



# IMPACT OF ORGANIC PRACTICES ON GROWTH, YIELD, BIOLOGICAL NITROGEN FIXATION AND GREENHOUSE GAS EMISSIONS BY THREE LOCAL PEA LANDRACES

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# Legume Production



**Legume production for consumption either as fresh pod or grains for food and feed is worldwide estimated**

**180 million ha**

**or 12% - 15% of the cultivated area**



**27% of the world crop production**

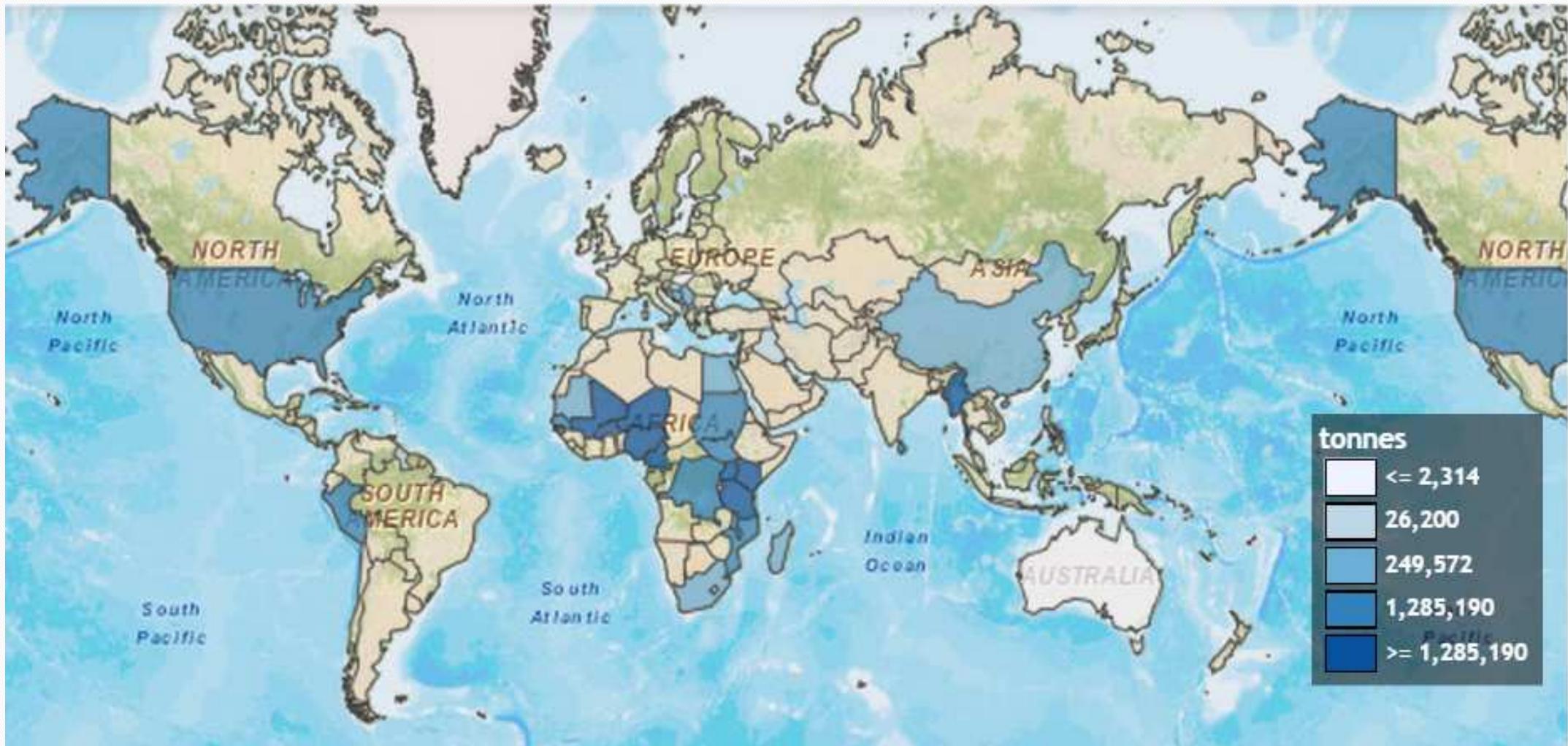


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# Global Legume Production



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# Main grain legumes



soybean



peas

common bean



faba bean



cowpea



spring vetch



lupine



peanuts



lentils

# Benefits arising from the use of grain legumes in crop rotations systems

## (a) Agronomic benefits

Improved soil structure

Pest and disease break

P mobilization

N provision

## (b) Cost reduction potential

Supports reduced tillage

Biocide savings

Fertilizer savings

## (c) Increased revenue

Increased yield

Increased quality

Increased gross margins

## (d) Economic balance

# Plant Genetic Resources for Food and Agriculture

- » Crop wild relatives
- » Landraces
- » Primitive cultivars
- » Ecotypes
- » Modern cultivars
- » Breeding lines
- » Special genetic stocks

