Organic agriculture and climate change

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Climate change : what is the problem ?

In order to limit to 2° C
the increase of temperature
of the planet,
we **MUST** divide by 2
the greenhouse gas emissions

Agriculture, food and climate change

- Agriculture and food are responsible for more than 30% of all greenhouse gases in the world
- Stock breeding alone is responsible for 18% of greenhouse gases, more than all transports

The three culprits : carbone dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O)

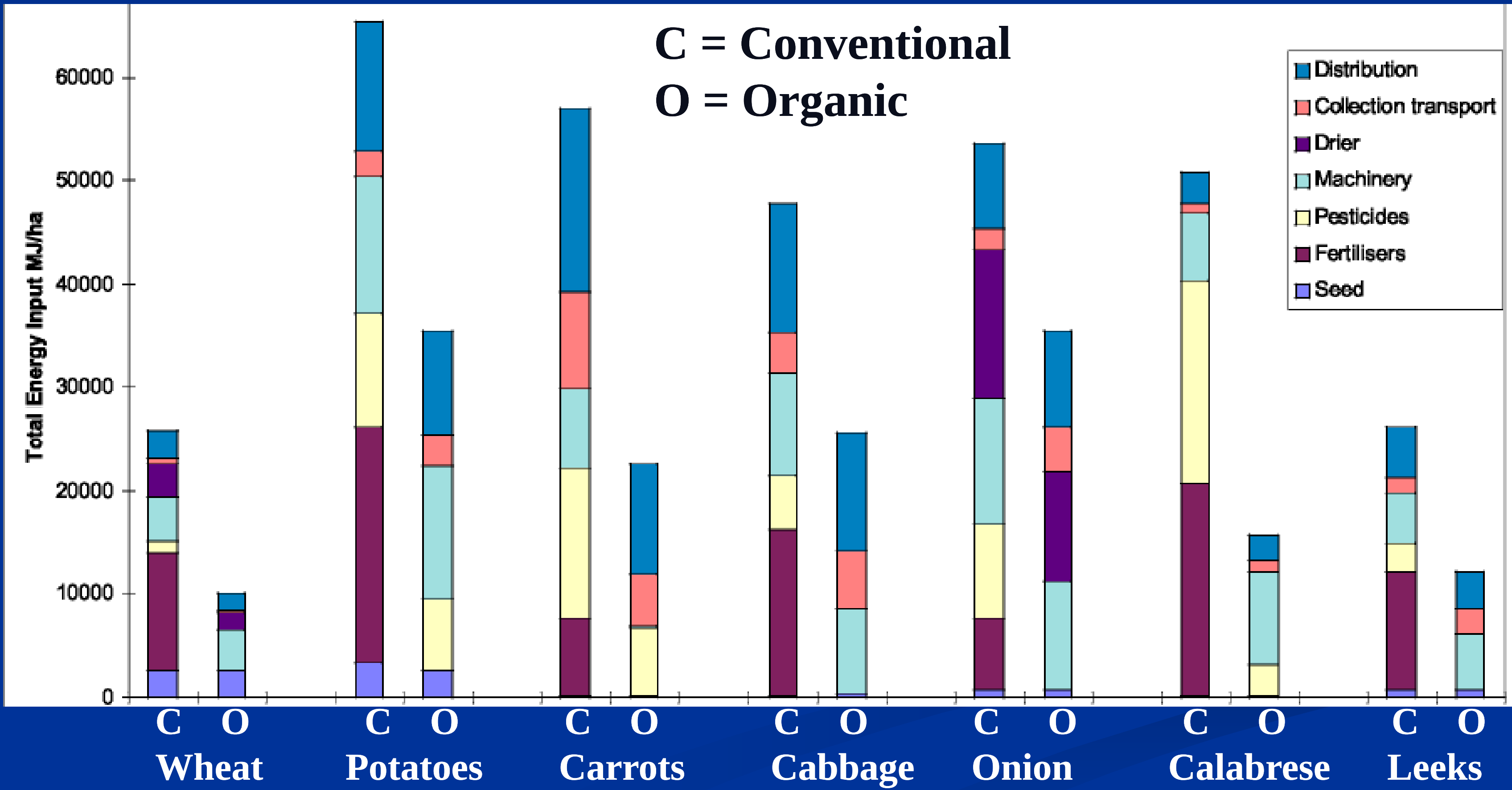
- CO_2 : mainly emitted by agriculture machines, transport, nitrogen fertilizers production, deforestation for meat production
- CH_4 : mainly emitted by enteric fermentation, manure and slurry fermentation, rice production
- N_2O : mainly emitted by soils

1kg methane = 25kg CO_2 (or 57kg at 2050 horizon)
1kg nitrous oxide = 310kg CO_2

Organic versus conventional agriculture
1. Energy consumption and CO_2 emissions

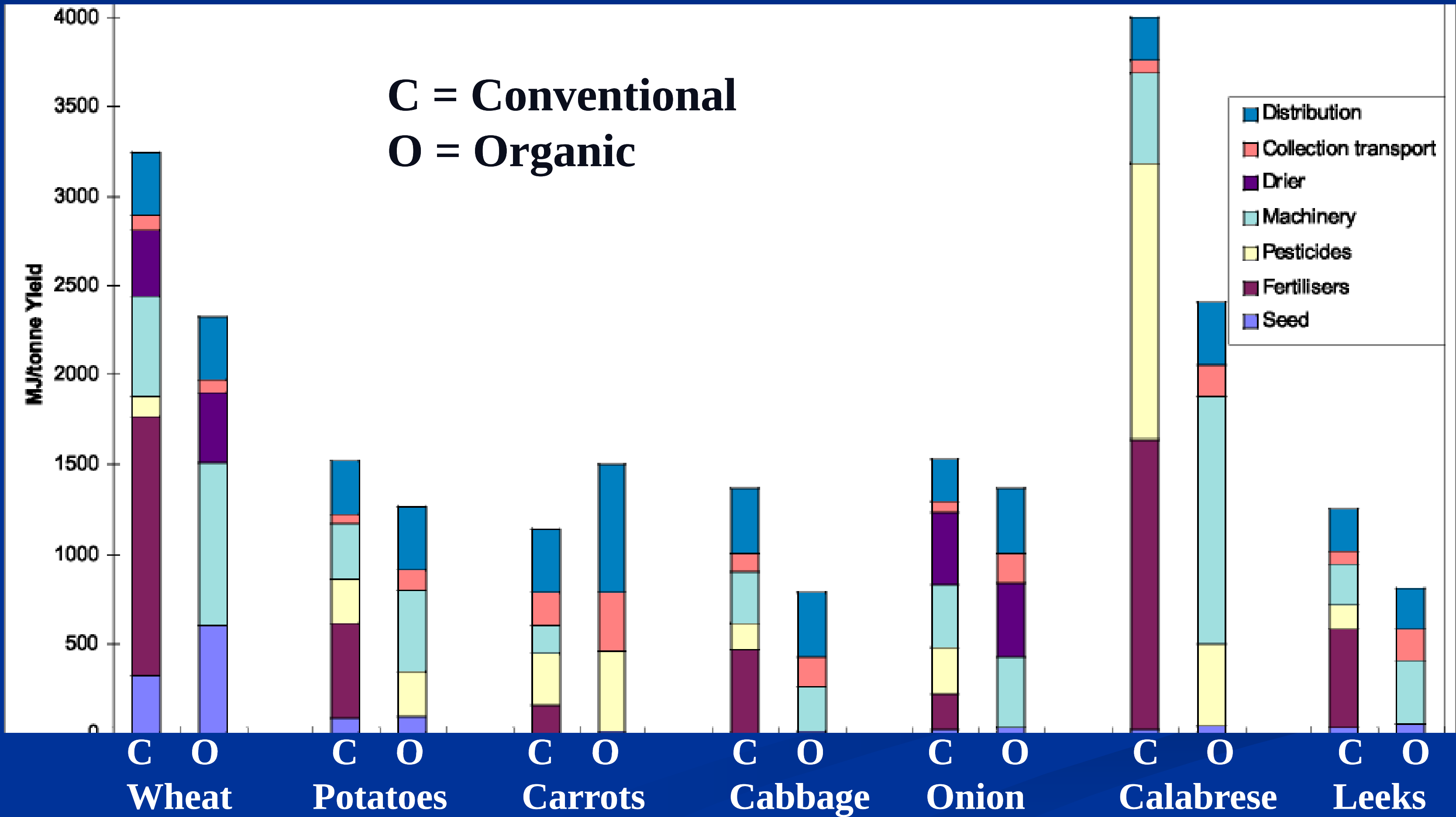
- In intensive conventional agriculture about half of the energy consumption and CO_2 emissions are imputable to the manufacture of nitrogen fertilizers
- Therefore the CO_2 emissions **per ha** in organic agriculture are, in many cases, about **half** of the ones in conventionnal
- The emissions **per ton** produced can be inferior or superior depending on the yields
- **Biogaz** production can reduce fossil energy consumption and CO_2 emissions

Energy consumption per area unit in organic and conventional agriculture (MJ/ha)



