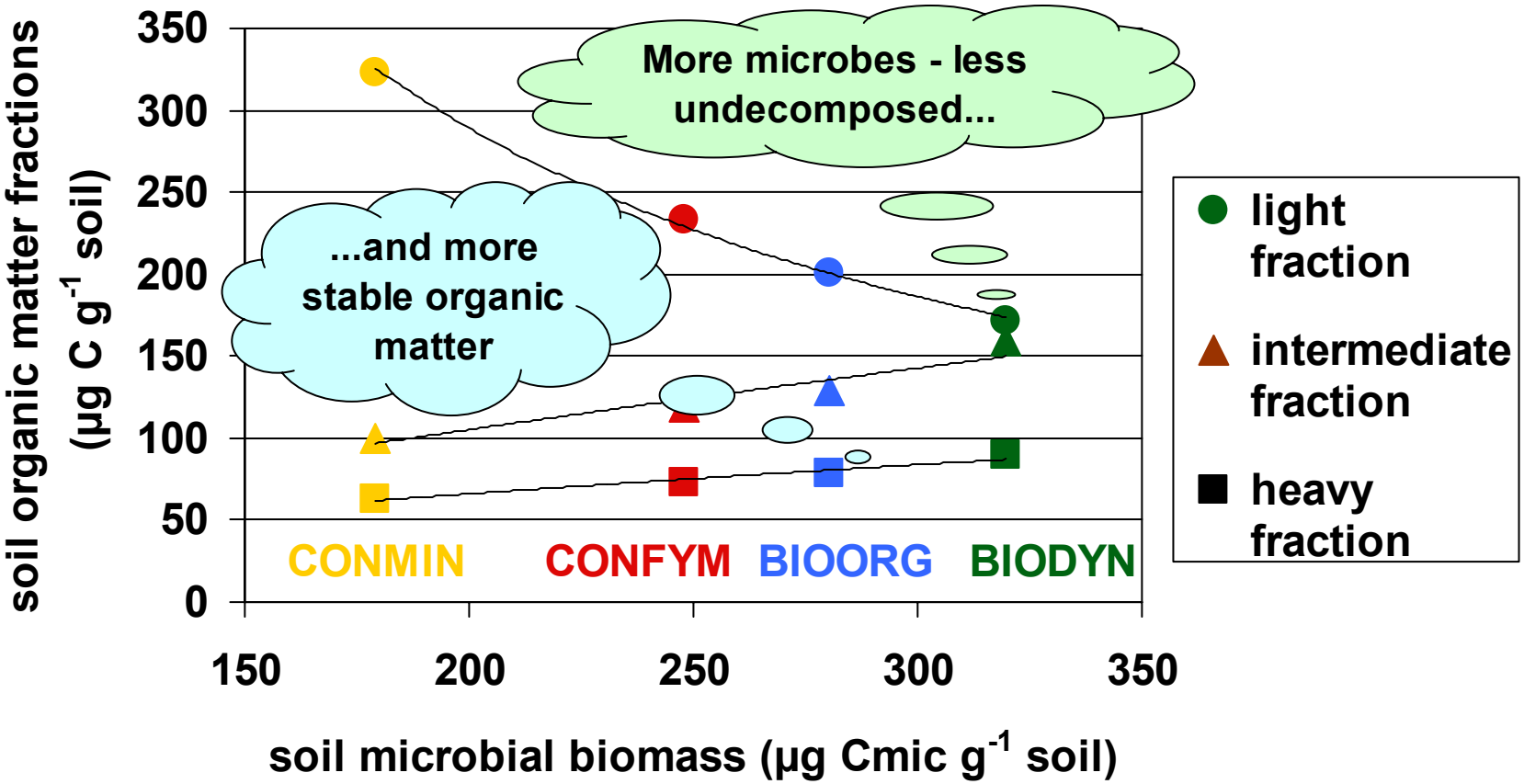
Long-term average (1997-2002)

