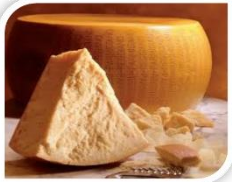
The results of the LIFE+ Climate changE-R project and the contribution of agriculture to the reduction of climate-altering factors: animal and crop sectors

The project started on 01/07/2013 and anded on 31/12/2016

Choise of
Dairy / beef-cattle farms


Data collection

Choice of the
method for GHG calculation

METHOD CML 1992

Impact Category		Normalization factor
Greenhouse	kg GWP	8,99E-05
Ozone Layer	kg ODP	6,74
Eutrophication	kg NP	3,00E-02
Acidification	kg AP	1,11E-02
Summer smog	kg POCP	5,98E-02
Energy Resources	MJ LHV	6,52E-06
Solid waste	kg waste	2,30E-03

Samples collection

GHG emissions estimation and carbon footprint calculation

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RIDUZIONE DELLE EMISSIONI DI GAS EFFETTO SERRA DA PARTE DEI SISTEMI AGRICOLI DELLA REGIONE EMILIA-ROMAGNA

Products – GHG emissions from cradle to gate

Milk

Milk for Parmigiano Reggiano

Beef cattle

What does carbon footprint mean

- Amount of greenhouse gas emissions (in kgCO2eq) associated to the production of an asset, taking into account the entire chain

From where and where we stop

- Emissions from the manufacture of all the technical means used by the dairy/beef farms: food, fertilizers, defense products, seeds, energy, detergents, etc.
- We stop at the farm gate

Reference units

- **1 kg of standard (FPCM) milk**
- **1 kg of live weight**

It's significantly influenced by

- Production level of milk and meat
- Stock replacement (the animals do not produce milk and suckler cows: produce enteric emissions, effluents, consume foods, etc.)
- Level of self-produced fodder (less impact than those purchased)
- Type of animal waste: manure leads to lower methane emissions, but more of nitrous oxide
- Use of chemical fertilizers: minor use avoids emissions to produce them

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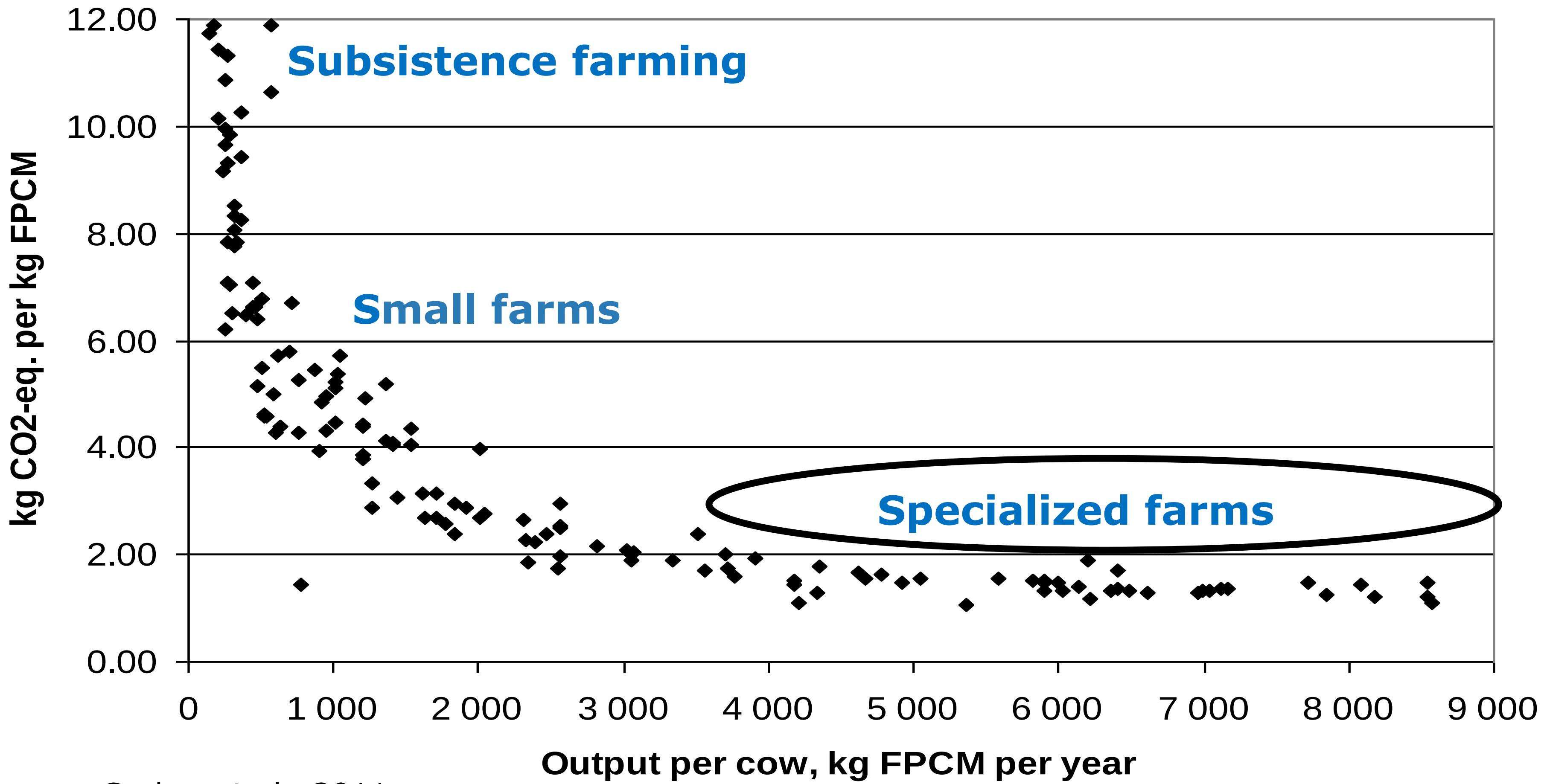
RIDUZIONE DELLE EMISSIONI DI GAS EFFETTO SERRA DA PARTE DEI SISTEMI AGRICOLI DELLA REGIONE EMILIA-ROMAGNA

Production efficiency decreases the carbon footprint



Source: Gerber et al., 2011

Environmental Impact Level (EIL LAA)

For forage production

- LAA1: according to ‘***Cross compliance***’
  (Reg. (EC) 1782/2003 and Reg. (EC) No 796/2004)
- LAA2: according to ‘***Integrated farming***’
  (Reg. (UE) 1305/13 Reg. (CE) 1698/05)
- LAA3: according to ‘**Best practices**’
  - ✓ Efficient use of manure (instead of chemical fertilizers)

Good practices in demonstration farms

- in the field:
  - ✓ efficient use of the slurry (on sorghum test) with innovative machinery

Waste approach
(no crop - low N efficiency)

Efficient use
(with crop – high N efficiency)

Mengoli Dairy farm
Dell'Aquila Fabrizio Ph.

- In dairy/beef farms:
  - ✓ Feed and TMR (Total Mixed Ratio) digestibility
  - ✓ Measurement of the manure potential biogas production (BMP)

Environmental Impact Level (EIL → LAA)

In dairy and beef farms

- LAA1: Emissions as reported in National Inventory
- LAA2: Emission calculated from farms' data
  - ✓ Feeds and Total Mixed Ration (TMR) composition
  - ✓ Nitrogen balance
- LAA3: Emission calculated from farms' data
  - ✓ Feeds and TMR composition and <u>digestibility</u>
  - ✓ Nitrogen balance and <u>manure potential gas production</u>