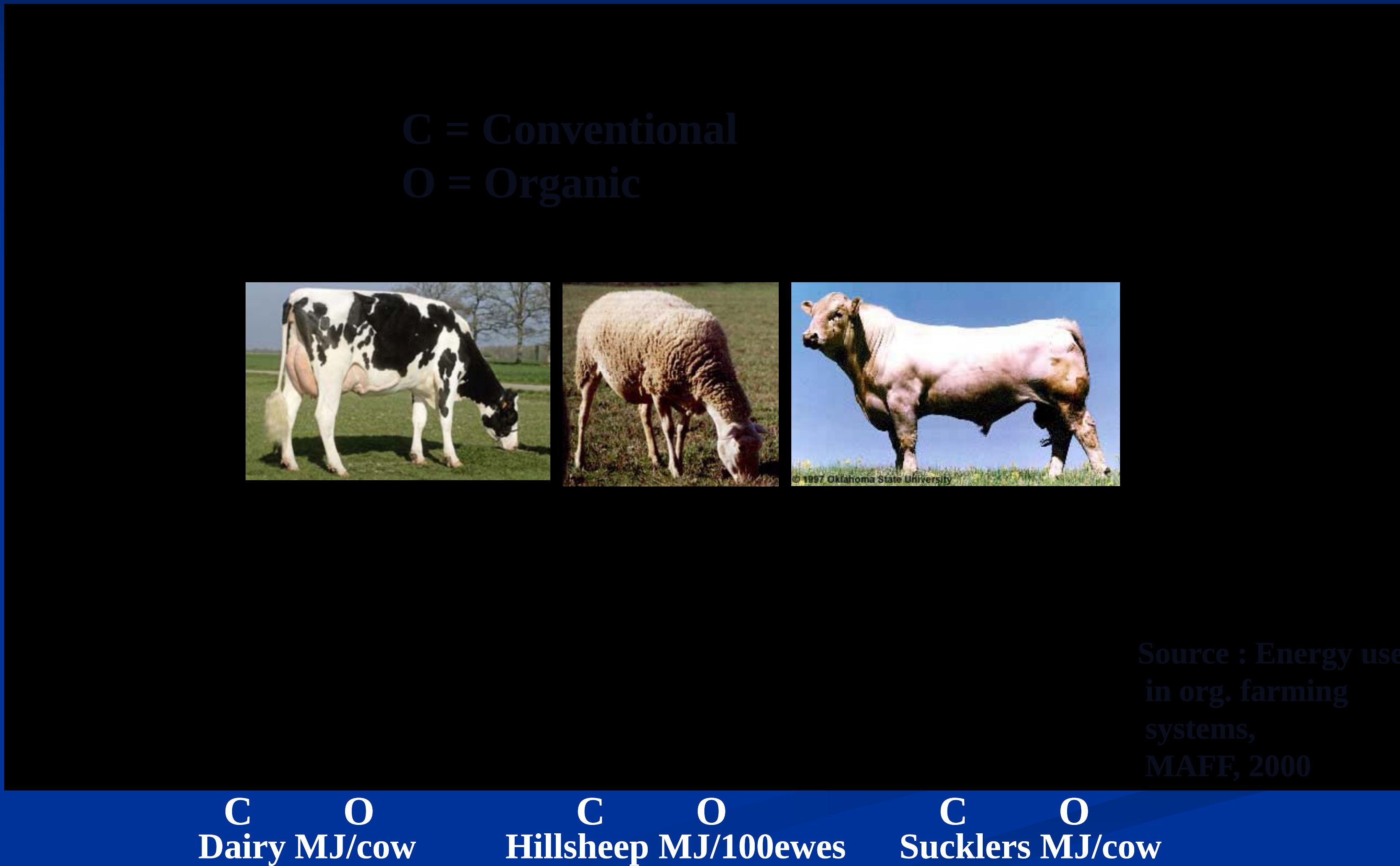
Source : Energy use in org. farming systems, MAFF, 2000

Energy consumption per tonne in organic and conventional agriculture (MJ/tonne)



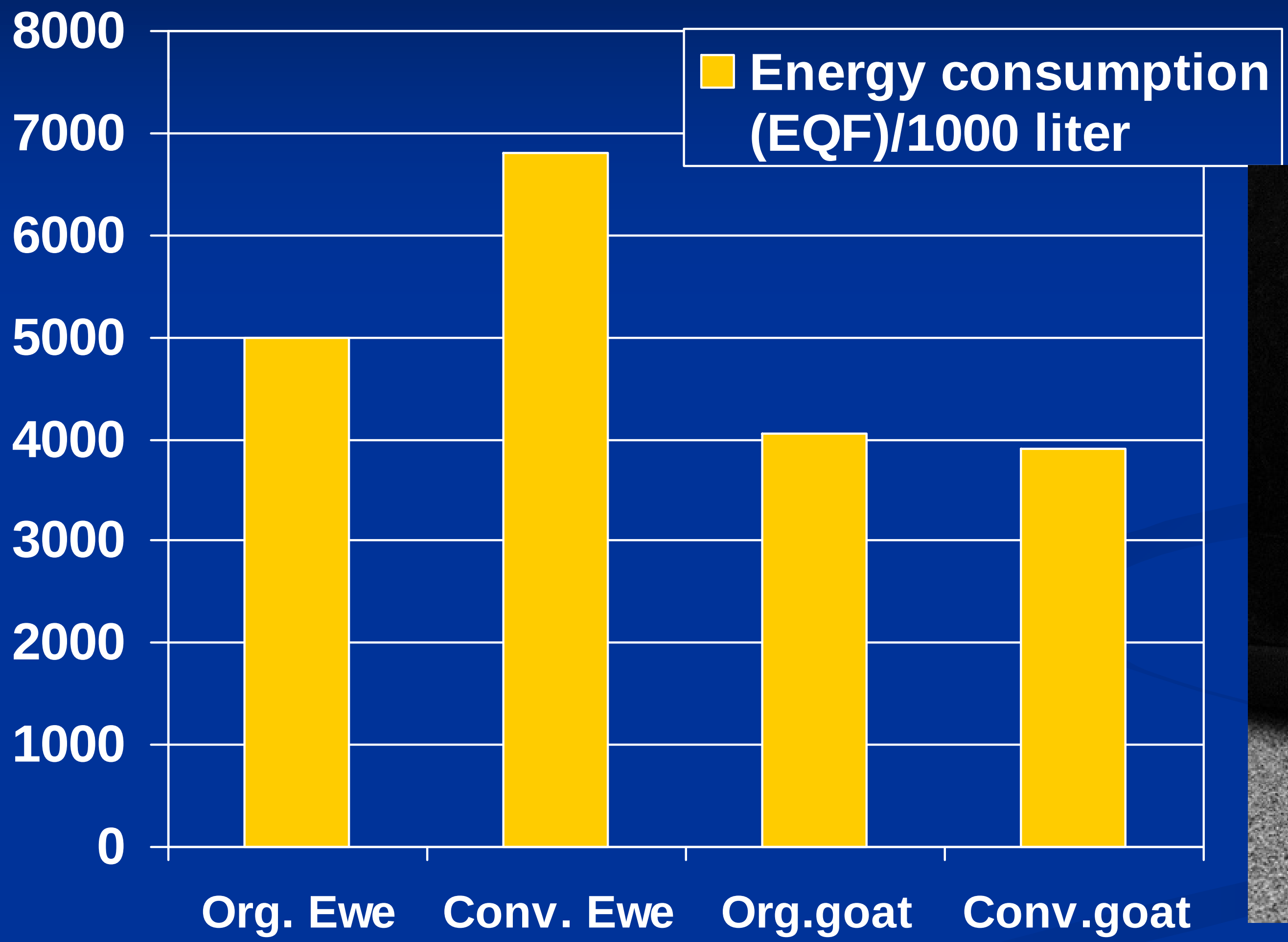
Source : Energy use in org. farming systems, MAFF, 2000

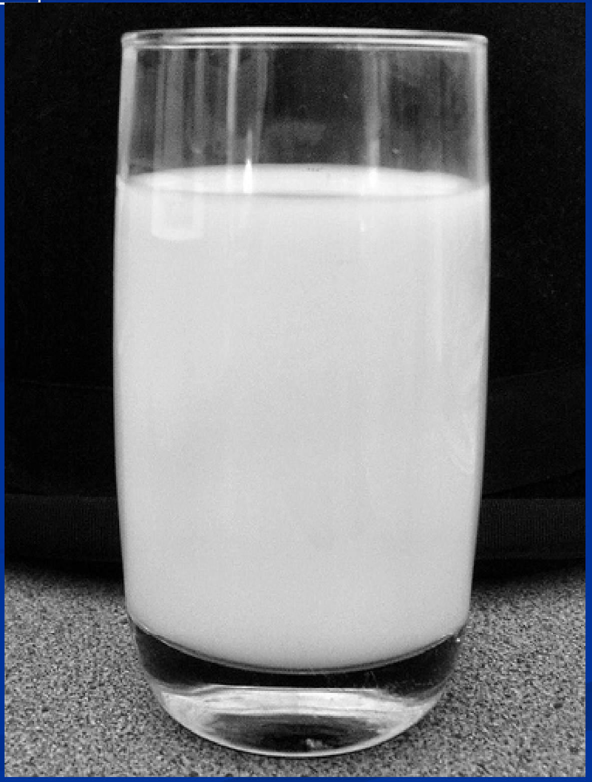
Direct and indirect energy consumption in different types of stock breeding



Source : Energy use in org. farming systems, MAFF, 2000

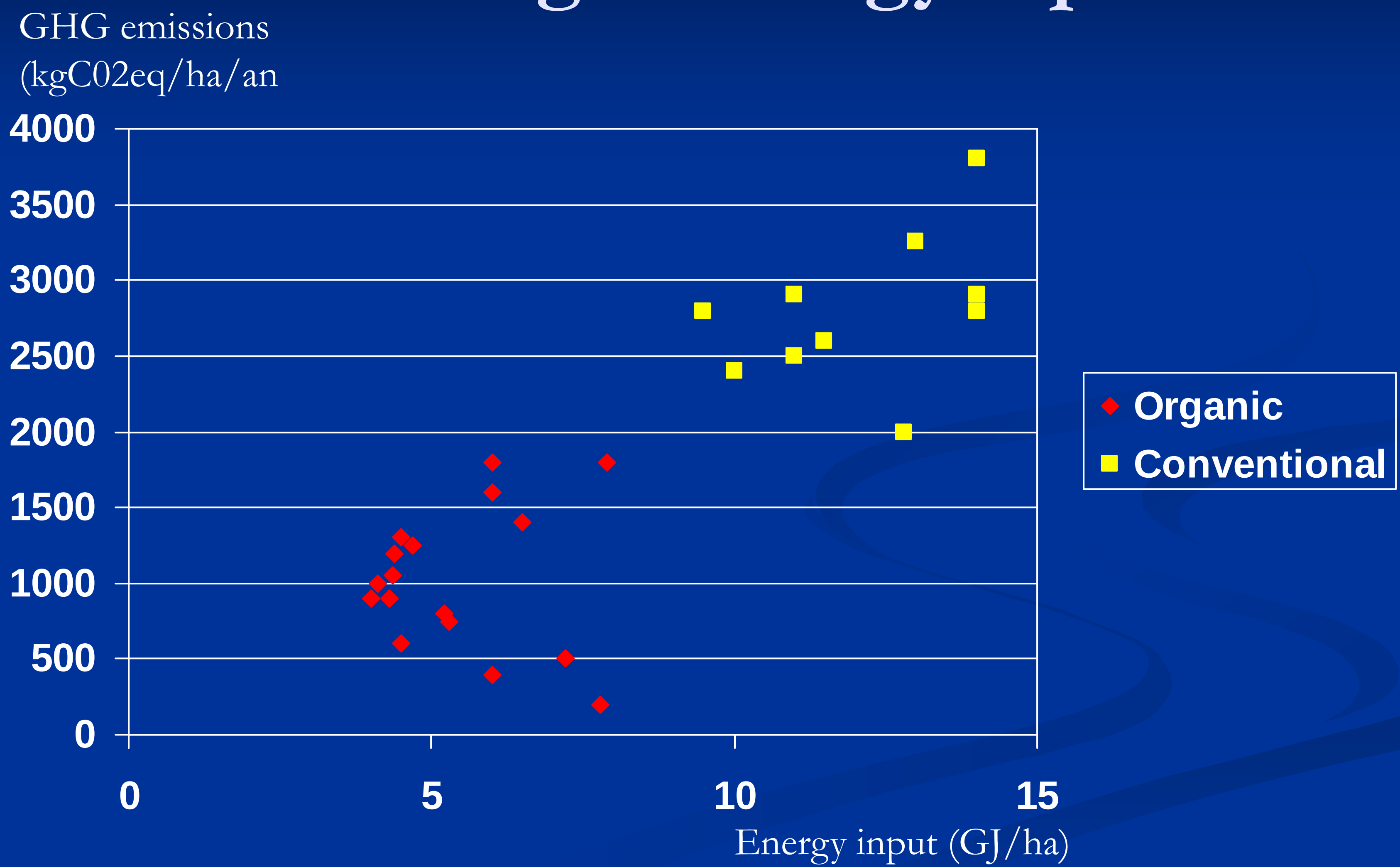
Energy consumption by liter milk in organic and conventional production