They are heterogeneous populations  
They present local adaptability  
They have been developed through nature and farmer's selection  
They present homoeostasis and thus resistance to biotic and abiotic stresses  
They have the tendency to keep a dynamic balance  
They are an evolving material

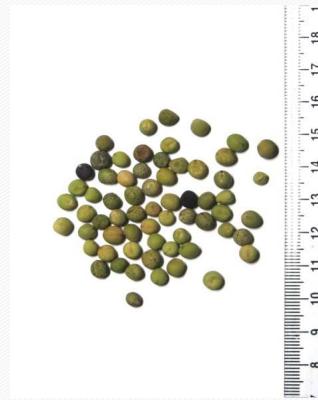
## Landraces

(Stehfest and Bouwman, 2006)



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## Pea (*Pisum sativum*) Landraces



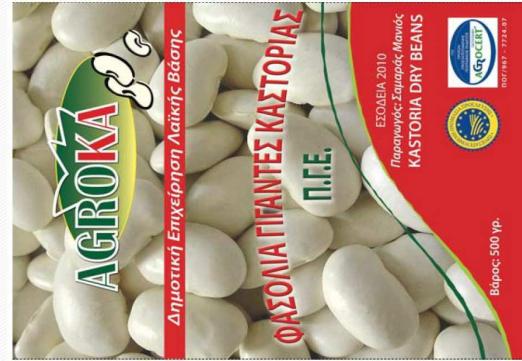
## Faba Bean (*Vicia faba*) Landraces from Mani



# Santorini Fava (PDO) (*Lathyrus clymenum*)



# Protected Geographical Indication (PGI) for Beans



## “Englowvi” Lentils (*Lens culinaris*)



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# Collected Greek Crop Landraces Populations



Lefkada  
(101)

Kefallinia  
(64)

Thessaloniki

Lemnos  
(146)

Lesvos  
(312)

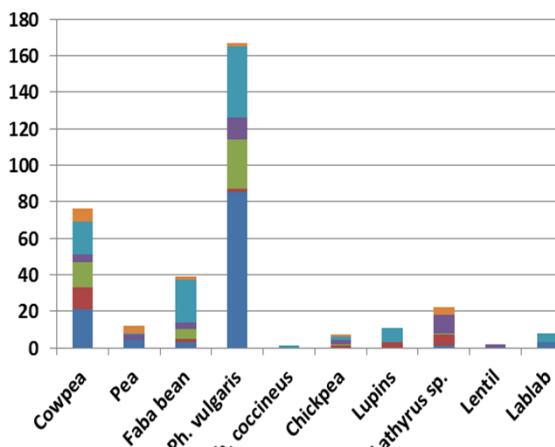
Athens

Skyros  
(50)

Andros  
(310)

N.Karpathos  
(45)

Messinia  
(260) Kithira  
(182)



# Characterizing Pea Landraces



# Characterizing faba bean and cowpea landraces



# Direct environmental impacts of biological N<sub>2</sub> fixation

**Biological N<sub>2</sub>-fixation** by rhizobia takes place at

- ambient T
- ambient atmospheric pressure

**Industrial N fixation** (Haber process):

- 400 - 600 °C
- 200 At

**Benefits of biological N<sub>2</sub>-fixation:**

- Strong reduction of energy input
- Strong reduction of CO<sub>2</sub> emissions



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# Common bean grown on pumice and treated with different N levels in the supplied nutrient solution

NS Treatment	$\delta^{15}\text{N}$ (‰)	Ndfa (%)	Total plant N content (kg ha <sup>-1</sup> )	Biologically-fixed N (kg ha <sup>-1</sup> )
Full N, -Rt	0.09 - 0.93	-4.8 c	212.2 a	-7.9 b
Full N, +Rt	0.23 – 0.85	-2.6 c	188.4 a	-6.2 b
1/3 of full-N, +Rt	(-1.15) - (-0.51)	58.1 b	93.0 b	54.3 a
Zero N, +Rt	(-1.93) - (-1.39)	100.0 a	48.7 c	49.2 a

**Restriction in N supply (1/3 of full N) stimulates biological N<sub>2</sub>-fixation in bean crops grown on inert media, when the plants are inoculated with *R. tropici*.**