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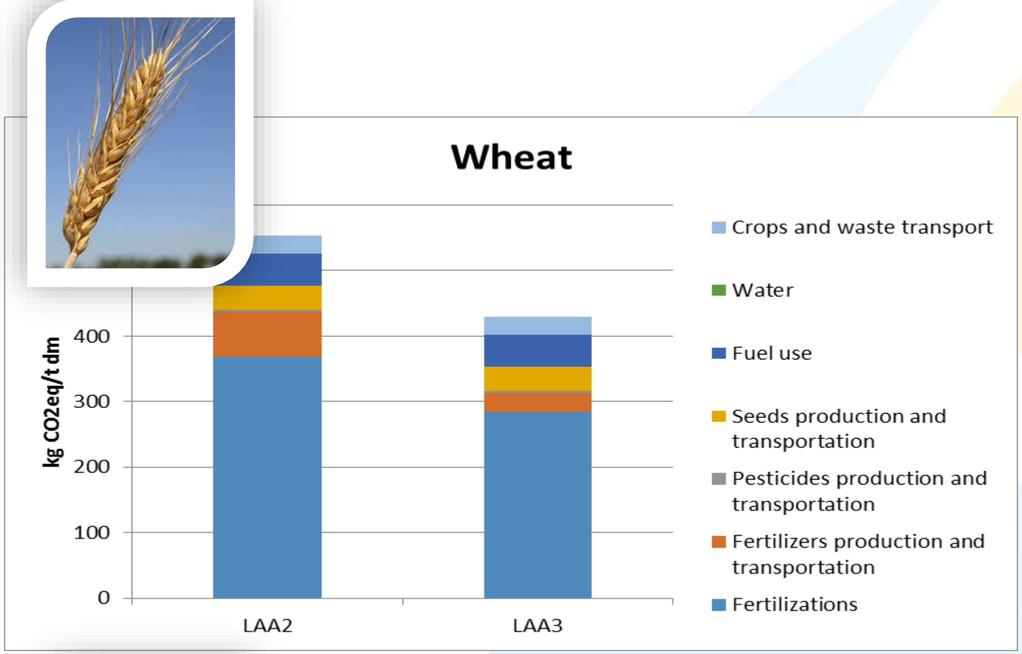
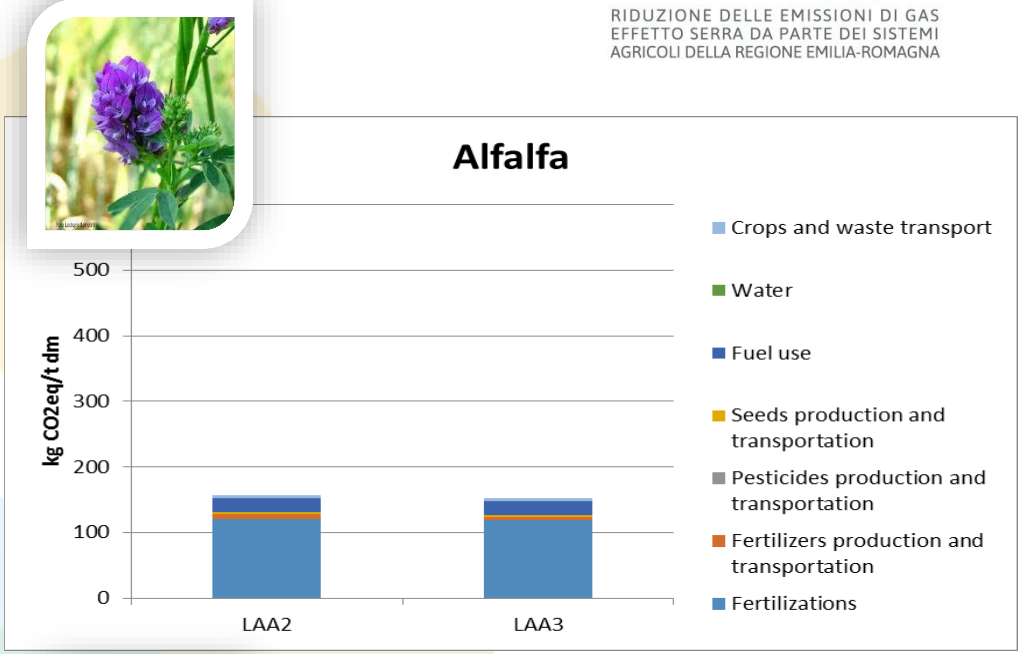
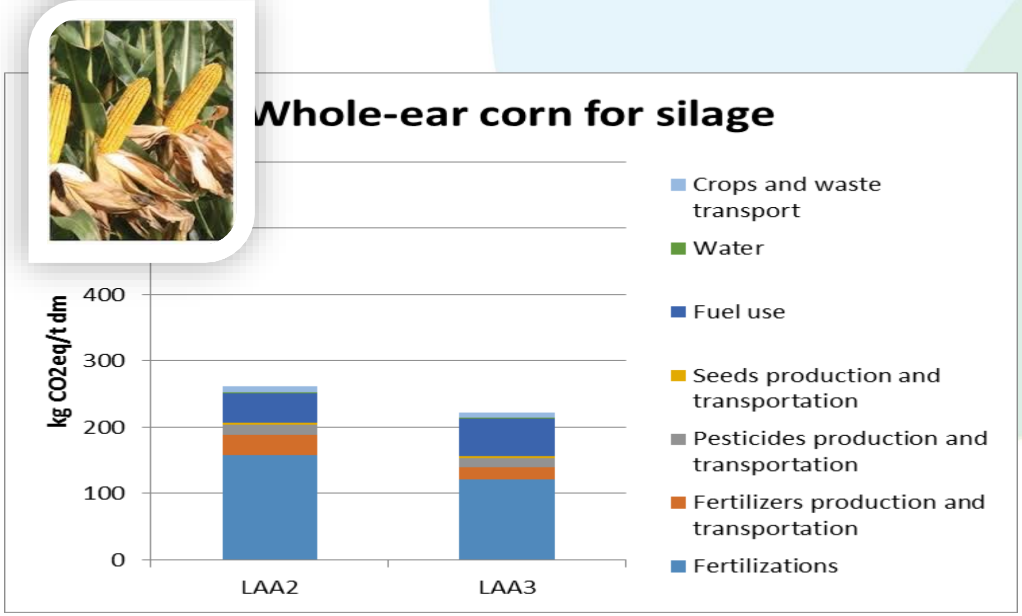
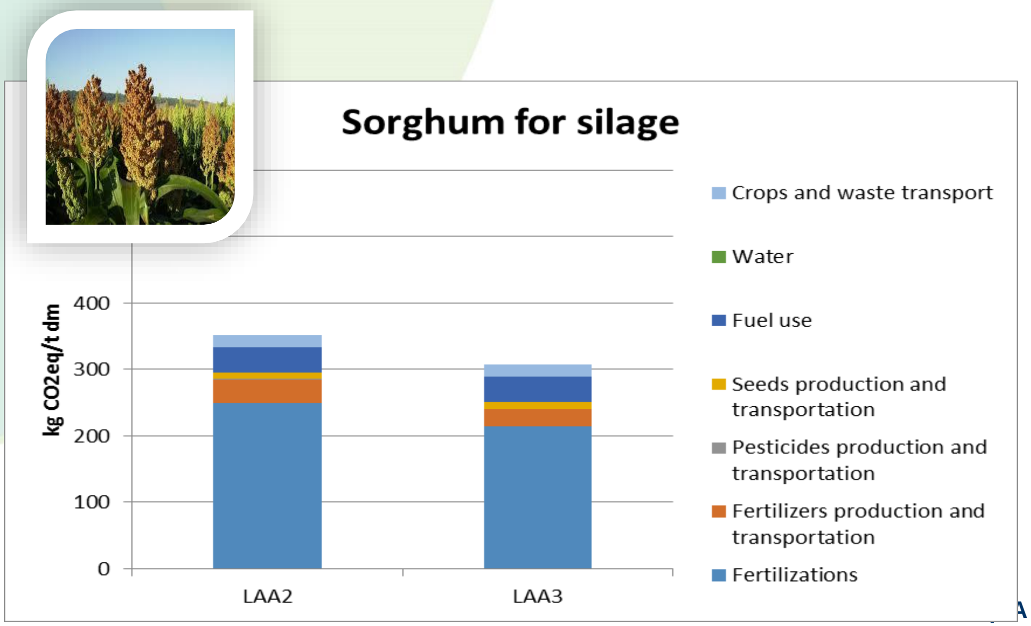
RIDUZIONE DELLE EMISSIONI DI GAS EFFETTO SERRA DA PARTE DEI SISTEMI AGRICOLI DELLA REGIONE EMILIA-ROMAGNA









Biochemical Methane Potential

CRPA-Lab
BMP Tests

UNI EN ISO 11734:2004: Evaluation of the "ultimate" anaerobic biodegradability of organic compounds in digested sludge - Method by measurement of the biogas production

Ration digestibility evaluation

uNDF Ration

Foecal uNDF

Apparent digestibility = [(Foecal uNDF – uNDF Ration) / Foecal uNDF] x 100

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Life

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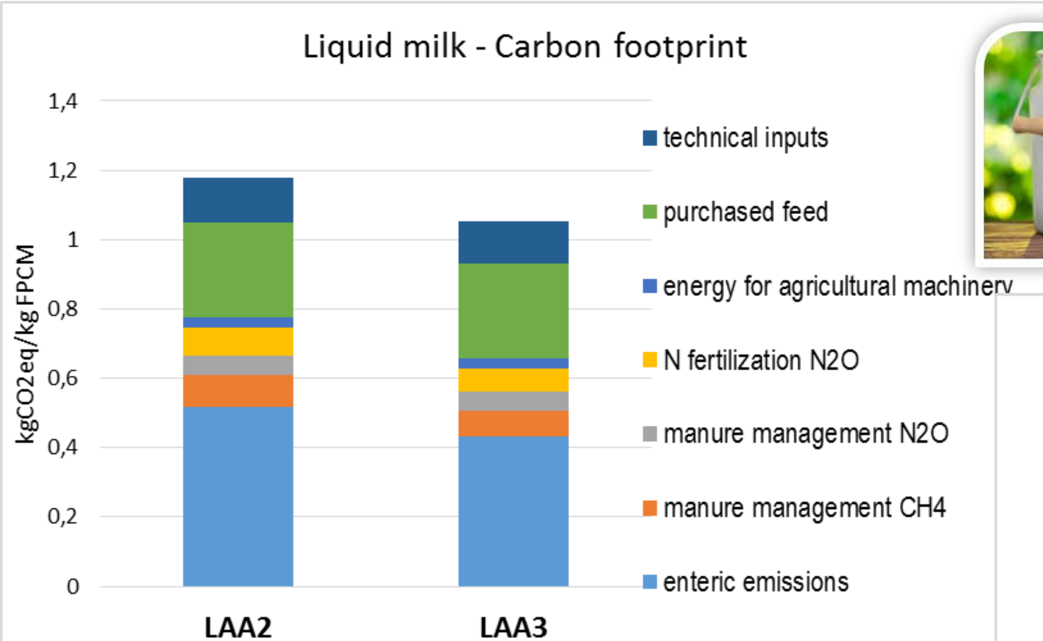
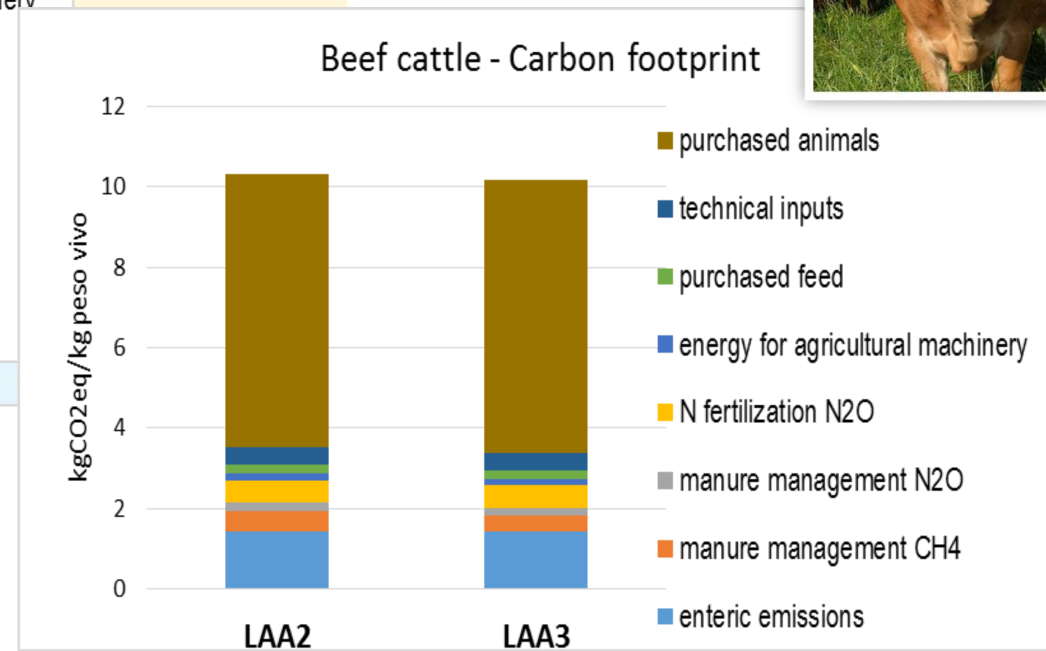
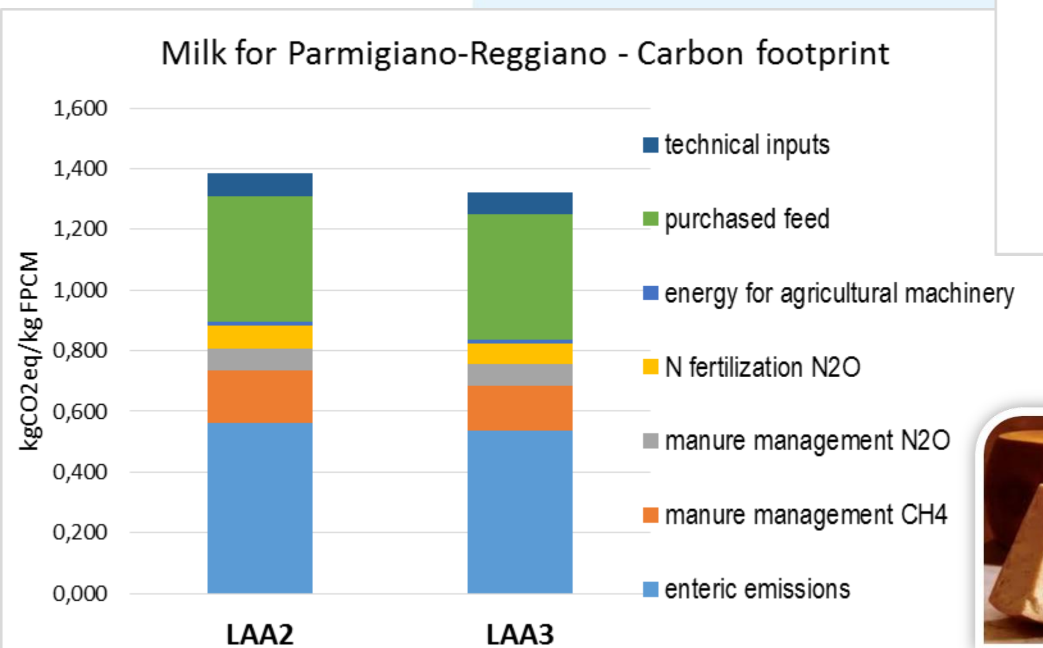
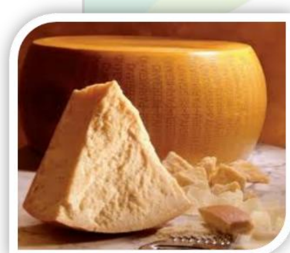
RIDUZIONE DELLE EMISSIONI DI GAS EFFETTO SERRA DA PARTE DEI SISTEMI AGRICOLI DELLA REGIONE EMILIA-ROMAGNA