Source : Lynch, Denmark

Greenhouse gases emissions according to energy input

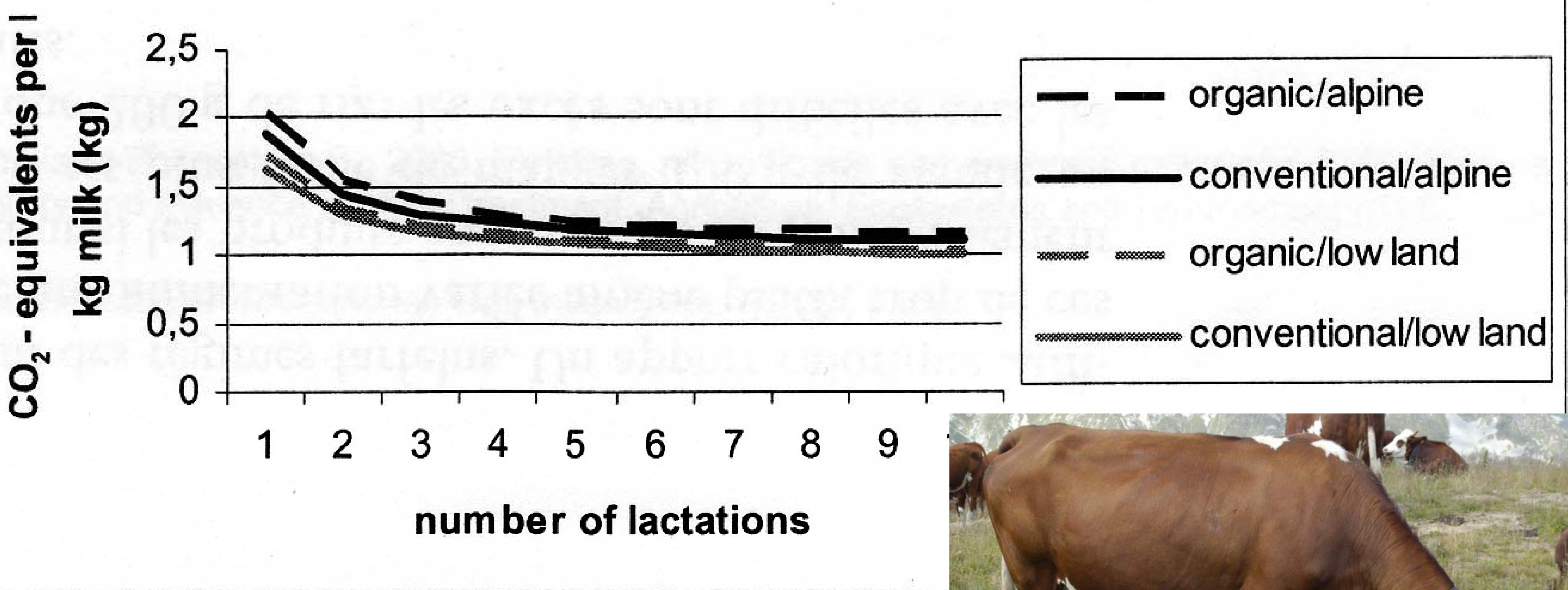


Hülsbergen, 2008

Organic versus conventional agriculture 2. Methane (CH_4) emissions

- The emissions due to **enteric fermentations** are lower in organic agriculture per ha, and also in most cases per kg milk since, in average, organic cows live longer than conventional
- **Composting** (aerobic fermentation) reduces the emissions due to manure fermentation
- Reduce the comsumption of **meat from ruminants** remain the best way to mitigate CH4 emissions

GHG emissions by liter milk according to the production system and the nomber of lactations



Source : Boincean, Moldavia

GHG emissions by solid or liquide manure

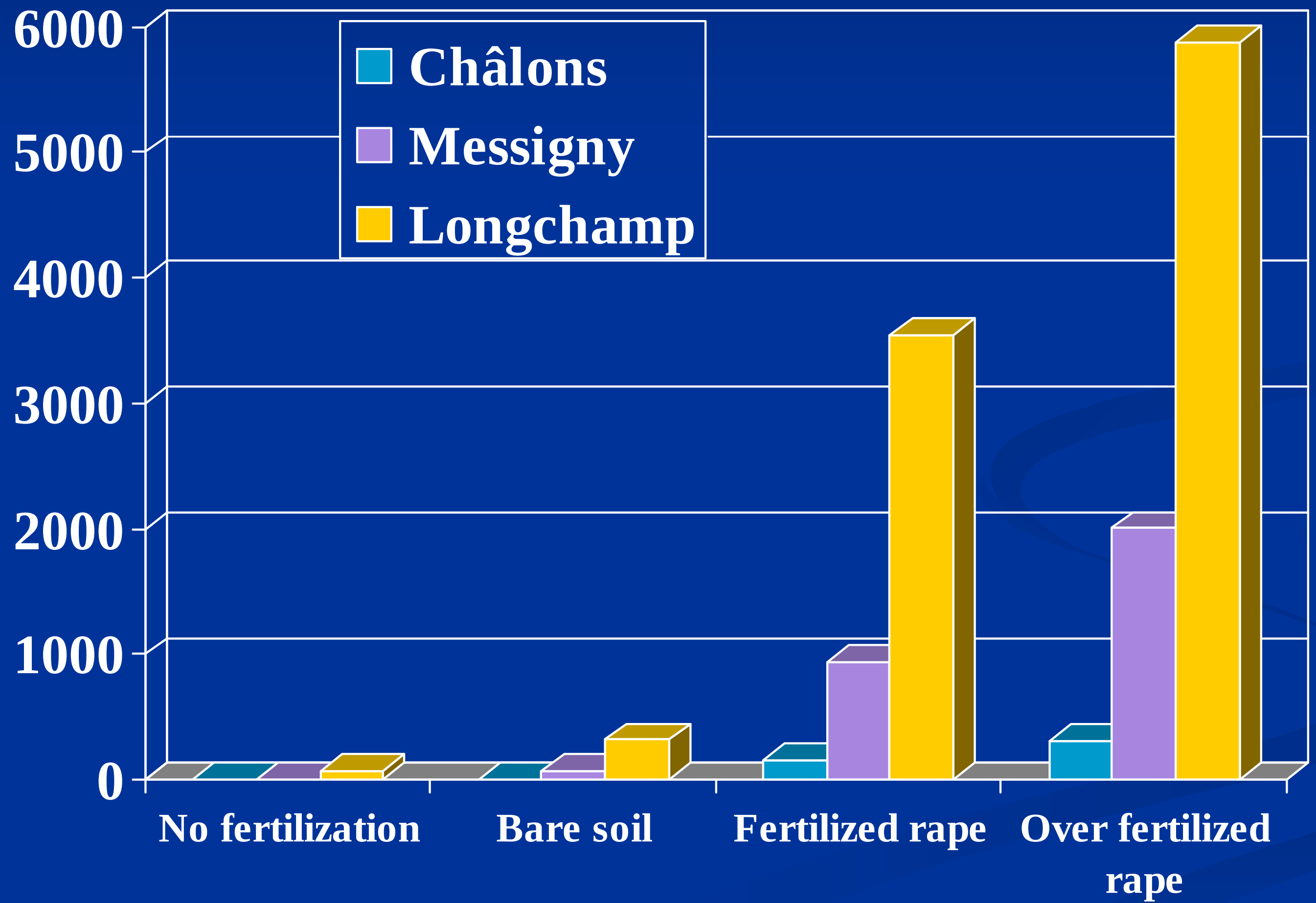
Compost :	487 kg CO2eq/cow/year
Manure heap :	729 kg CO2eq/cow/year
Slurry :	1481 kg CO2eq/cow/year

Source : Pattey, 2008

Organic versus conventional agriculture 3. Nitrous oxide (N2O) emissions

- N2O emissions vary strongly with several factors (type of soil, humidity, crop, compaction…)
- N2O emissions increase rapidly with the level of nitrogen fertilization
- Therefore N2O emissions are lower in organic than in conventional agriculture
- Biologically fixed nitrogen by legumes emits much less N2O than nitrogen spread as fertilizers (mineral or organic)
- For exemple, the production of hay from tomithy emits 7 times more N2O than the same quantity of hay from clover

N2O emissions (in g N/ha) in 5 months according to the type of soil and the fertilization