Correlation soil microbial biomass - yield

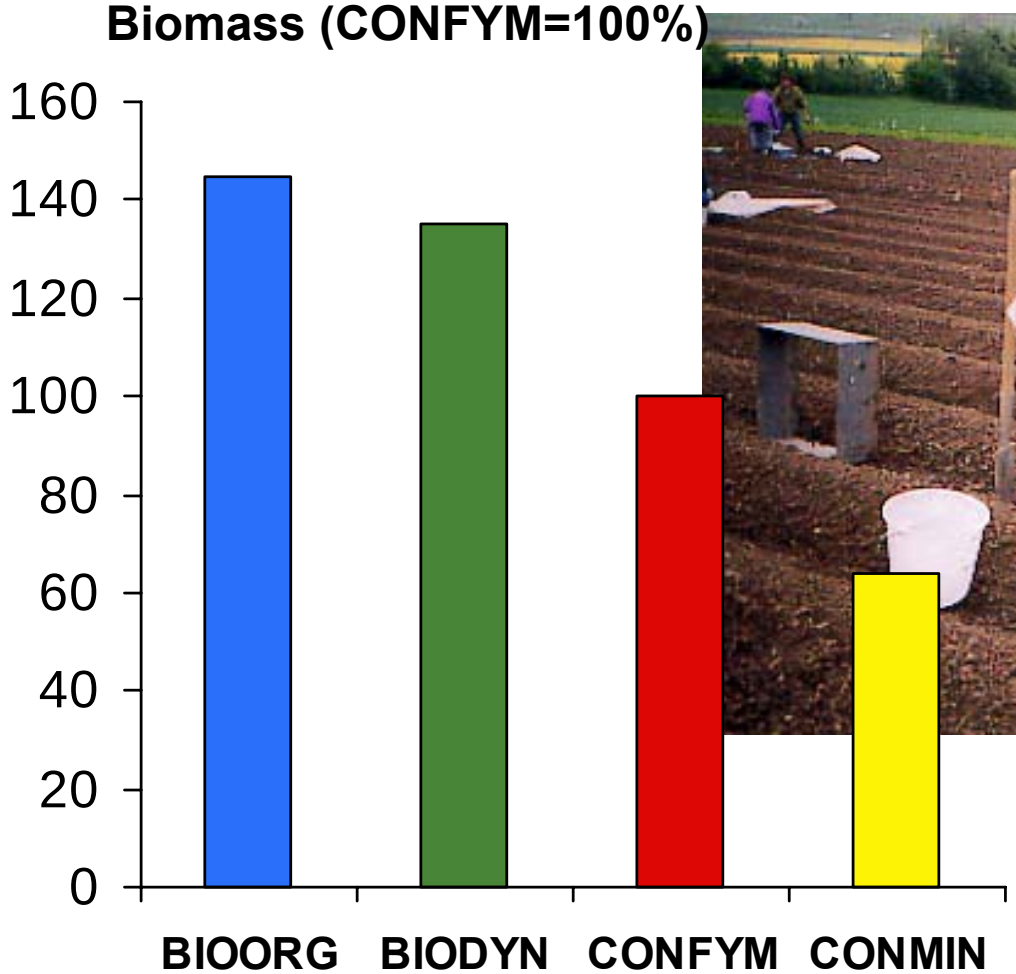


Mäder et al., 2001

DOK field trial - Density fractions



Earthworm biomass DOK trial



Pfiffner et al., 1998

Biol. Agric.Hortic.