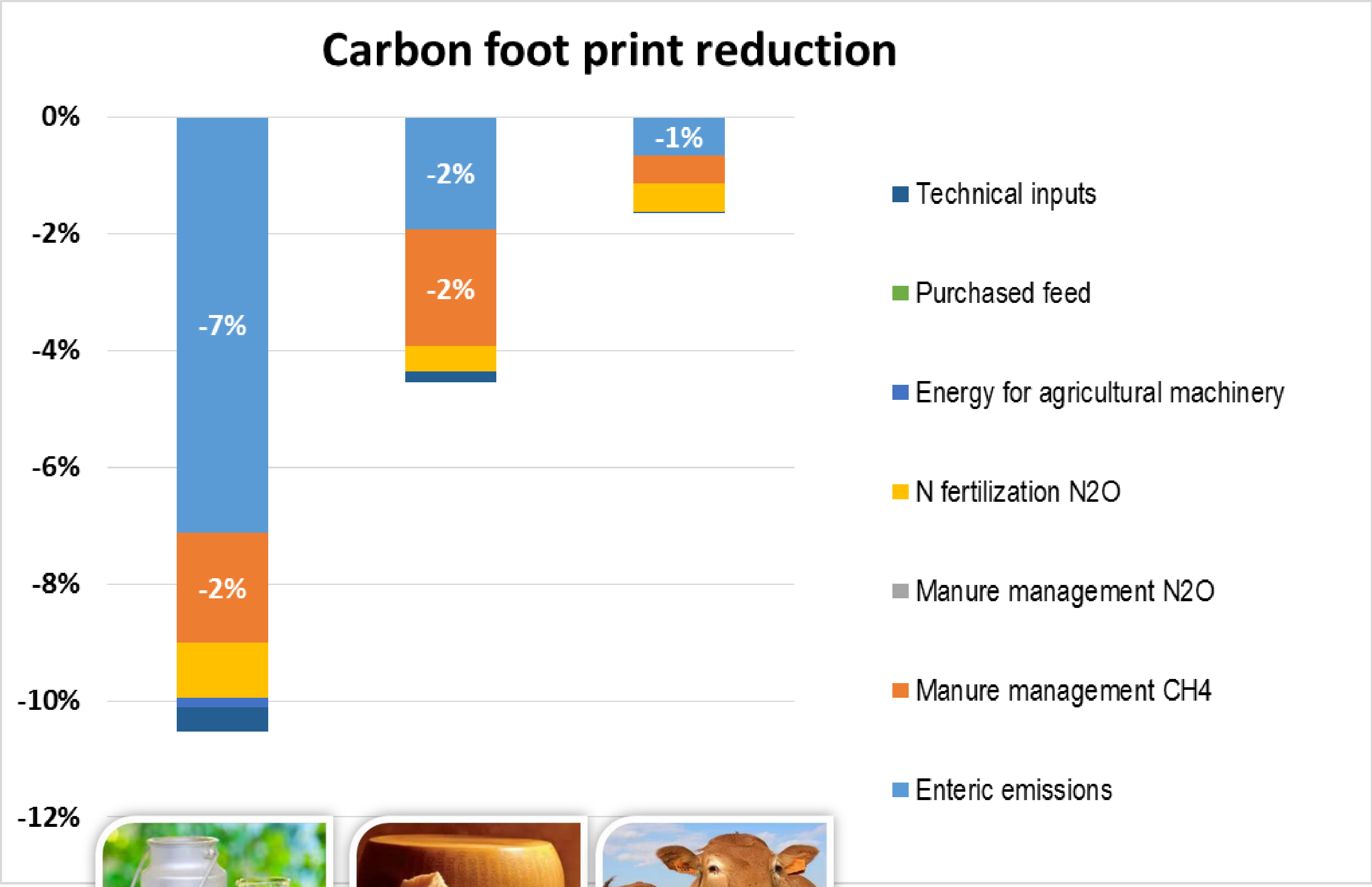


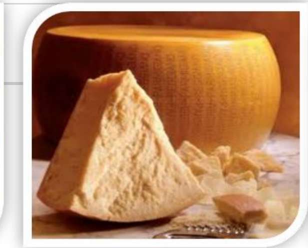




C.R.P.A.

Centro Ricerche Produzioni Animali - CRPA S.p.A


Carbon foot print reduction
0%
-2%
-4%
-6%
-8%
-10%
-12%
-7%
-2%
-2%
-2%
-1%
Technical inputs
Purchased feed
Energy for agricultural machinery
N fertilization N2O
Manure management N2O
Manure management CH4
Enteric emissions



Conclusions

Carbon footprint evaluation helps to identify the most effective mitigation options:

✓ Reduction of off-farm inputs:

- reduction of the share of non-food products in the farms,
- reduction of protein content of the Total Mixed Ration,
- reduction of mineral fertilizers due to optimizing slurry
- saving of energy and fuel

✓ High quality of feed (hay and fodder),

✓ Improvement of the production level efficiency.

These measures allow, in general, more economic margins for producers

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CLIMATE CHANGE-R
RIDUZIONE DELLE EMISSIONI DI GAS EFFETTO SERRA DA PARTE DEI SISTEMI AGRICOLI DELLA REGIONE EMILIA-ROMAGNA

CROPS
Assessment of greenhouse gas emissions (Carbon footprint)

Objectives:

- To assess the environmental impact, in terms of **carbon footprint**, related to the cultivation of **Durum Wheat**, **Tomato** and **Green Bean** for industrial processing, **Peach** and **Pear**, at three different levels of environmental impact (LAA1-Cross-compliance rules, LAA2-IP-Integrated Production, LAA3-IP+agronomic and plant protection advanced techniques).
- To use **Life Cycle Assessment**, in order to detect and identify practices aimed at mitigating GHG emissions from agricultural production.

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Methodology used for the determining of carbon footprint:

- ***Life Cycle Assessment*, LCA**.
- Calculation software: SimaPro (ver. 7.3.3)
- Database: Ecoinvent (ver. 2.2).

To calculate the CO_2 eq have used the conversion factors IPCC 2007:

GHG	formula	GWP 100-yr
Carbon dioxide	CO_2	1
Methane	CH_4	25
Nitrous oxide	N_2O	298

The system boundaries

The assessment of the life cycle begins with the tillage of the soil for planting or seeding, until the farm gate.

LCA functional unit

1 kg of the product as it is (wheat, green beans, tomatoes, peaches, pears).

What we have considered

We have considered the emissions caused by:

- ✓production of the technical means employed during plant and cultivation (plant infrastructure, irrigation system, fertilizers, agrochemicals, pheromones, water);
- ✓plant and cultivation operations (fuels' production and combustion, electricity);
- ✓direct and indirect N_2O emissions;
- ✓transport of technical means in the farm;
- ✓waste disposal.

What have we left out

We have not considered:

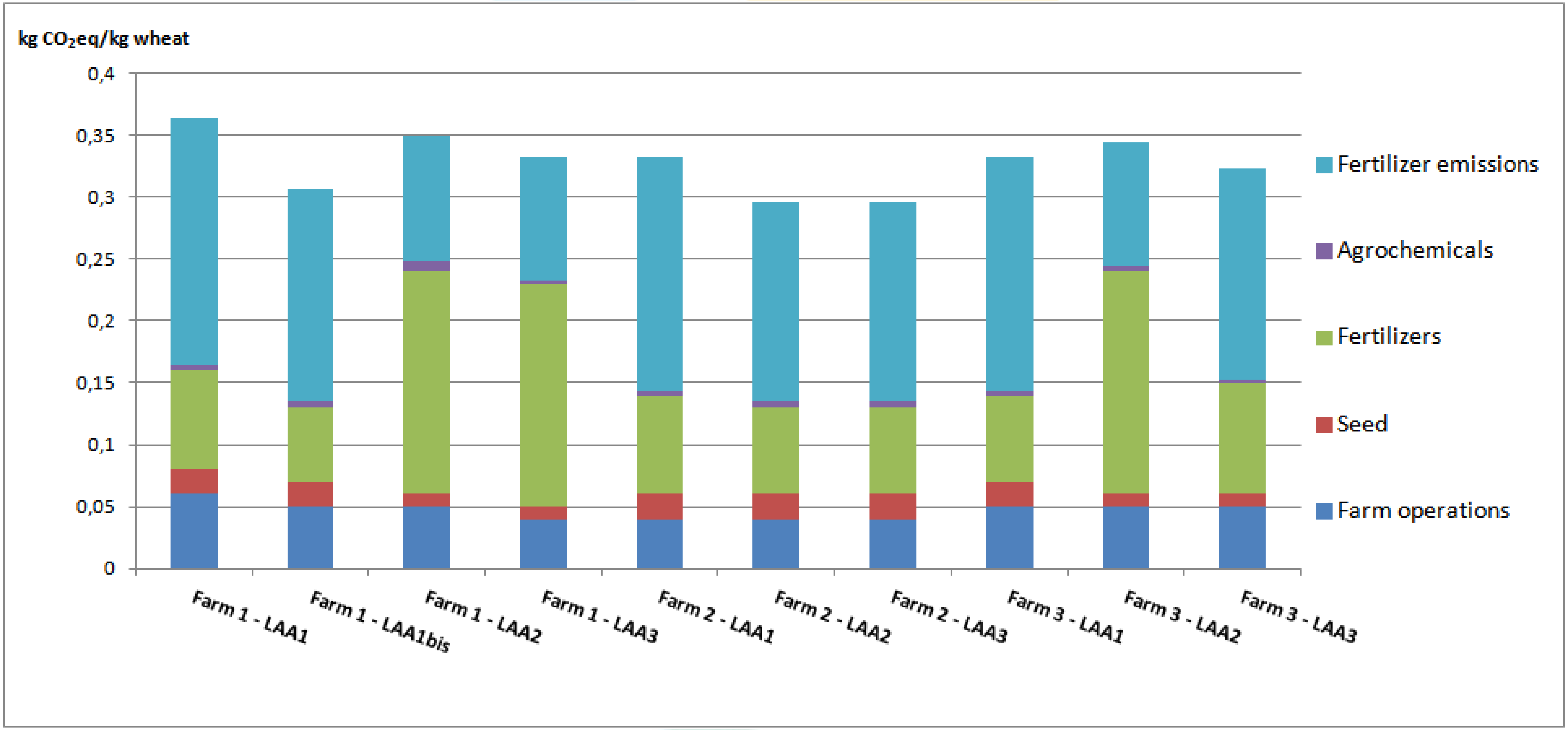
- ✓human labor.
- ✓production of: tractors and other agricultural machinery, farm buildings.
- ✓biogenic CO_2 emissions and CO_2 sequestration.
- ✓seedlings production for fruit and tomato (not present in Ecoinvent database).
- ✓packaging of planting materials in the orchard.

	**LAA1** Environmental impact level	**LAA2** Environmental impact level	**LAA3** Environmental impact level	**Effectiveness in reducing GHG***
CROP ROTATION	LAA1: soil depleting crop (low residual fertility); LAA1 bis: soil building crop (high residual fertility)	Soil building crop (high residual soil fertility)	Soil building crop (high residual soil fertility)	**High**
SOIL TILLAGE	No obligations	Integrated Production	IP Guidelines + SUSTAINABILITY RULES request (minimum tillage when possible)	Medium
PLANT PROTECTION AND WEED CONTROL	Cross compliance (mandatory level)	Integrated Production	IP Guidelines + DSS indications	Significant
FERTILISATION	Cross compliance (mandatory level)	Integrated Production	IP Guidelines + DSS indications	**High (80%[+])**

* significant, medium, high

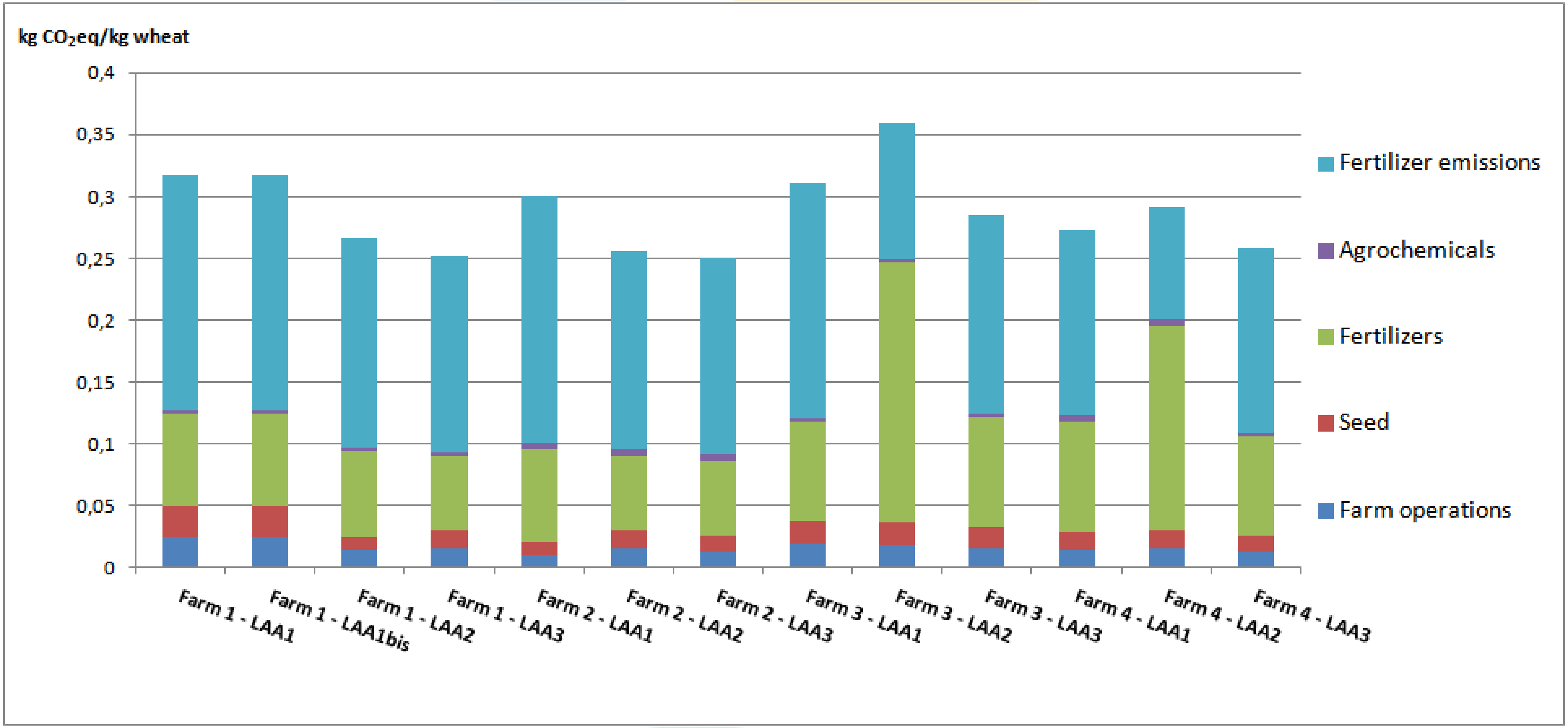
\+ of whole emissions

Greenhouse Gases: comparison of the cases studied in 2015 in terms of CO_2 eq per kg of **durum wheat**



Fertilizers + fertilizer emissions: about 75-80% of whole emissions

Greenhouse Gases: comparison of the cases studied in 2016 in terms of CO_2 eq per kg of **durum wheat**



Fertilizers + fertilizer emissions: about 83-91% of whole emissions

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RIDUZIONE DELLE EMISSIONI DI GAS EFFETTO SERRA DA PARTE DEI SISTEMI AGRICOLI DELLA REGIONE EMILIA-ROMAGNA

Emission reduction of **durum wheat**

LAA1

LAA3

from -3 to -20%

For the reduction of emissions has been particularly important the correct choice of precession (improving soil fertility) and the optimization of inputs of nitrogen fertilizers through the use of decision support system.

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Dissemination of results in the demonstration farms

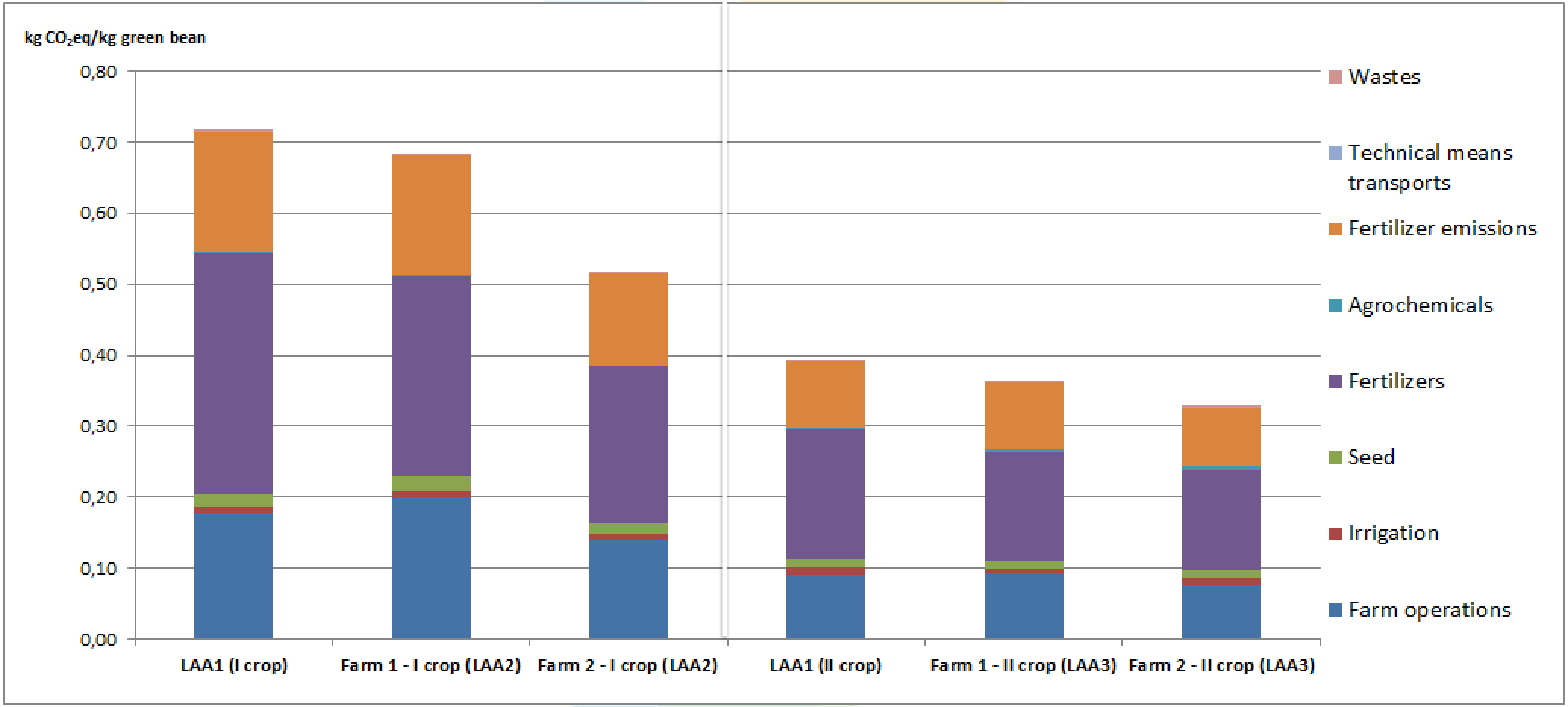
Copparo (Ferrara)