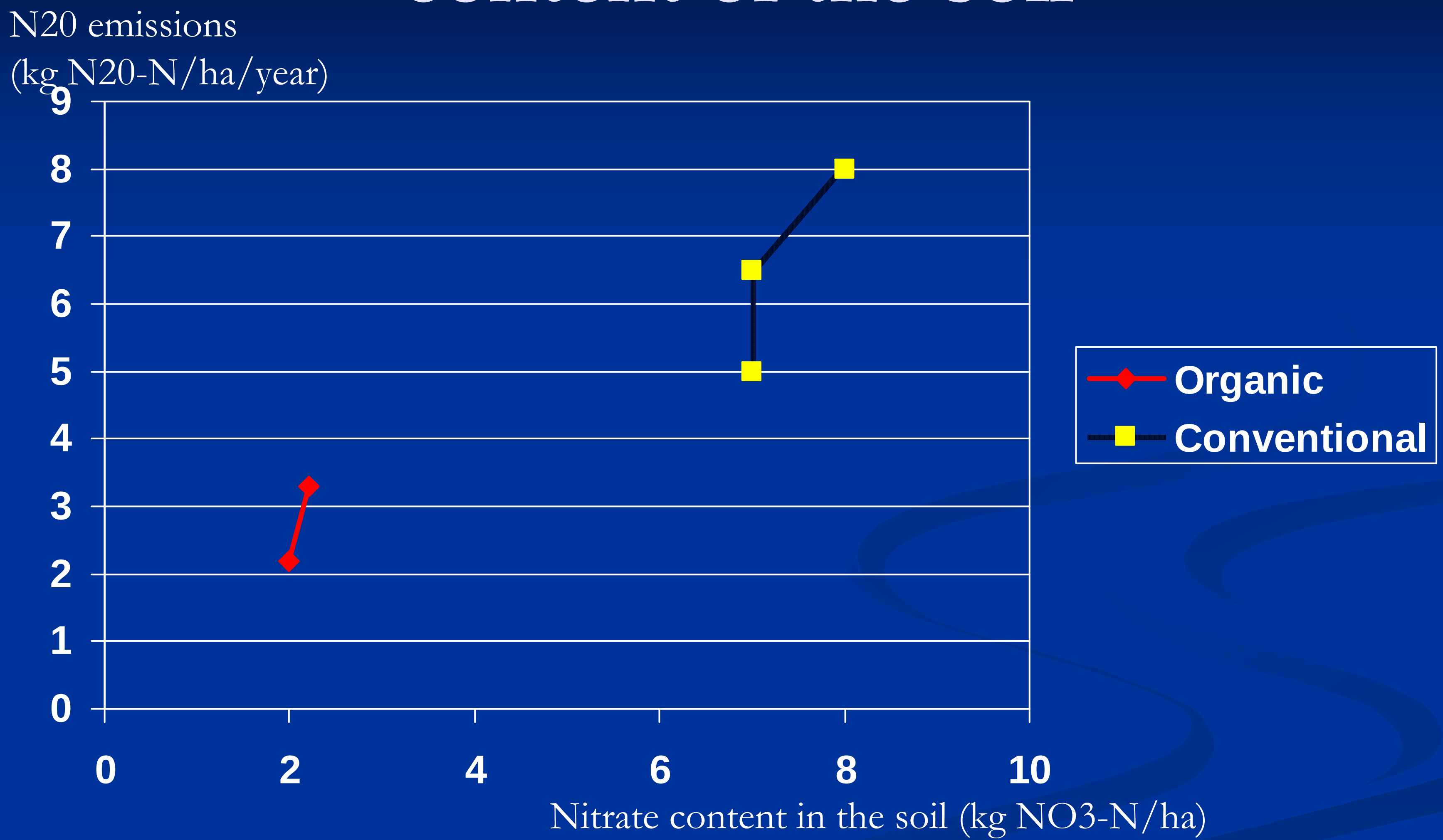
Source : Germon JC et col., 1999

N2O emissions from potato and forage crops according to N fertilization and previous crop

Treatment/crop/previous crop	N2O emissions (kg N/ha/year)
Potato fertilized	14.3
Potato non fertilized	4.0
Potato after clover	4.9
Potato after timothy	8.1
Clover	3.9
Timothy	14.5

Source : Lynch, Canada

N2O emissions in terms of nitrate content of the soil

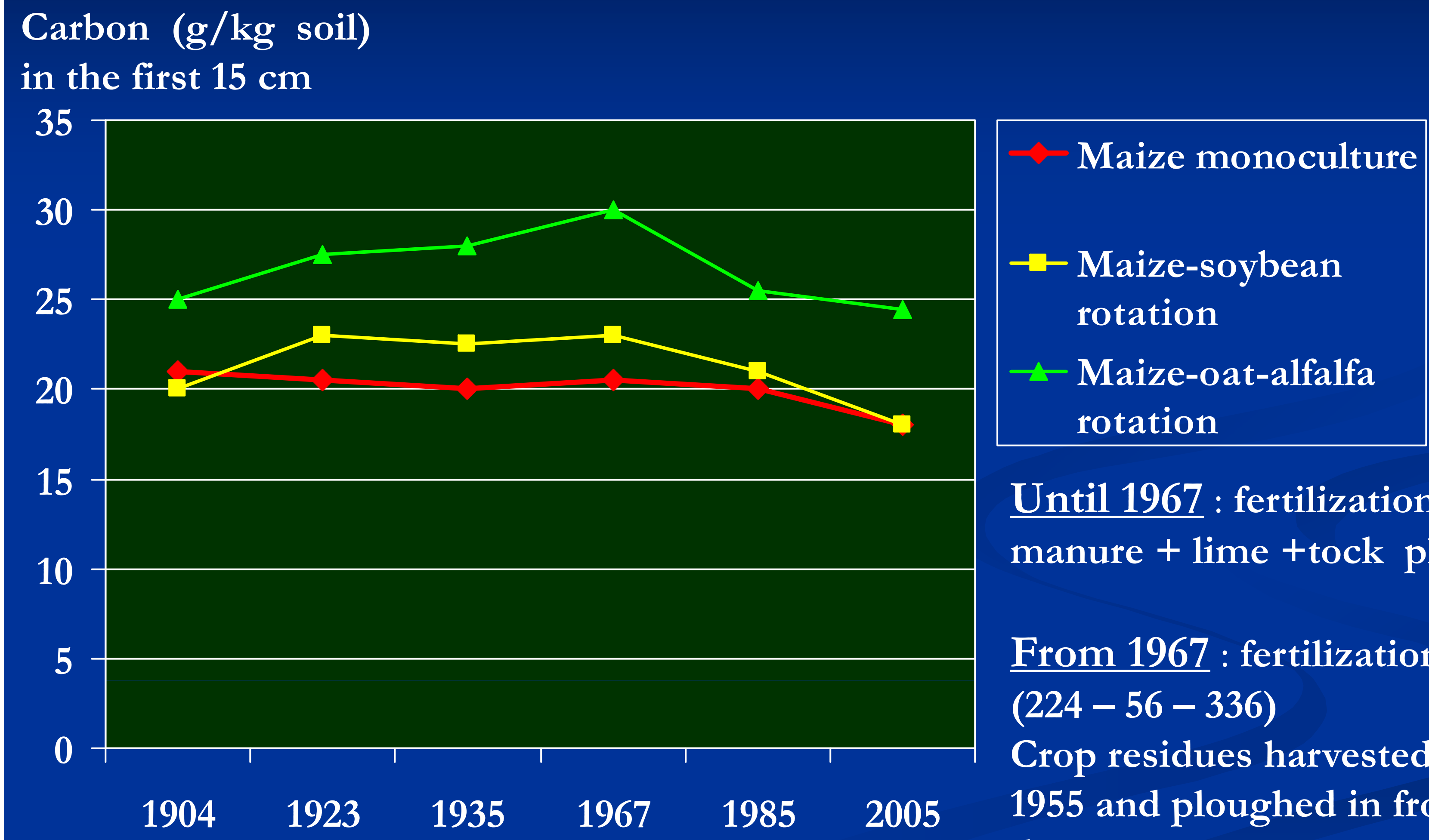


Source : Sehy U (2004) N20 Freisetzungz landwirtschaftlich genutzer Böden unter den Einfluss Von Bewirtschaftung-Witterungs- und Standort Faktoren. Dissertation TU-München-Weihenstephan, Institut für Bodenbiologie, 173 p.

Organic versus conventional agriculture
4. Carbon sequestration

- Most experiments have shown that **organic agriculture sequestres more carbon** in the soil than conventional agriculturre (between 100 and more than 1000kg/ha/year)
- However organic agriculture without livestock and with poor rotations can desequestre carbon
- The best way to sequestre carbon in the soil is the change in soil use : turn annual crops to grassland or forest

Impact of fertilisation on carbon content in the sol

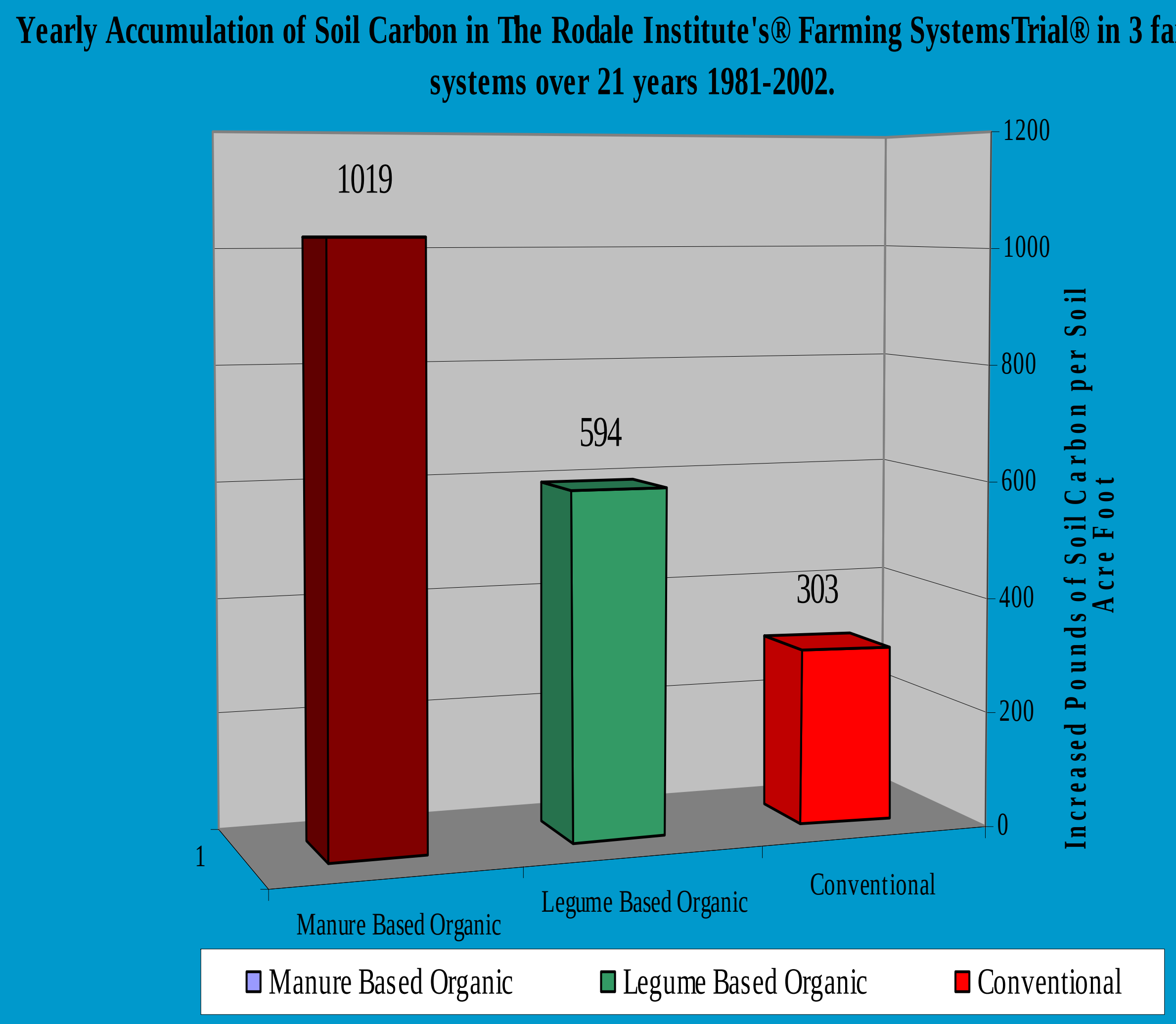


Until 1967 : fertilization with ma manure + lime +tock phosphate

From 1967 : fertilization with NPK (224 – 56 – 336)
Crop residues harvested until 1955 and ploughed in from that date