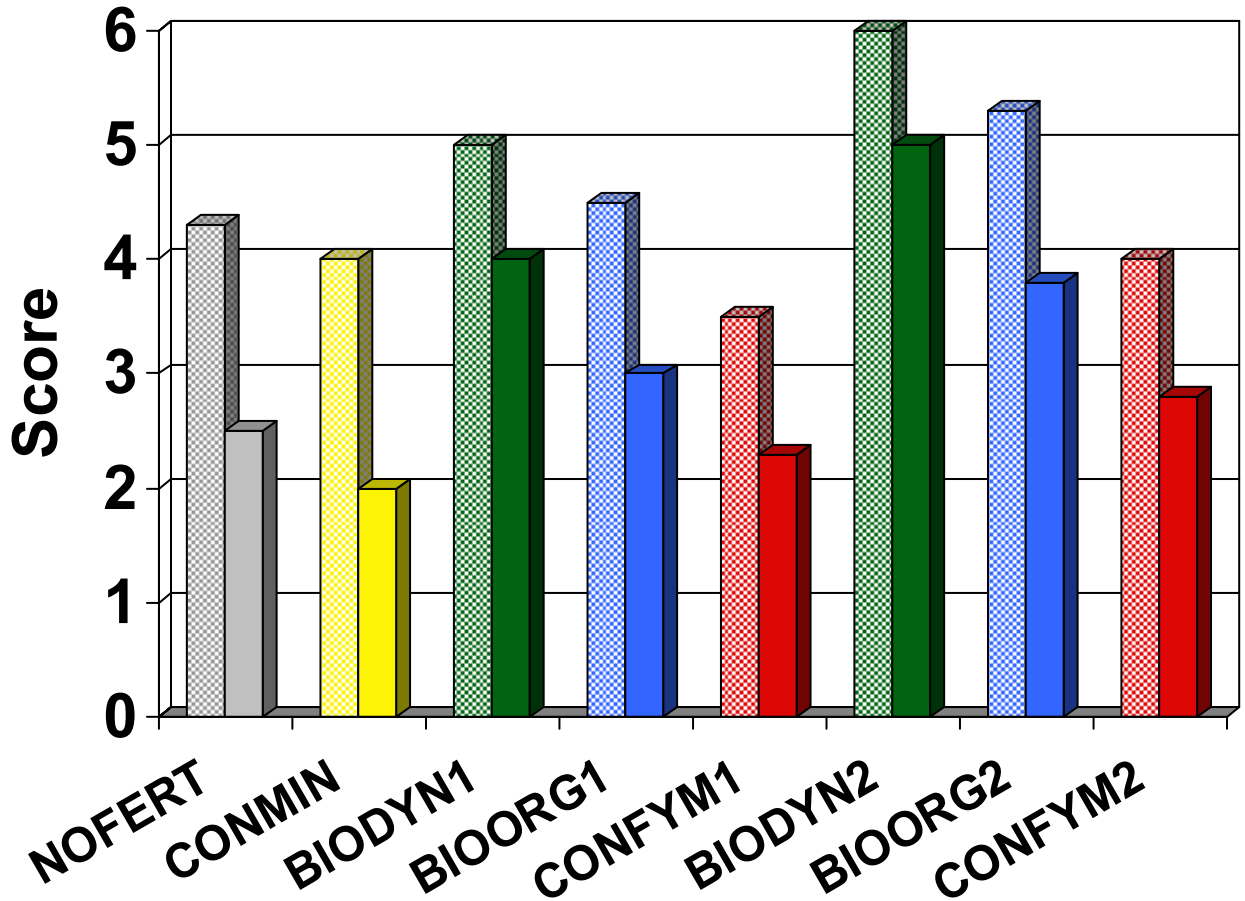
Erosion DOK-field trial

Fotos: Fliessbach Nov. 2002

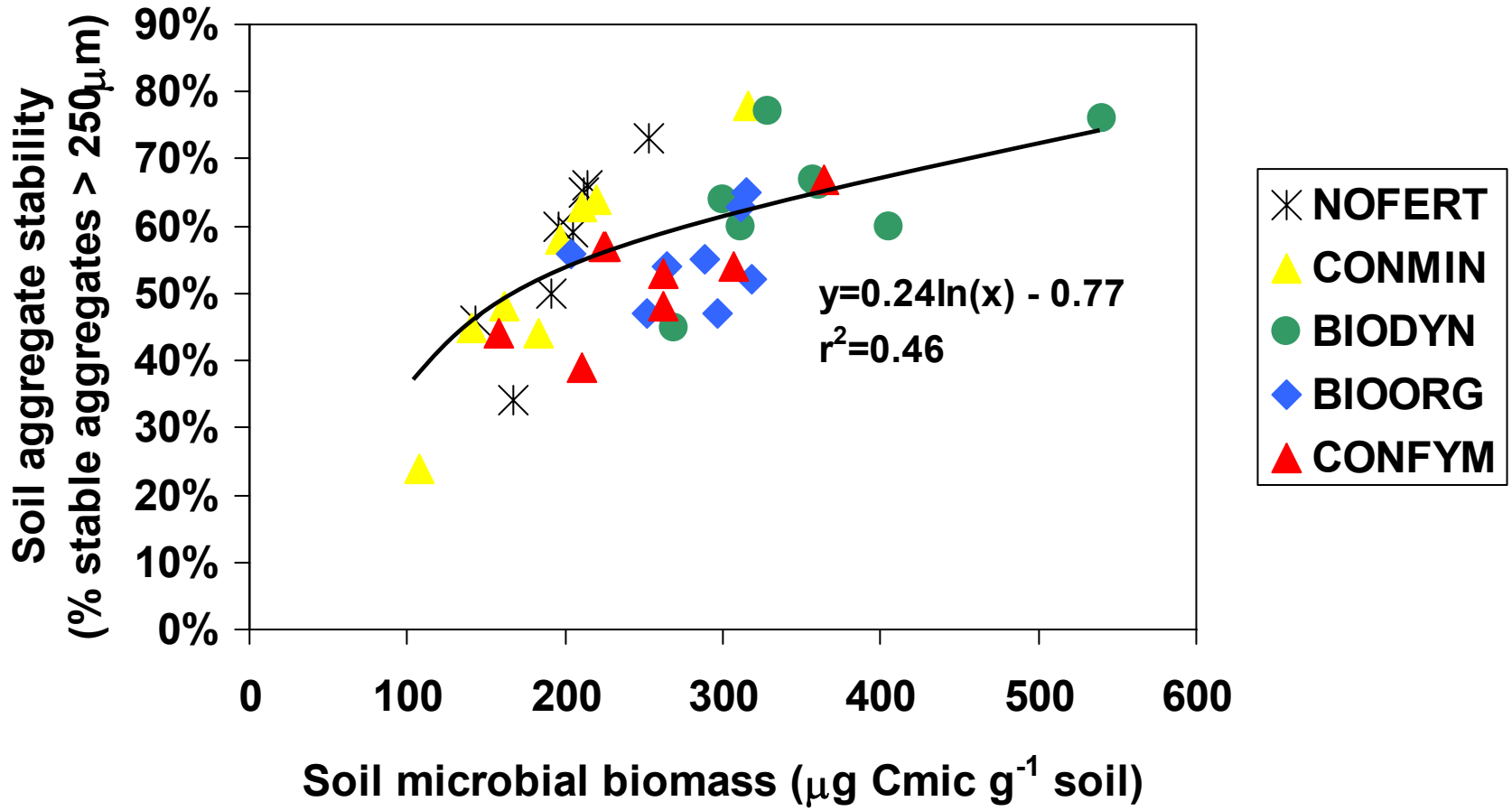
Conventional
without manure

Bio-dynamic with
composted manure

DOK-trial: Soil structural stability

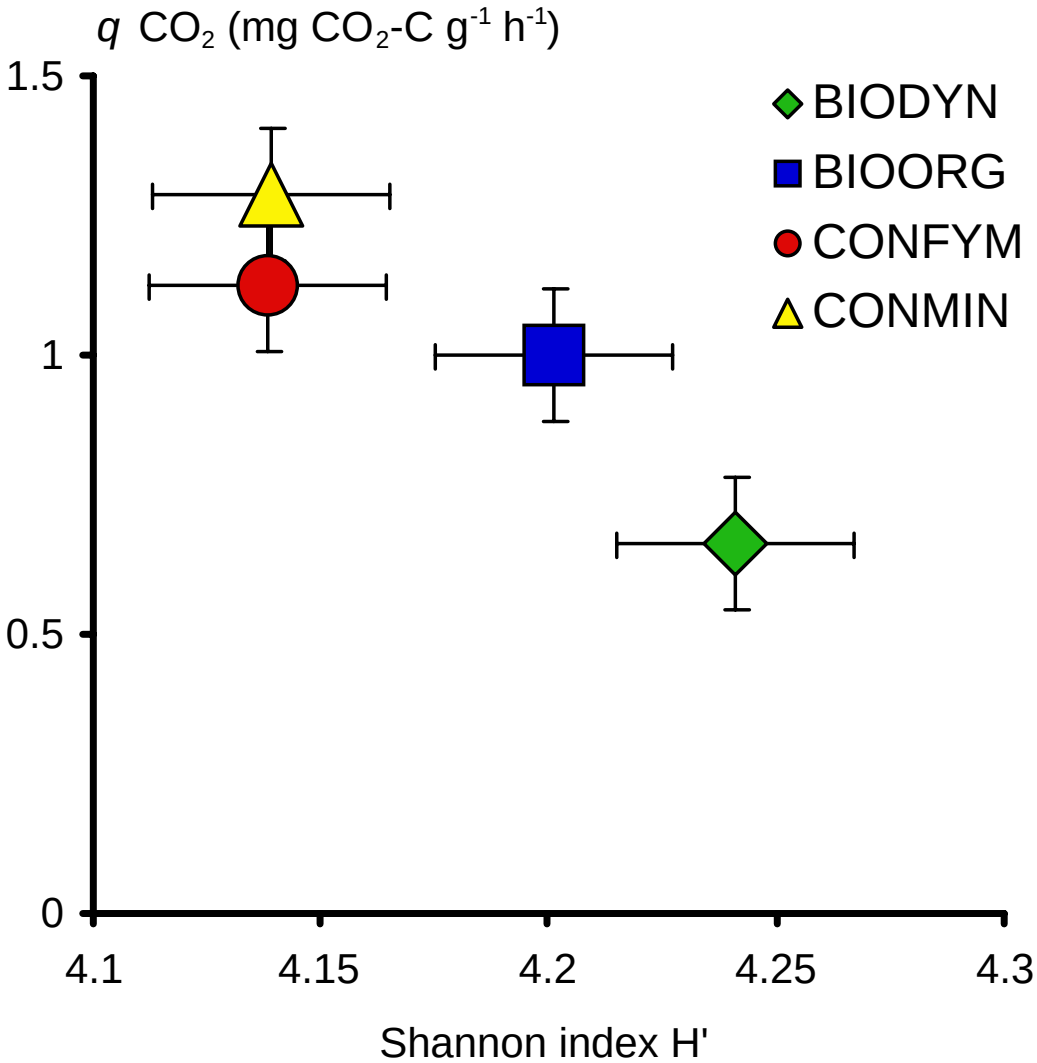


Meaningful parameters: Correlation aggregate stability – biomass



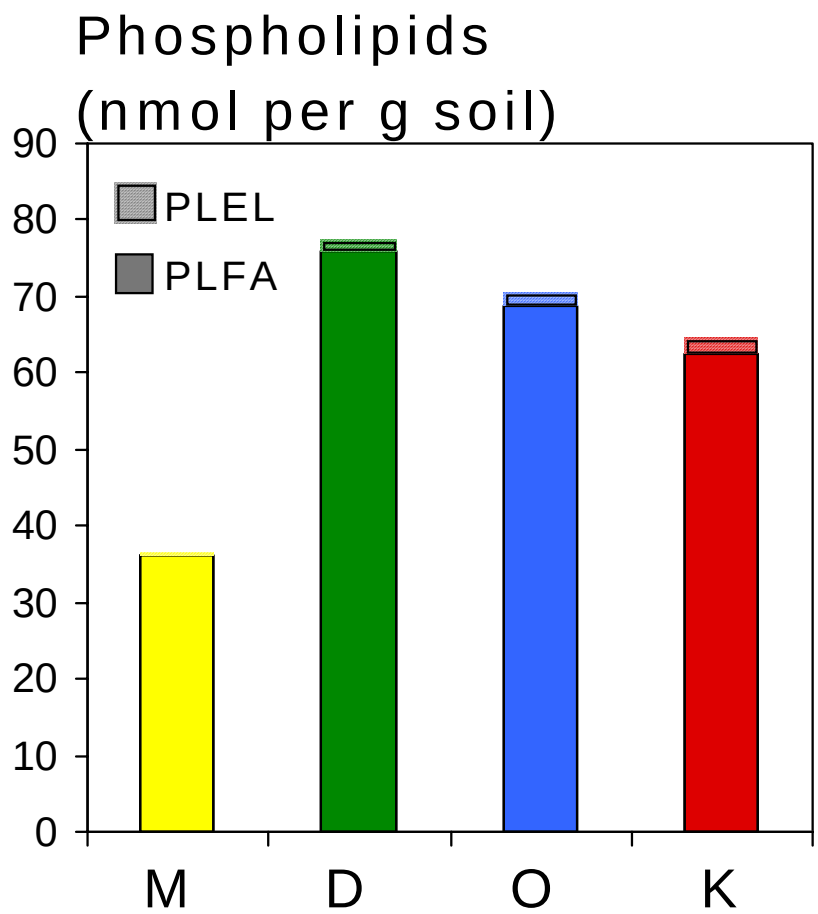
Fließbach et al., 2000

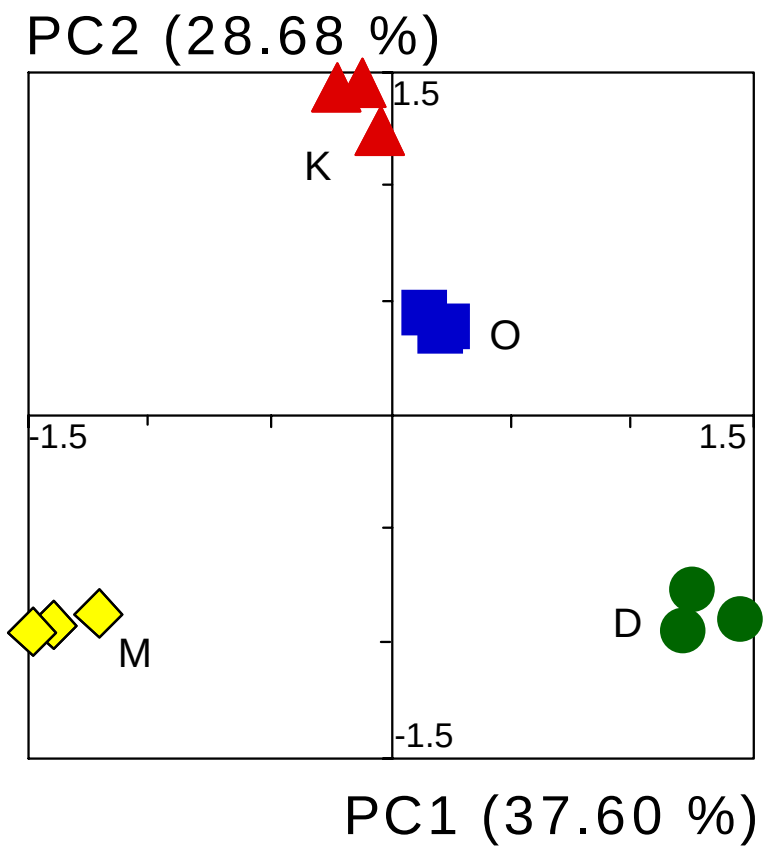