Parma

 **GREEN BEAN**	**LAA1** Environmental impact level	**LAA2** Environmental impact level	**LAA3** Environmental impact level	**Effectiveness in reducing GHG***
CROP ROTATION	Cross compliance (mandatory level)	Integrated Production	Soil building crop (high residual soil fertility) in comparison with soil depleting crop	Medium (-18%)
SEASON SEEDING	Cross compliance (mandatory level)	Integrated Production	Summer seeding (II crop) in comparison with spring seeding (I crop)	**High (-40%)**
IRRIGATION	Cross compliance (mandatory level)	Integrated Production with standard sprinkler irrigation	Integrated Production + tensiometer	Significant (-8%)

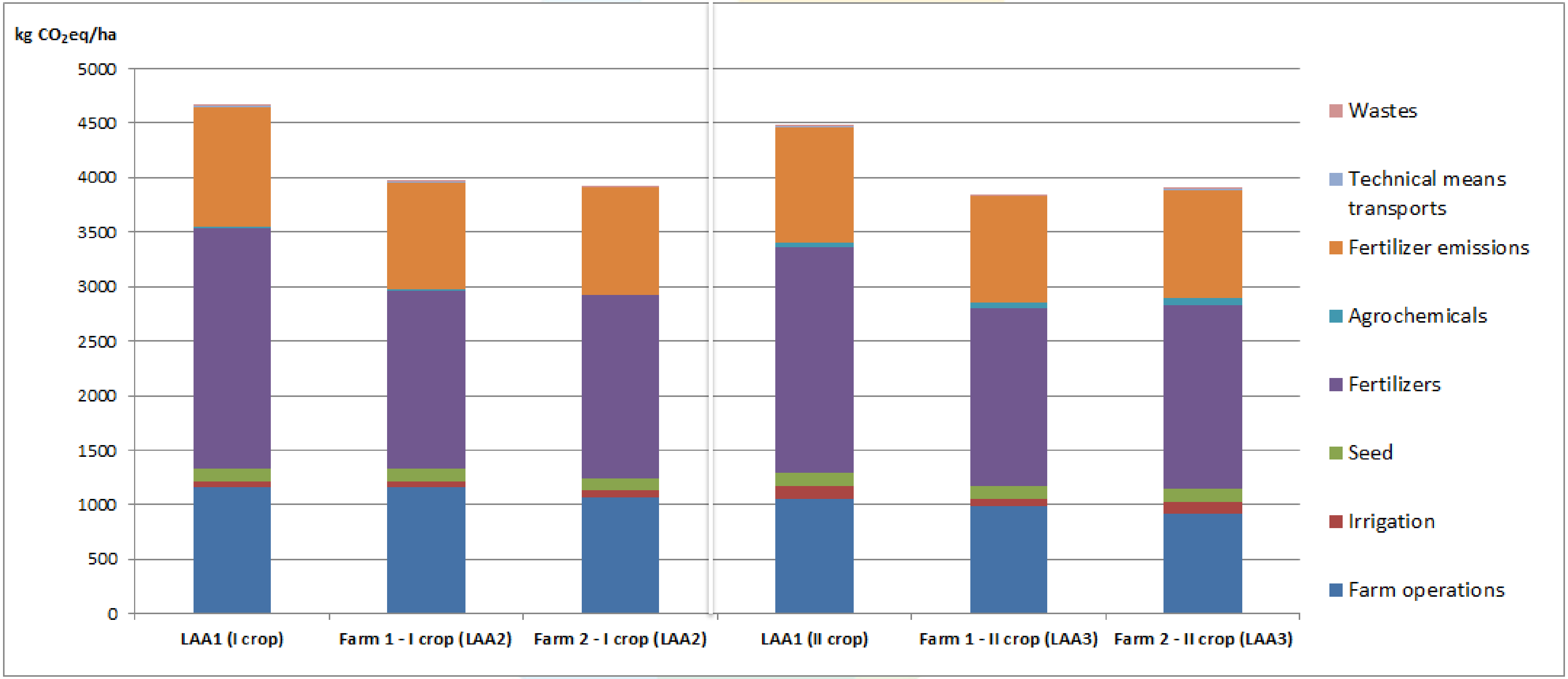
* significant, medium, high

Greenhouse Gases: CO_2 eq per kg of **green beans** (2015)



Fertilizers + fertilizer emissions: 66-71% of whole emissions

Greenhouse Gases: CO_2 eq per hectare of **green beans** (2015)



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RIDUZIONE DELLE EMISSIONI DI GAS EFFETTO SERRA DA PARTE DEI SISTEMI AGRICOLI DELLA REGIONE EMILIA-ROMAGNA

Emission reduction of **green bean**

LAA1
Spring sowing

LAA3
Summer sowing

up to -40%

The summer sowing enables better efficiency of the resources used and a lower carbon footprint than the spring sowings. Also significant is the influence of rotation with a soil building crop.

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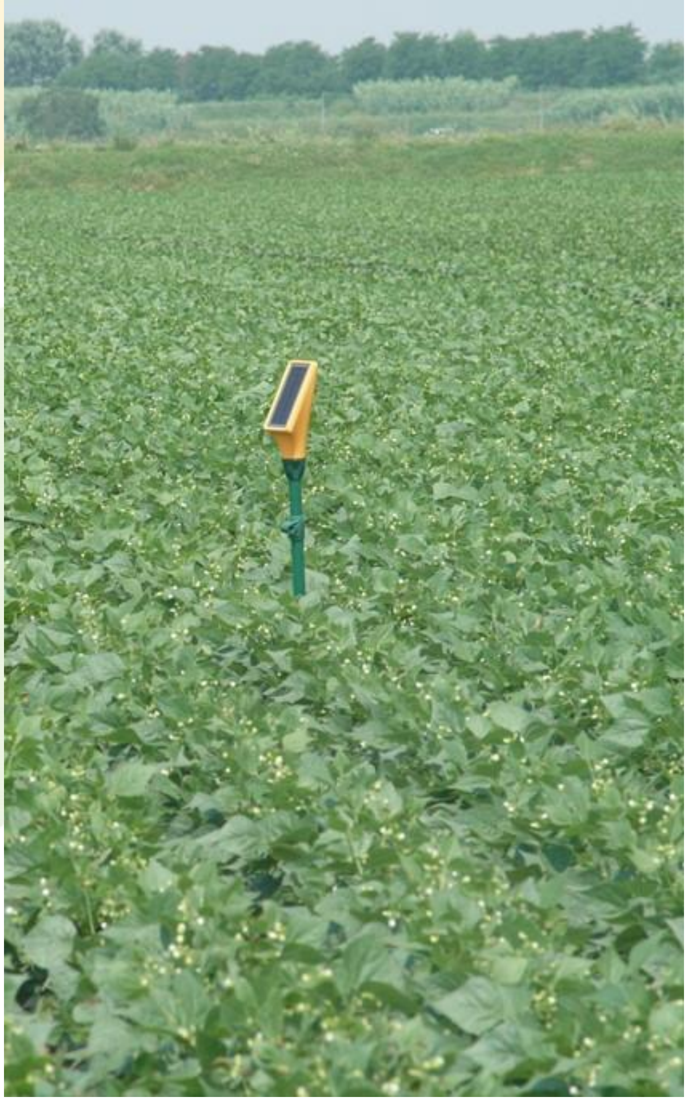
Dissemination of results in the demonstration farms



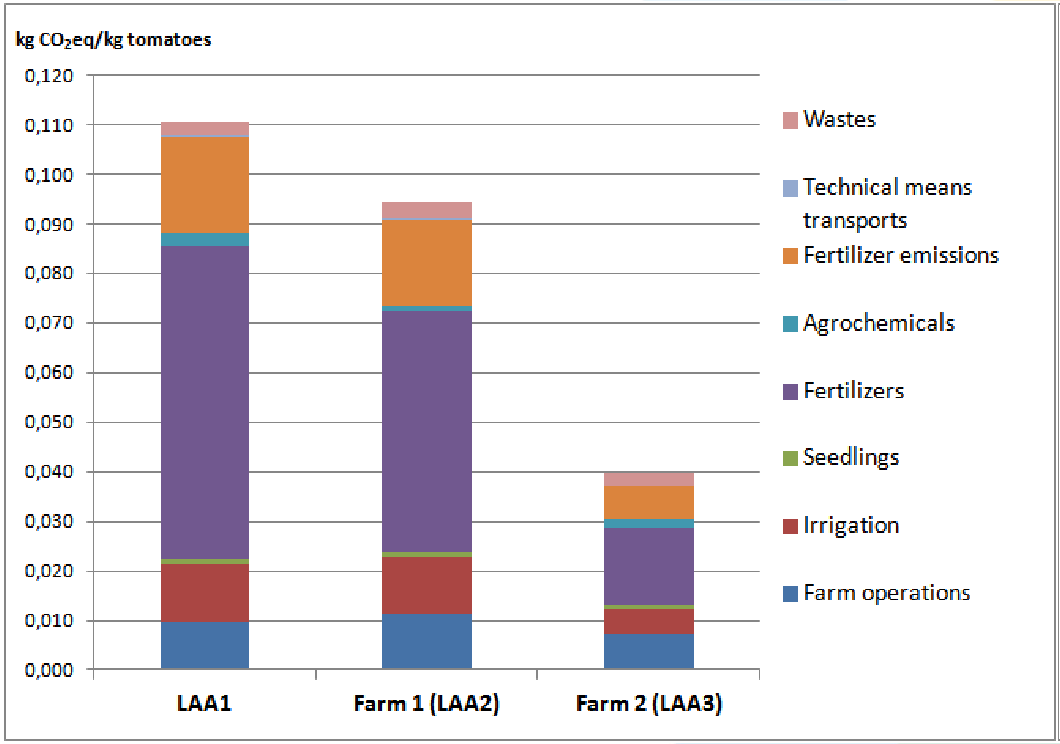
Ravenna

 **TOMATO for industrial processing**	**LAA1** Environmental impact level	**LAA2** Environmental impact level	**LAA3** Environmental impact level	**Effectiveness in reducing GHG***
FERTILISATION	Cross compliance (mandatory level)	Integrated Production	Most of the nutrients is distributed via **fertigation**	**High (44-63%$^{+}$)**
IRRIGATION	Cross compliance (mandatory level)	Integrated Production with standard sprinkler irrigation	**water hoses on the ground** + IRRINET system (DSS)	Medium (10-20%$^{+}$)