Source : Kahn SA et al. The Myth of Nitrogen Fertilization for Soil Carbon Sequestration, *J Environ Qual*, 36:1821-32, 2007

Carbon sequestration in the soil in organic and conventional agriculture (long term experiment)



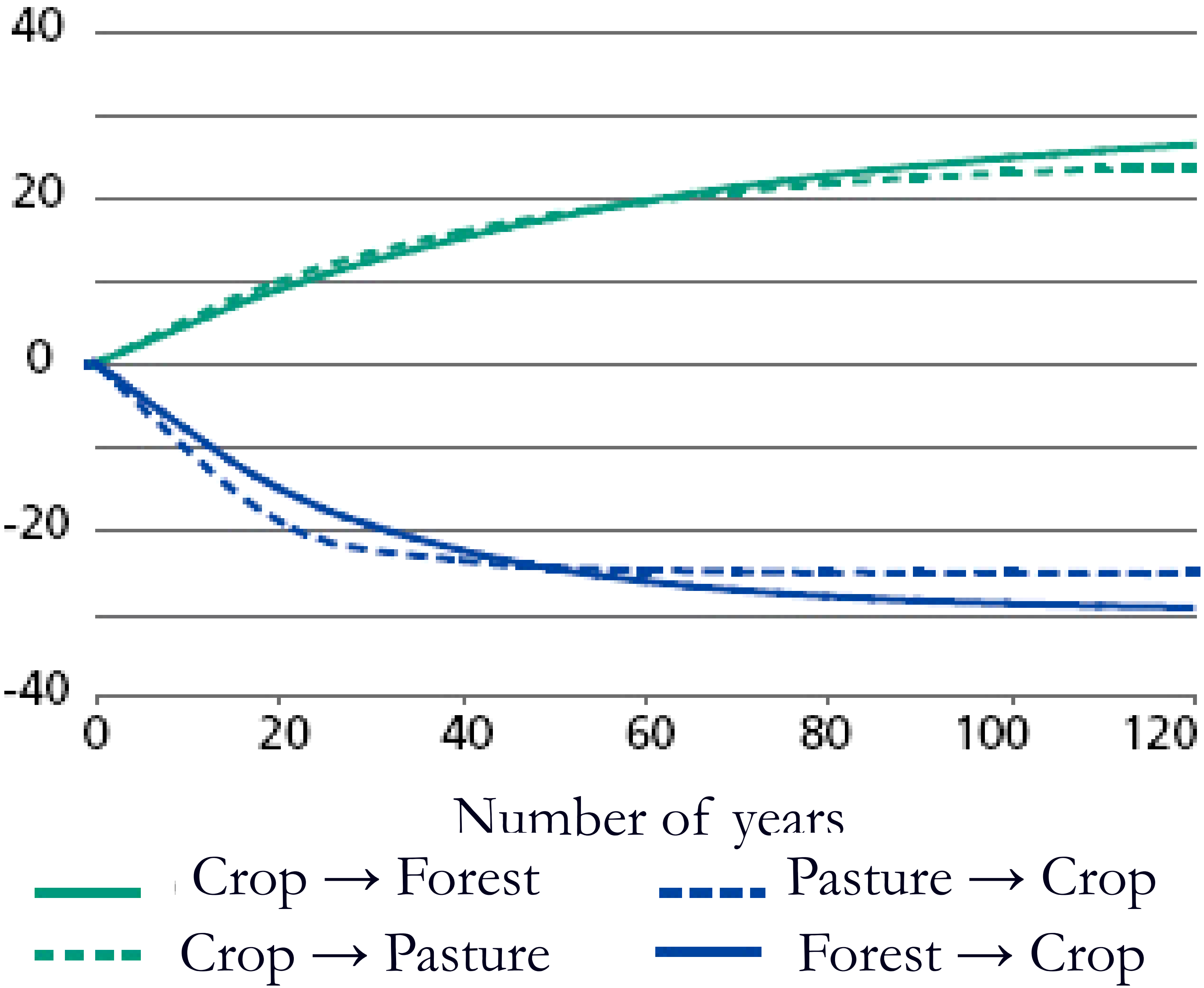
Source: Rodale Institute

Potentiel of sequestration of carbon by various agricultural practices

No till	0 to 0,2 tC/ha/year
Green manure	0,15 tC/ha/year
Animal manure or composr	0,3 to 0,5tC/ha/year
Permanent grass cover (vignard and orchards)	0,4 tC/ha/year
Improved rotations, with legumes	0,2 tC/ha/year
Plantation of hedges	0,1 tC/ha/year
Conversion to organic agriculture	0,1 to 0,7 tC/ha/year

Sources : INRA ;Fibl ; Rodale Reasearch center ; Foereid, 2004 ; West, 2002

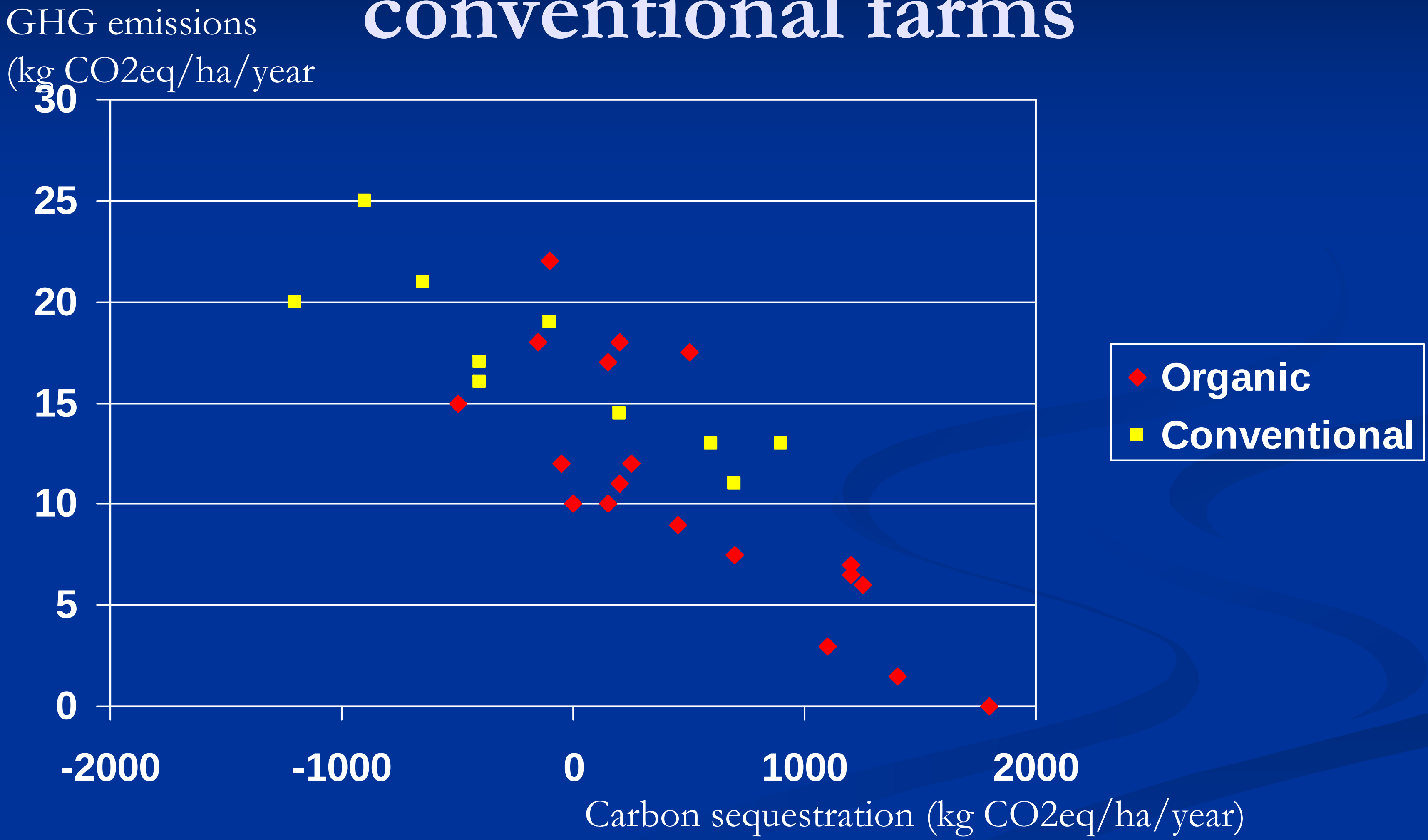
Carbon sequestration according to land use change



Organic versus conventional agriculture
5. Global Warming Power (GWP)