Correlation metabolic quotient and diversity



Mäder et al., 2002: Science 296, 1694

Total PLFA/PLEL (biomass) and PCA of PLFA patterns

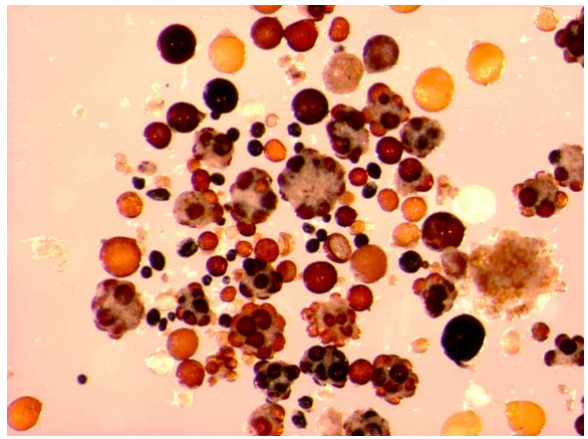


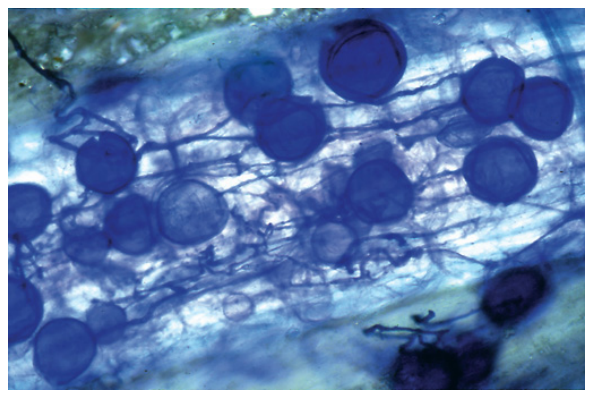


Mycorrhiza diversity DOK trial (microscopy)

Mycorrhiza diversity (species number)

Grassland	W	26
	V	27
	G	26
Arable		
Rotation	O	26
	L	18
Monocropping	F	13
	S	10
	R	8





Oehl et al., 2003

AEM, 2816

21 years of research in the DOK trial

	Organic	Conventional
Winter wheat crop yield	4.7 t/ha	5.6 t/ha
Fertilization NH_4NO_3 equivalent	122 kg/ha	360 kg/ha
Energy gasoline equivalent	340 l/ha	570 l/ha
Plant protection active ingredients	0-200 g/ha	6.0 kg/ha
Soil Fertility soil microbial biomass ≈	40 t/ha 700 sheep	24 t/ha 400 sheep

Mäder, Fliessbach (2003)

Conclusions

- Higher efficiency of production because of lower input in organic as compared to integrated farming systems
- Ecological performance of organic farming systems was better in most cases as indicated by environmental indicators for agriculture.
- Organic farming systems in the DOK trial enhance chemical, physical and biological indicators of soil quality
- Soil fertility and biodiversity in the DOK trial was found to be higher in organic farming systems.

FiBL “annual crops” department

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