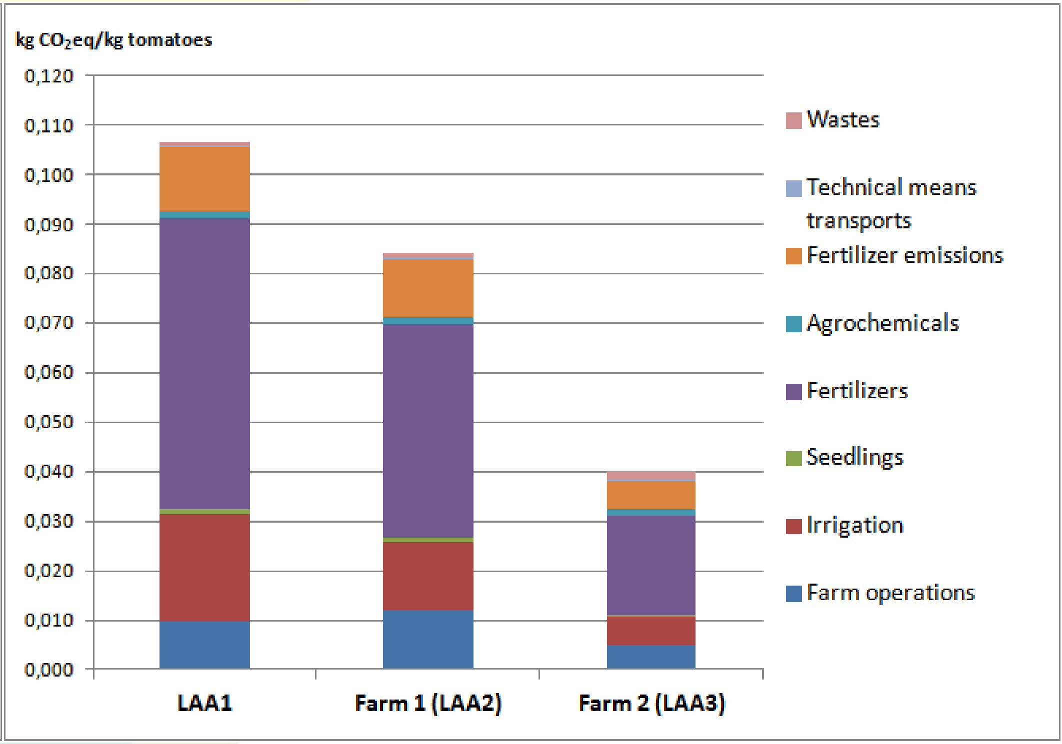
*significant, medium, high
+ of whole emissions

Greenhouse Gases: comparison of the cases studied in 2014 and 2015 in terms of CO_2 eq per kg of **tomatoes**

2014



2015

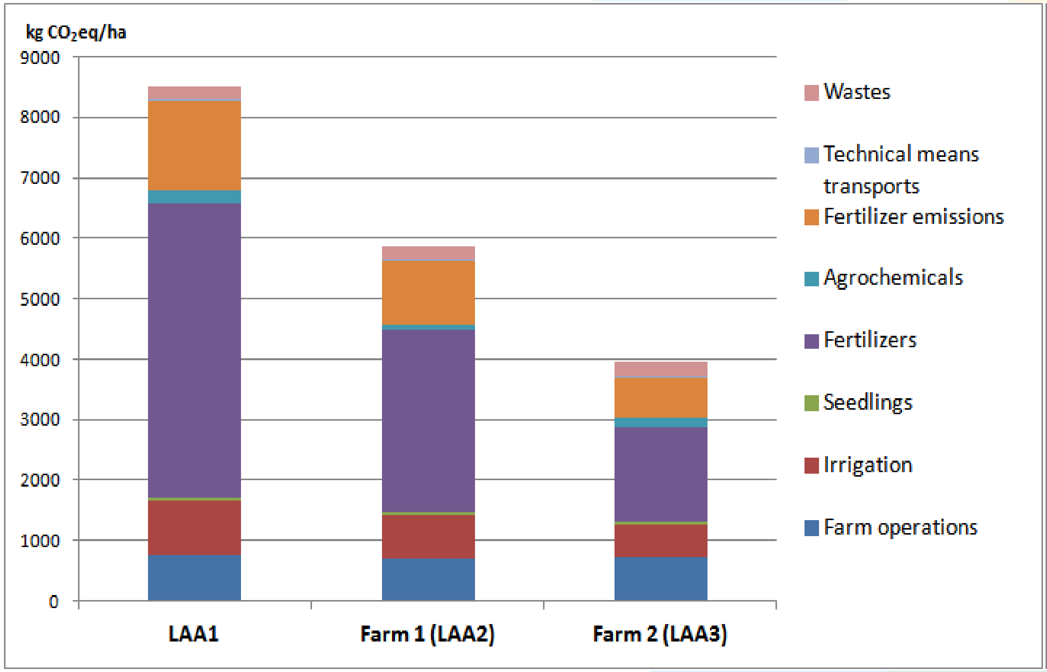


2014: fertilizers + fertilizer emissions: 44-63% of whole emissions

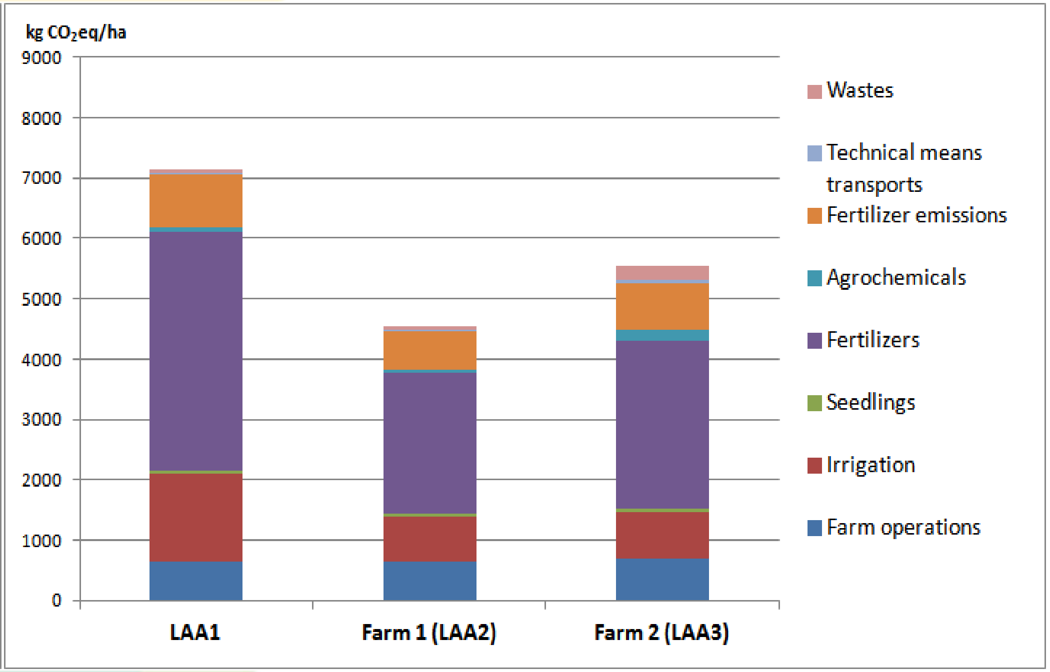
2015: fertilizers + fertilizer emissions: 50-55% of whole emissions

Greenhouse Gases: comparison of the cases studied in 2014 and 2015 in terms of CO_2 eq per hectare of **tomatoes**

2014



2015



Emission reduction of **tomato**

LAA1

LAA3

up to -50%

The use of micro-irrigation with driplines for fertigation (simultaneous distribution of water and fertilizers), allowing to maximize yeld, makes more efficient use of technical means and allows to significantly reduce the carbon footprint of the crop

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RIDUZIONE DELLE EMISSIONI DI GAS EFFETTO SERRA DA PARTE DEI SISTEMI AGRICOLI DELLA REGIONE EMILIA-ROMAGNA

 PEACH	**LAA1** Environmental impact level	**LAA2** Environmental impact level	**LAA3** Environmental impact level	**Effectiveness in reducing GHG***
PLANT PROTECTION	Cross compliance (mandatory level)	Integrated Production	**Mating disruption** against Cydia molesta or Cydia molesta + Anarsia lineatella and eventual chemical treatments when it exceeds threshold level in sexual traps	Significant (3-5%[+])
FERTILISATION	Cross compliance (mandatory level)	Integrated Production	The most important part of nutrient are distributed via **fertigation**	**High (60-70%[+])**
IRRIGATION	Cross compliance (mandatory level)	Integrated Production	**Irrinet DSS** (WEB system based on water uptake, meteo data and field irrigation)	Medium (5-7%[+])
THINNING	traditional fruit thinning	traditional fruit thinning	traditional fruit thinning and **flowers mechanical thinning**	Significant (3-4%[+])