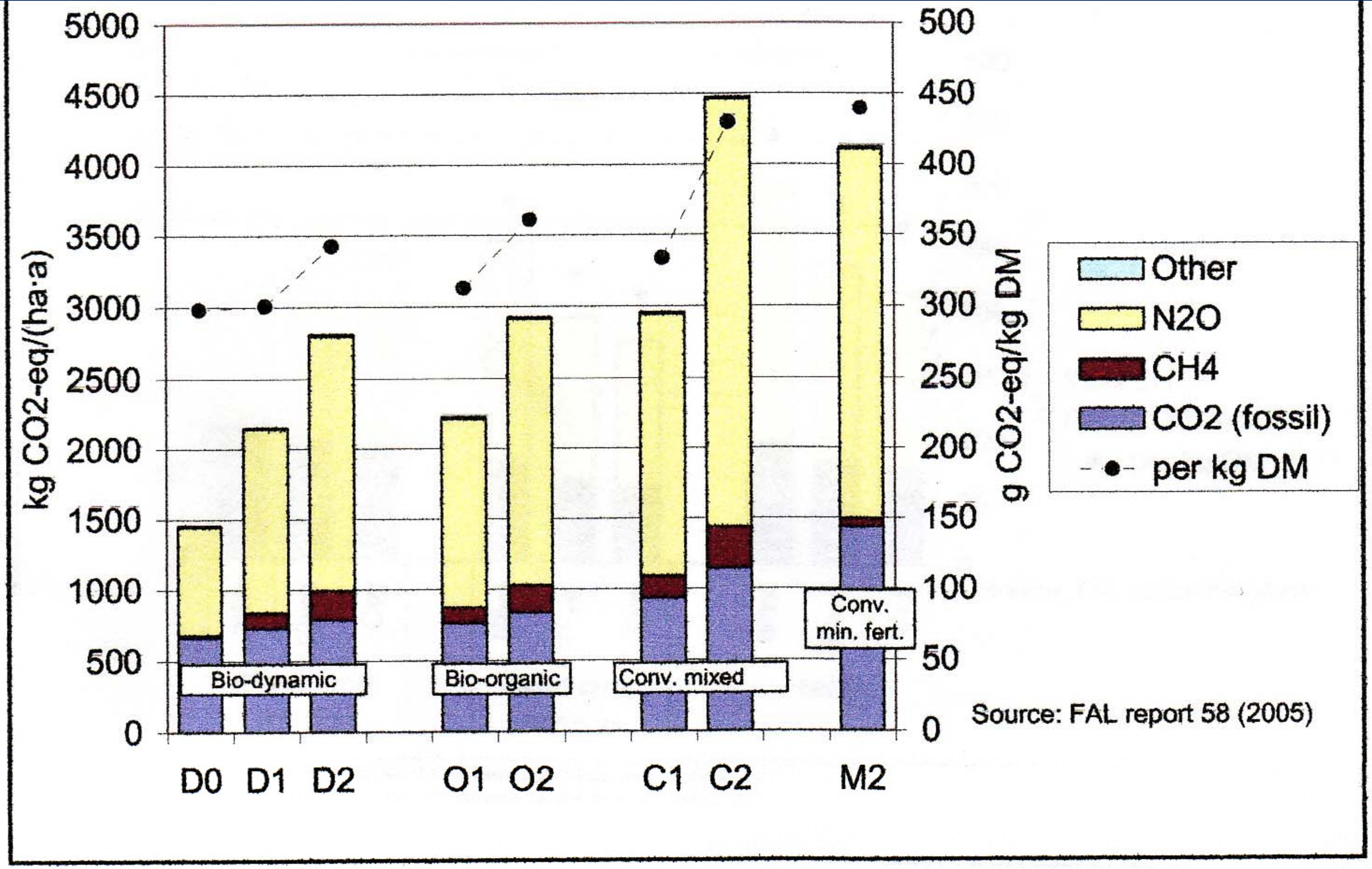
- Adding the emissions of the three gases (CO_2, CH_4 and N_2O), organic agriculture emits **per ha** 20% to 80% less than conventional
- The emissions **per ton** can be lower or higher according to the type of production and the difference in yield between organic and conventional production
- Taking in account the sequestration of carbon, the emissions remain lower in most cases, also per ton, in organic production

GHG emissions and carbon sequestration in organic and conventional farms



Hülsbergen, 2008

GHG emissions in organic and conventional production systems (DOC experiment, Fibl)



GHG gases emission in intensive and extensive grazing (kgCO2eq/ha/an)

Greenhouse gases	Intensive grazing	Extensive grazing
CO_2	- 376	-1395
N20	+ 130	+ 20
CH_4	+ 887	+ 456
Bilan	+ 641	- 919

Source : Soussana JJ, Sources et puits de gaz à effet de serre en prairie pâturée et stratégies de réduction, INRA, 2004

Legumes, a key in the reduction of GHG emission by agriculture

- For the same amount of nitrogen, the emissions by biologically fixed nitrogen are much lower than by nitrogen fertilizers
- The more nitrogen is fixed by legumes, the less mineral nitrogen (in conventional agriculture) is needed, avoiding the emissions by the manufacture of this nitrogen and reducing the emissions by the soil
- Moreover, annual legumes sequestre carbon in the soil, improve the soil and increase the yields

GHG emissions per ton chemical nitrogen ($ton\ CO_2eq/ton\ N$)

Energy consumption by manufacture	2.7 tons CO_2
N_2O emissions by manufacture	4.0 tons CO_2eq
Direct N_2O emissions by application	4.9 tons C02eq
Indirect applications by application	4.1 tons CO_2eq
Total	**15.7 tons CO_2eq**

Source :Aubert C (estimation)

N2O emissions by nitrogen fertilization ($kg\ CO_2eq/kg\ N$) (estimation)

Chemical nitrogen	15kg CO2eq/kg N
Organic nitrogen	9kg CO2eq/kg N
Biologicaly fixed nitrogen	1 to 2kg CO2eq/kg N

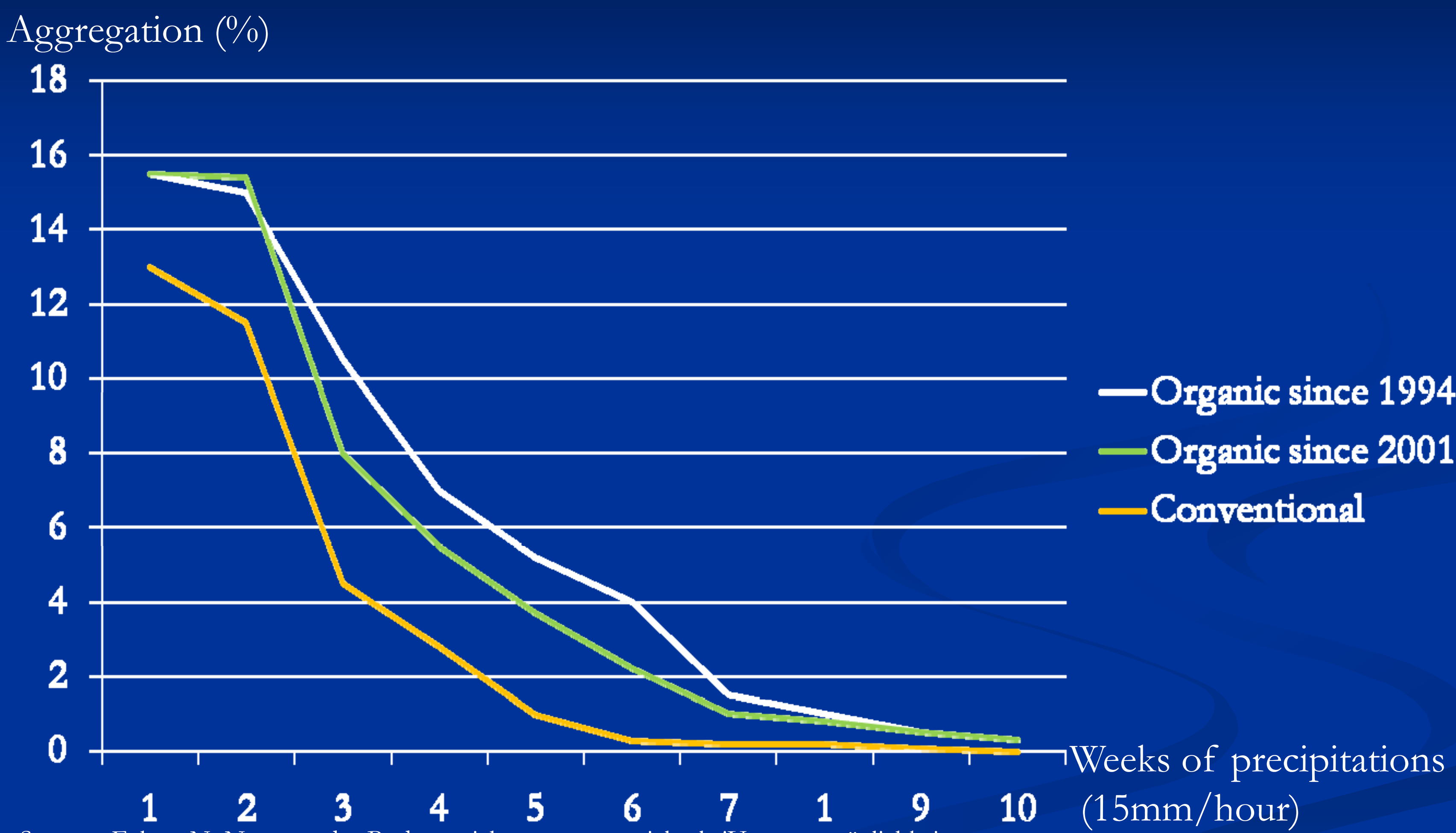
Source :Aubert C (estimation)

Rapidity of infiltration of water in organic and conventional soils

	Conventional	Organic
Infiltration (%)	100	200
Earthworms	100	142
Humus content (%)	3,3	2,8

Source : Lilienthal H Hochwasserschutz durch ökologische Bodenbewirtschaftung, Paper presented at the KTBL Conference « Klimawandel und Ökolandbau, » 1-2 December 2008, Göttingen, Germany

Stability of aggregats in organic and conventional soils



Source : Fohrer N Nutzung des Bodenspeicherungspotenzials als !Vorsorgemöglichkeir für Starkregenereignisse und TrockenperiodenPaper presented at the KTBL Conference « Klimawandel und Ökolandbau, » 1-2 December 2008, Göttingen, Germany

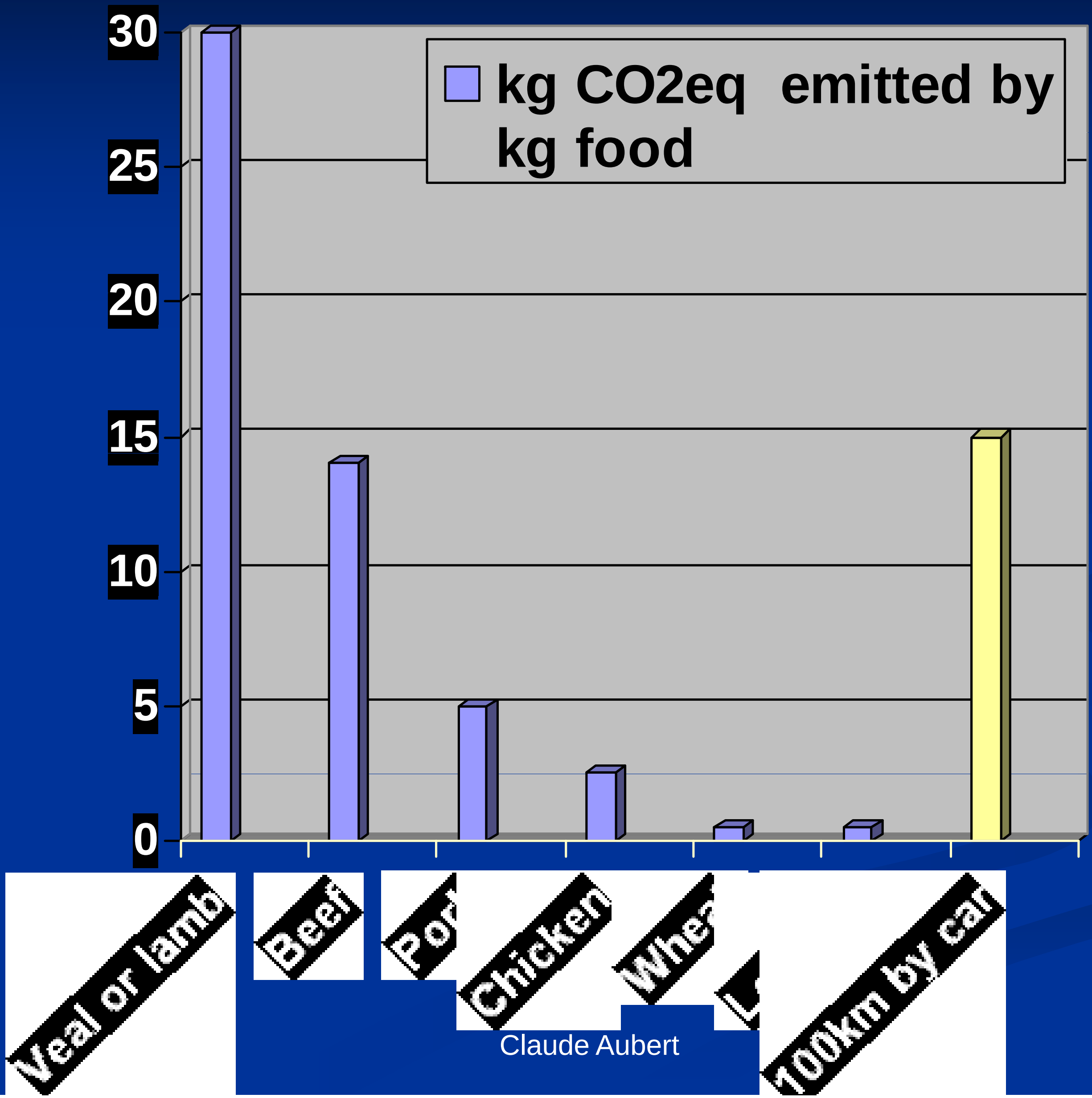
Mitigate the GHG emissions by organic (and conventional) agriculture Some priority technical choices