* significant, medium, high
\+ of whole emissions

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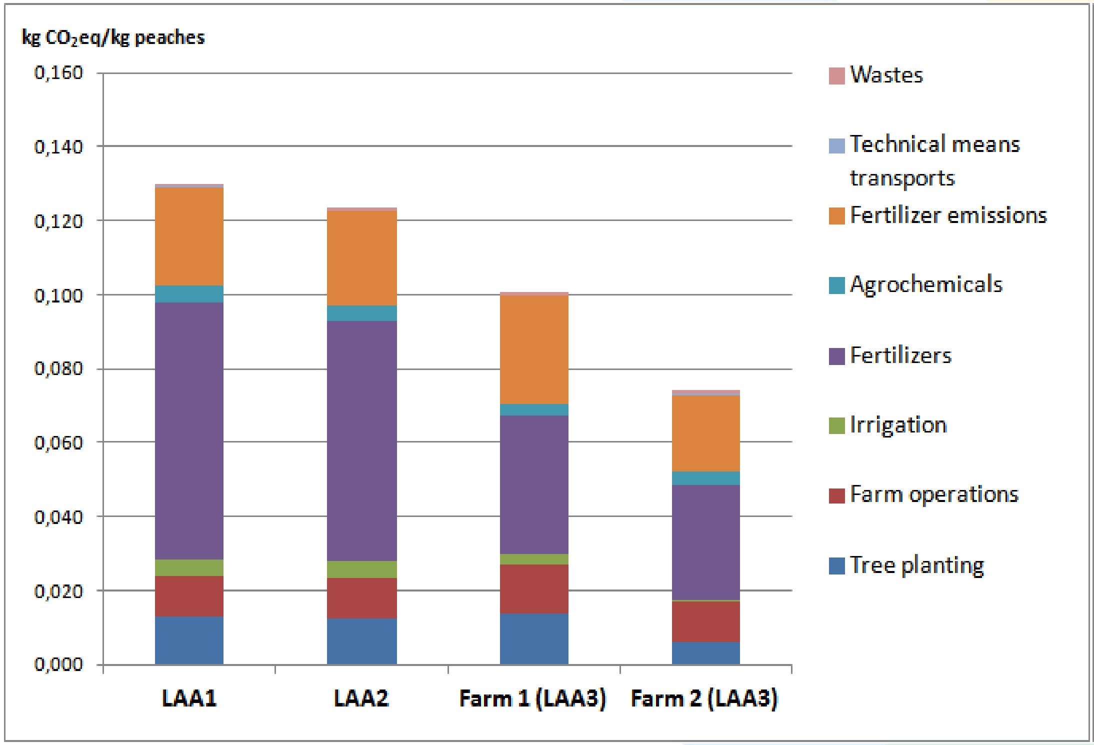
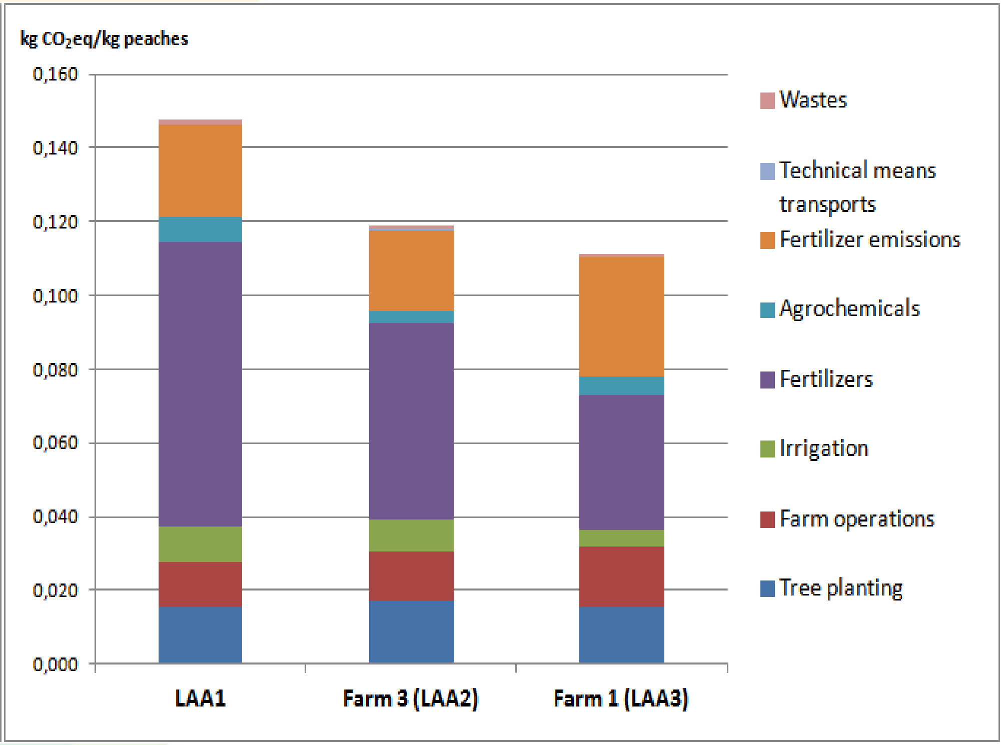
Greenhouse Gases: comparison of the cases studied in 2014 and 2015 in terms of CO_2 eq per kg of **peaches**

2014



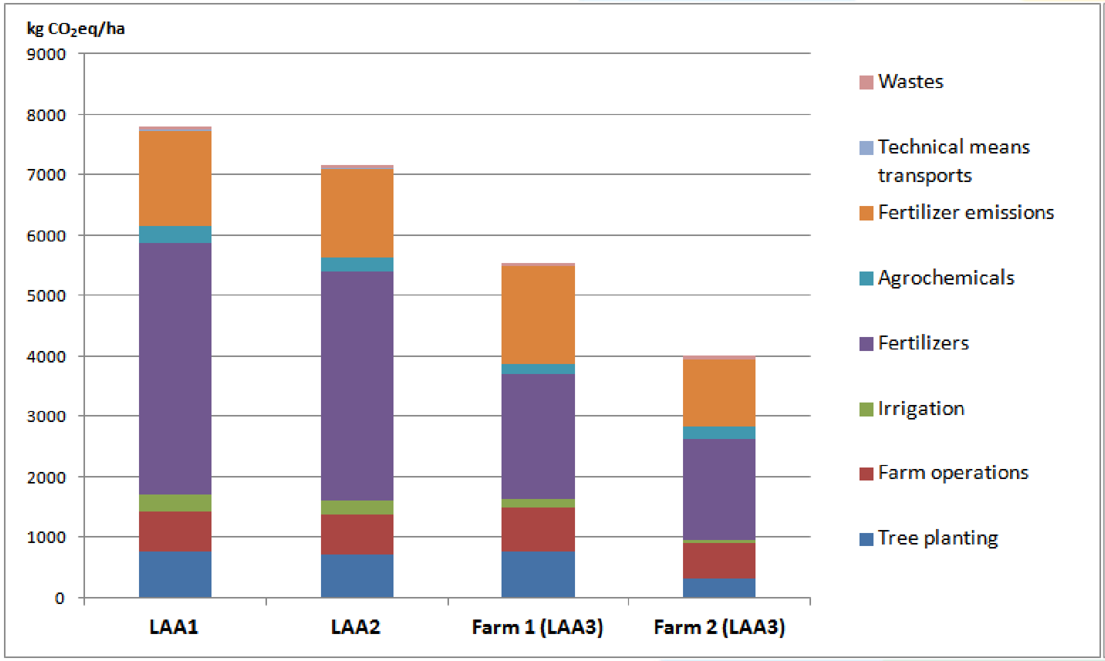
2015



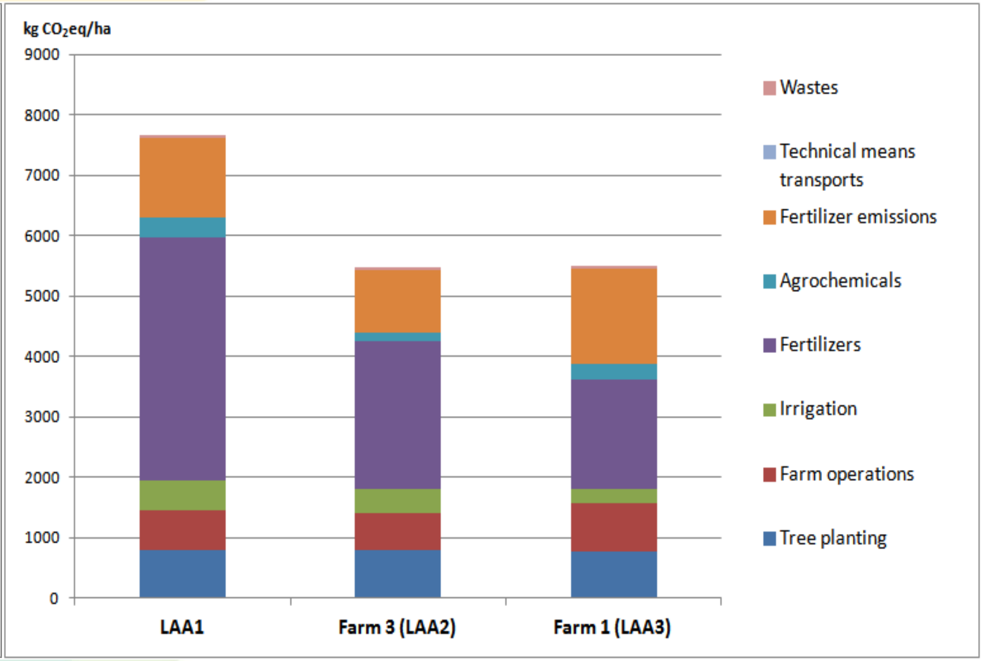
Fertilizers + fertilizer emissions: about 60-70% of whole emissions

Greenhouse Gases: comparison of the cases studied in 2014 and 2015 in terms of CO_2 eq per hectare of **peach** orchard

2014



2015



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RIDUZIONE DELLE EMISSIONI DI GAS EFFETTO SERRA DA PARTE DEI SISTEMI AGRICOLI DELLA REGIONE EMILIA-ROMAGNA

Dissemination of results in the demonstration farms

Imola (Bologna)

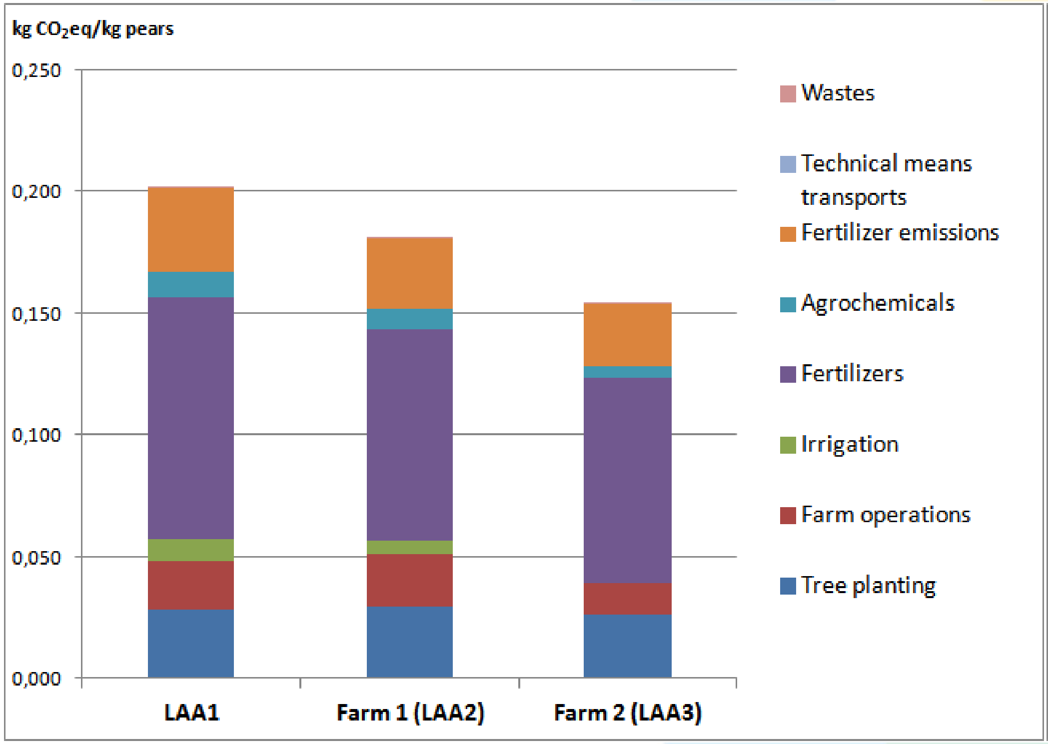
 PEAR	**LAA1** Environmental impact level	**LAA2** Environmental impact level	**LAA3** Environmental impact level	**Effectiveness in reducing GHG***
PLANT PROTECTION	Cross compliance (mandatory level)	Integrated Production	**Mating disruption** against Cydia pomonella and eventual chemical treatments when it exceeds threshold level in sexual traps	Significant (2-6%$^{+}$)
FERTILISATION	idem	Integrated Production	Most of the nutrients is distributed via **fertigation**	**High (44-71%$^{+}$)**
IRRIGATION	idem	Integrated Production	**Irrinet DSS** (WEB system based on water uptake, meteo data and field irrigation)	Medium (3-14%$^{+}$) <1% with photovoltaic
OPERATIONS OF PRUNING AND HARVESTING, IRRIGATION	fuel fruit harvester and use of mains electricity	fuel fruit harvester and use of mains electricity	Use of electric fruit harvester and irrigation system powered by **photovoltaic panels**	Medium (- 11%)$^{\#}$

*significant, medium, high

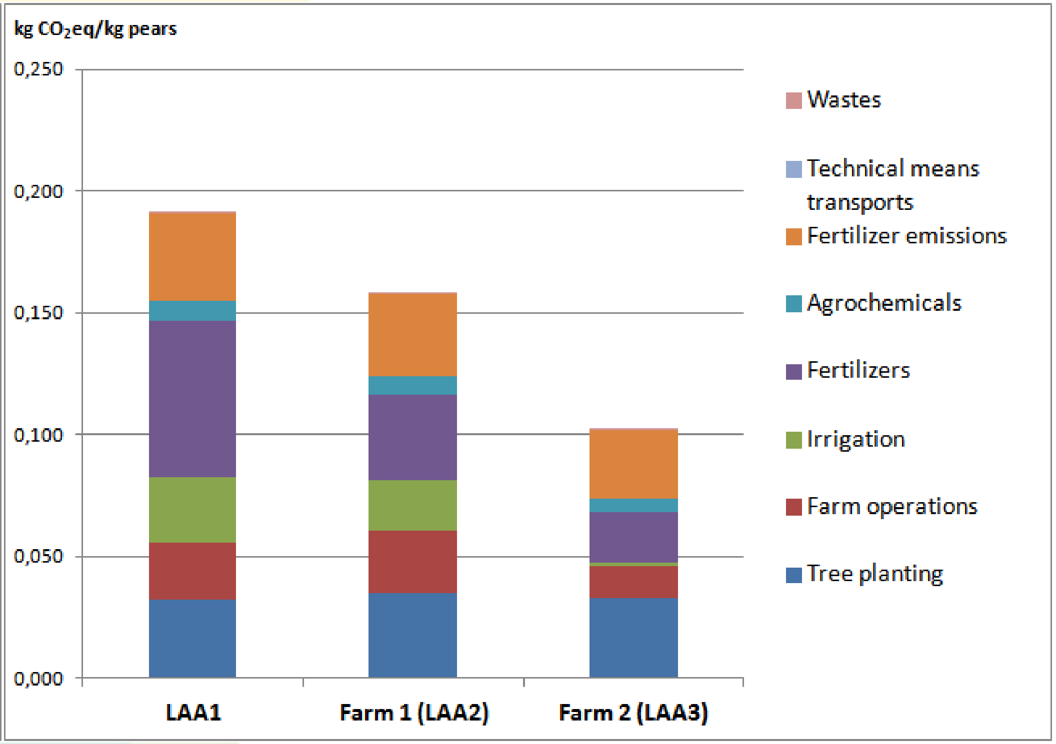
+ of whole emissions, # reduction using photovoltaic electricity

Greenhouse Gases: comparison of the cases studied in 2014 and 2015 in terms of CO_2 eq per kg of **pears**

2014



2015

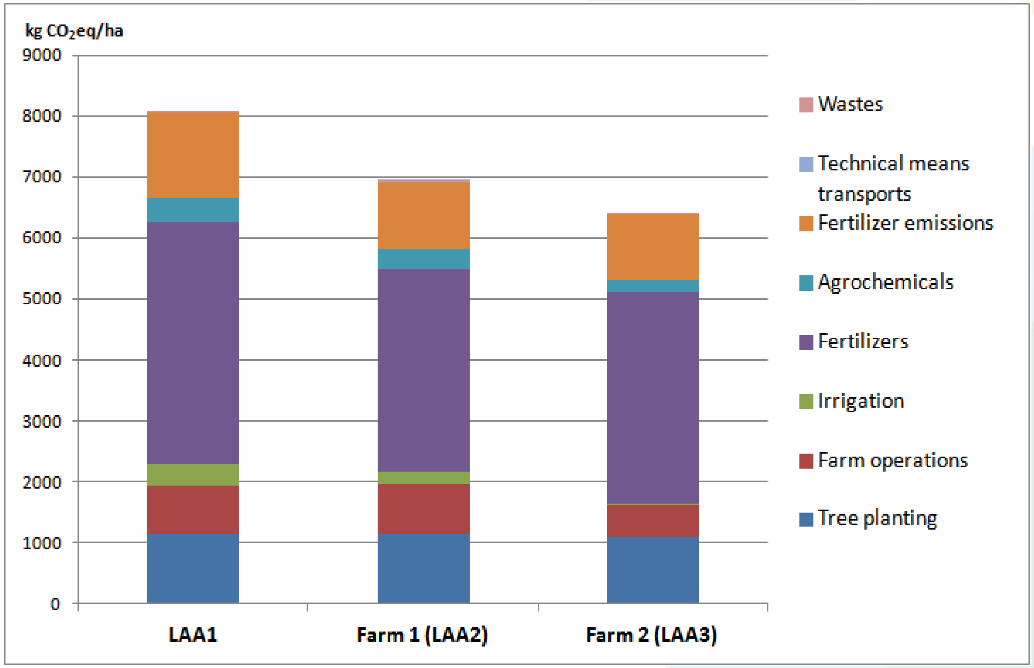


2014: fertilizers + fertilizer emissions: 64-71% of whole emissions

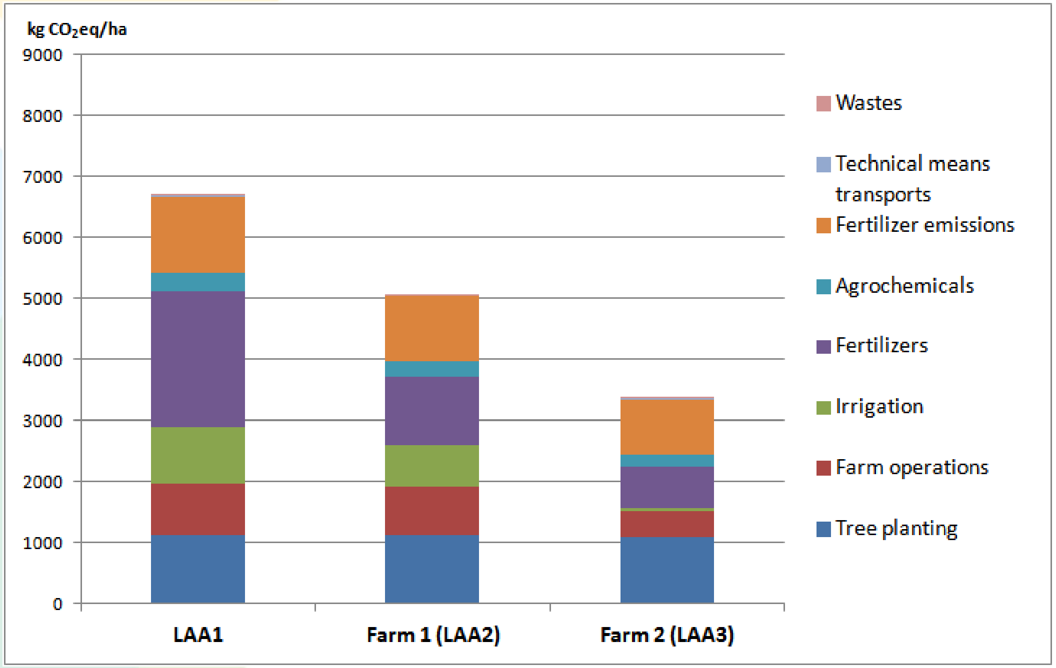
2015: fertilizers + fertilizer emissions: 44-53% of whole emissions

Greenhouse Gases: comparison of the cases studied in 2014 and 2015 in terms of CO_2 eq per hectare of **pear** orchard

2014



2015



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Life

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RIDUZIONE DELLE EMISSIONI DI GAS EFFETTO SERRA DA PARTE DEI SISTEMI AGRICOLI DELLA REGIONE EMILIA-ROMAGNA

Dissemination of results in the demonstration farms

Modena

Emission reduction of **peach**

LAA1

LAA3

from -25% to -33%

Emission reduction of **pear**

LAA1

LAA3

from -24% to -53%

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RIDUZIONE DELLE EMISSIONI DI GAS EFFETTO SERRA DA PARTE DEI SISTEMI AGRICOLI DELLA REGIONE EMILIA-ROMAGNA

For **peach** and **pear** the following practices contribute to reduce GHG:

- **Fertigation** with drip distribution system to make more efficient the use of water and fertilizers.
- Use of local sensors and decision systems support for **irrigation optimization**.
- Use of **renewable energy sources** (eg. solar photovoltaic).
- Using **wooden poles**, rather than in reinforced concrete, for the support of the orchard.
- **Mechanical thinning** of the flowers, instead of manual of the fruits, to reduce the time of use and consumption of the machines.
- **Mating disruption**: a defense method from insects to reduce the use of chemical insecticides with benefits on reducing emissions and the environmental quality.

More generally, how to reduce the carbon footprint:

- **Increasing production efficiency**: sustainable intensification that boosts production through a more efficient use of inputs.
- **Reducing emissions**: optimizing primarily the nitrogen fertilization (amount, timing, precision technologies, mode of distribution especially for livestock manure) and the use of agrochemicals and water.
- **Producing and saving energy**: all the measures of energy saving and increasing the energy efficiency of machines used can contribute, as well as installation of power plants from renewable sources (e.g. Solar).
- **Carbon sequestration** from the atmosphere: all agricultural practices that tend to the preservation of soil fertility increasing organic matter content (conservation agriculture).