- Replace, as far as possible, nitrogen fertilizers by biological fixation by growing more legumes
- Feed the ruminants more grass and less maize silage and concentrate (grain, soycake)
- Improve the rotations (more legumes, more green manure)
- Compost animal dejections
- Produce biogas

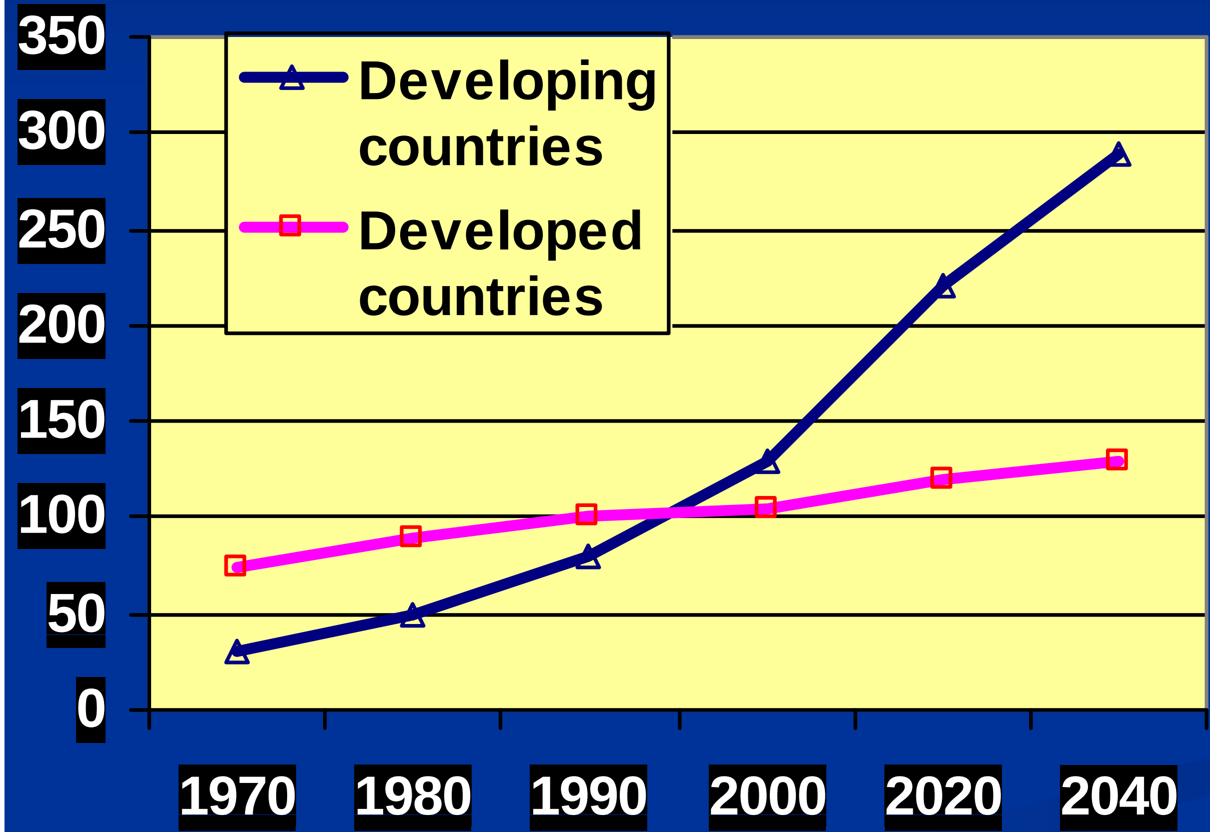
Impact of our food habits
A few exemples

- Producing 1 kg lamb or veal emits 30 times more GHG than producing the same amount of proteins as soybean or other legumes
- Eating fruit or vegetable imported by plane emits 50 times more CO_2 than eating the same thing locally produced
- Eating 1kg deep frozen french fries emits 5.7kg GHG (the same as driving 40km in an average car!)

GHG content of vegetable and animal food



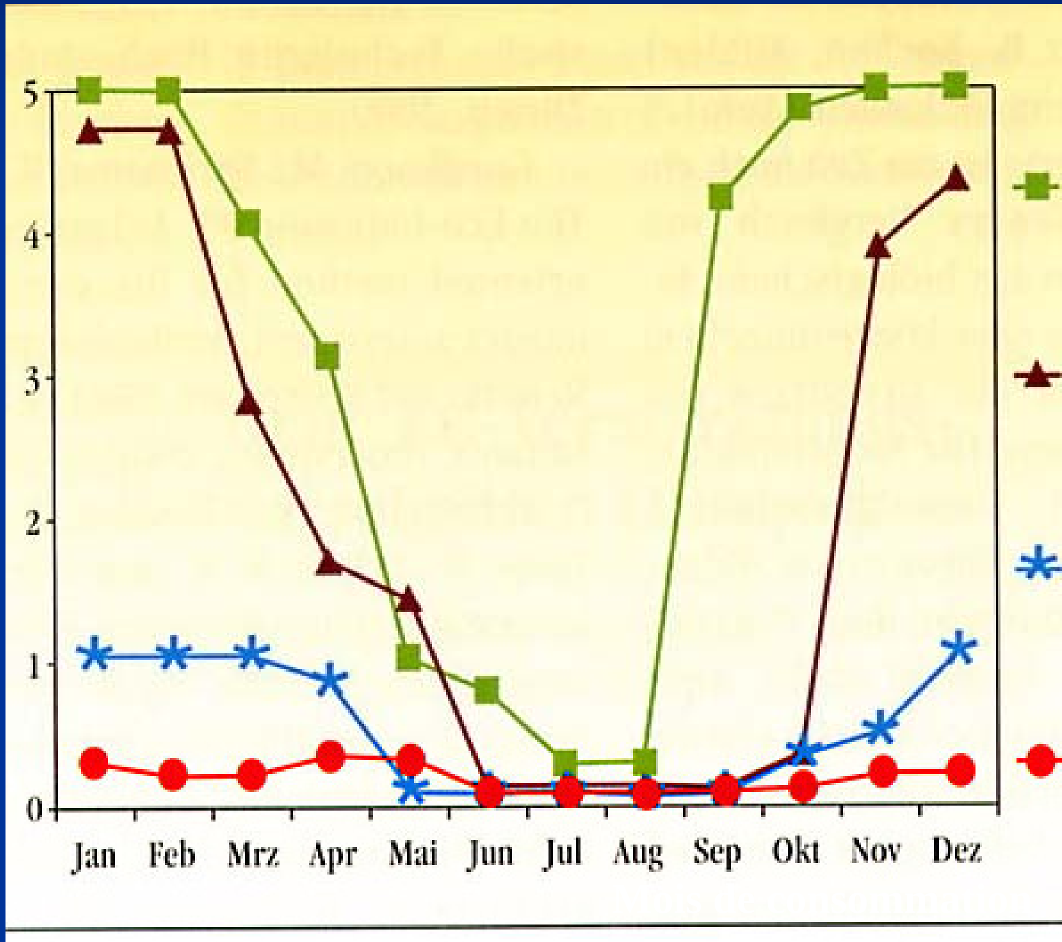
World production of meat from 1970 to 2040 (projection) (millions tons/year)



Source : *Livestock's long shadow*, FAO, 2006

Oil consumption (kg oil/kg) for vegetables according to the season

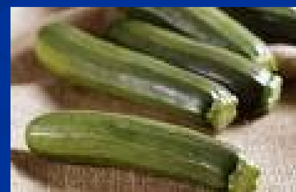
(for european consumers)



Green asparagus

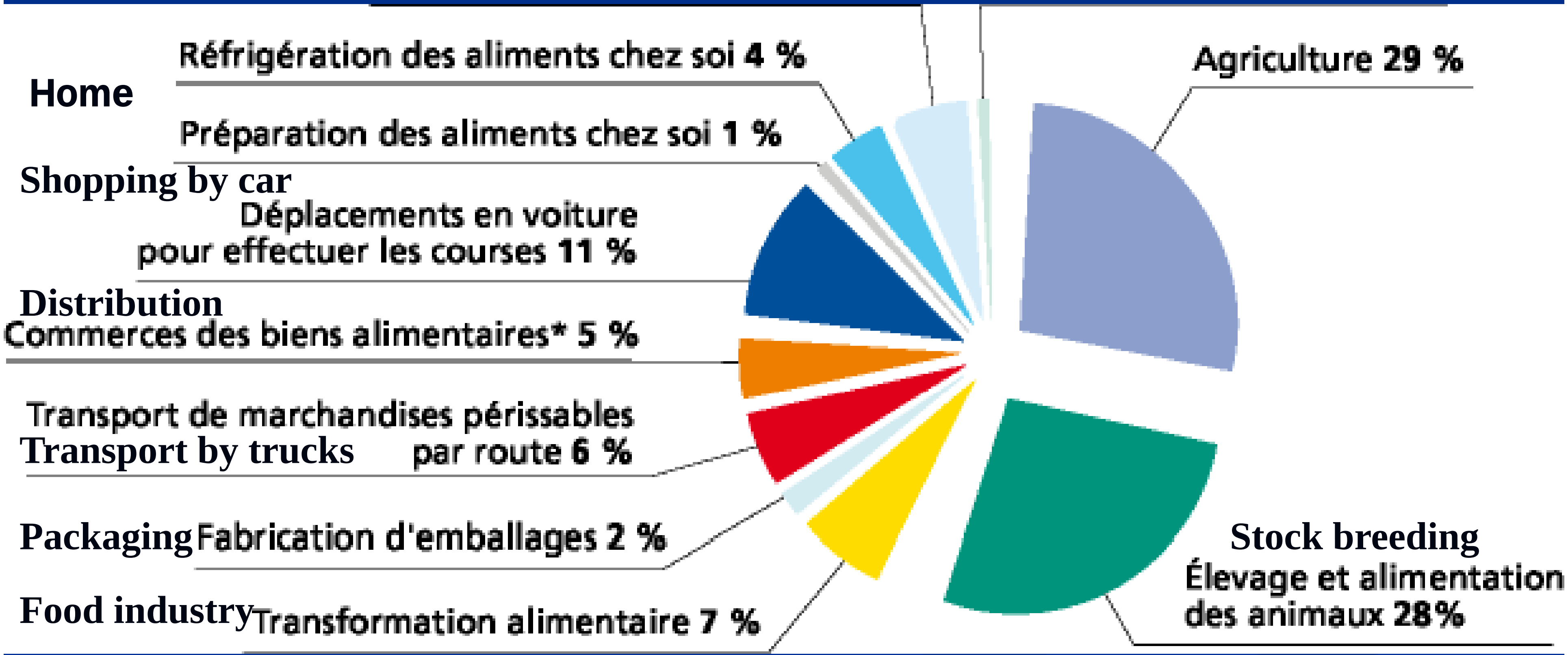
Green beans

Zucchinis



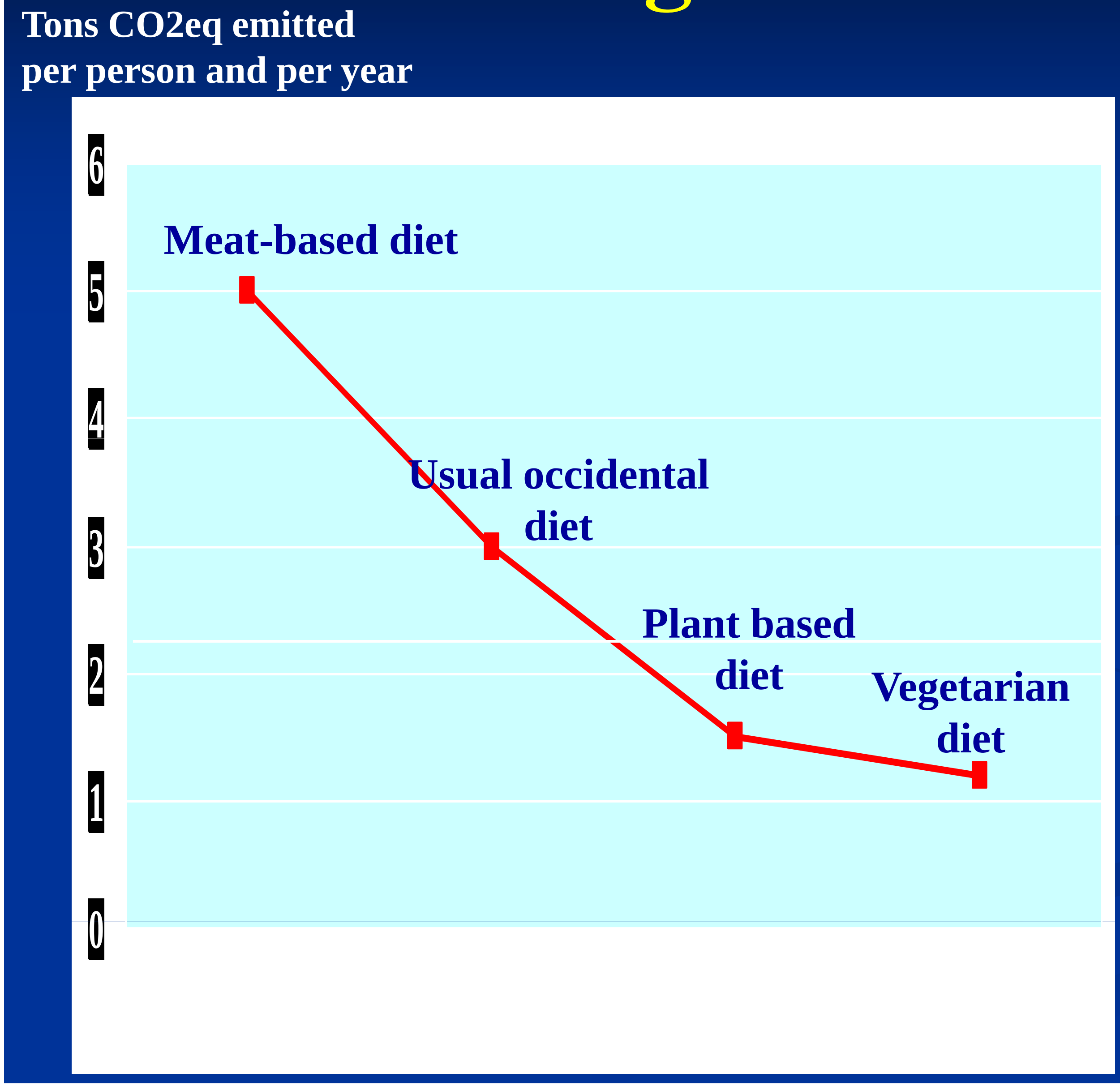
Tomatoes

GHG emissions from the soil to the plate



Source : IFEN

Amount of CO2eq in our plate according to our food habits



Meat-based : meat at all meals, beef, veal or lamb daily

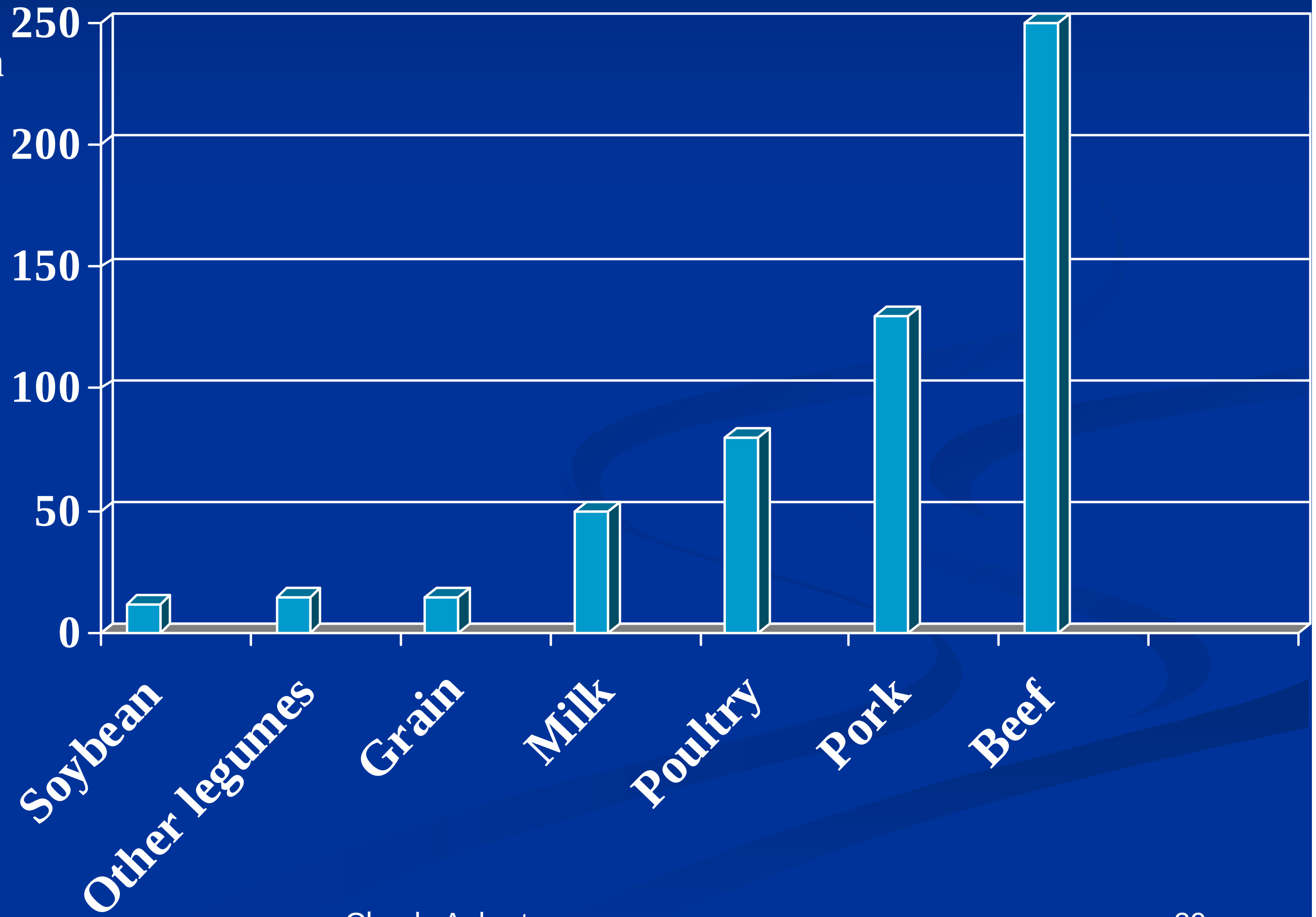
Usual occidental: about 200g meat daily including 50g beef, veal or lamb

Plant-based: meat occasionaly, mainly poultry

Vegetarian : no meat

Source : C. Aubert, 2007

Area required to produce 1 kg animal or vegetable protein



Food habits changes to mitigate GHG emissions

- Eat less meat, especially ruminant meat (beef, veal, lamb)
- Eat less animal products in general
- Eat local products
- Eat less processed and frozen food
- Eat less packaged food
- Eat more grain, legumes, vegetable, fruit

Conclusion (1)

- Organic agriculture emits less GHG than conventional agriculture
- Organic agriculture can still improve its mitigation potential (better rotations, more legumes, energy savings, renewable energy…)
- Changing our food habits (organic, less meat, local…) is the easiest and least expensive way to mitigate our GHG emissions

Conclusion (2)

Divide by two, or more, the GHG emissions of agriculture and food is possible but it needs political and individual will to change agriculture and food habits


Thank you
for your attention