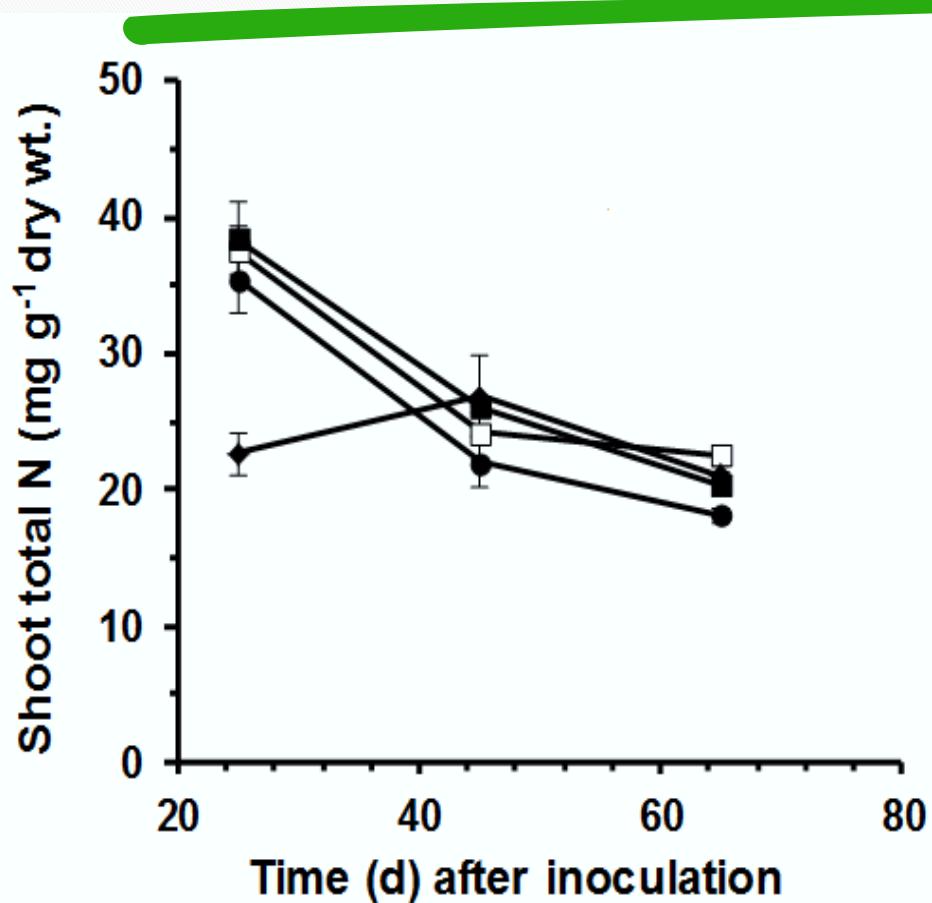
$\delta^{15}\text{N}$ : Differences between the abundance of <sup>15</sup>N in plant and atmospheric N

Ndfa: proportion of plant N derived from atmospheric N<sub>2</sub>-fixation

Rt: inoculation with *Rhizobium tropici*, strain CIAT 899

Kontopoulou and Savvas, unpublished

# Common bean crop (*Phaseolus vulgaris* L.) grown hydroponically on pumice and treated with different N levels in the supplied nutrient solution



*Similar shoot N levels in plants treated with full or restricted (1/3 of the full) N supply and inoculated with Rt*

*BNF was able to fully cover the plant nitrogen requirements*

CIAT899: inoculation with *Rhizobium tropici*, strain CIAT 899



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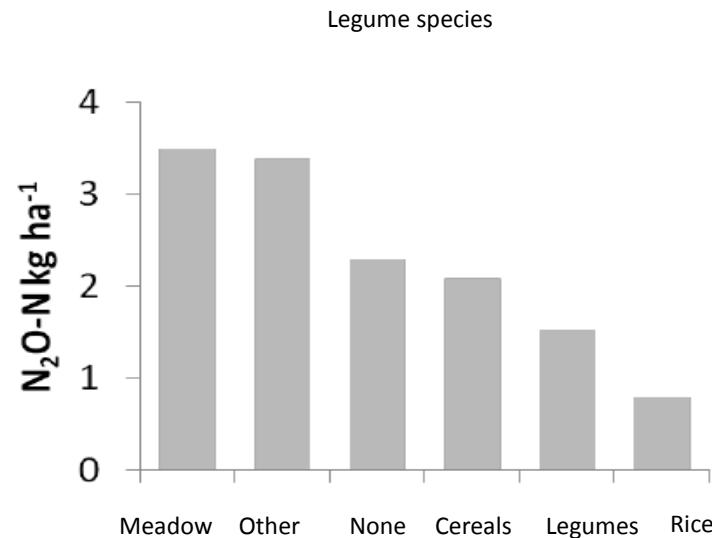
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# Direct environmental impacts of biological N<sub>2</sub> fixation

Legumes in crop rotations substitute for inorganic N fertilizers in the following crops and improve soil fertility

The reduced use of chemical nitrogen fertilizers restricts the emissions of nitrous oxide (N<sub>2</sub>O), which contributes to the greenhouse effect



(Stehfest and Bouwman, 2006)

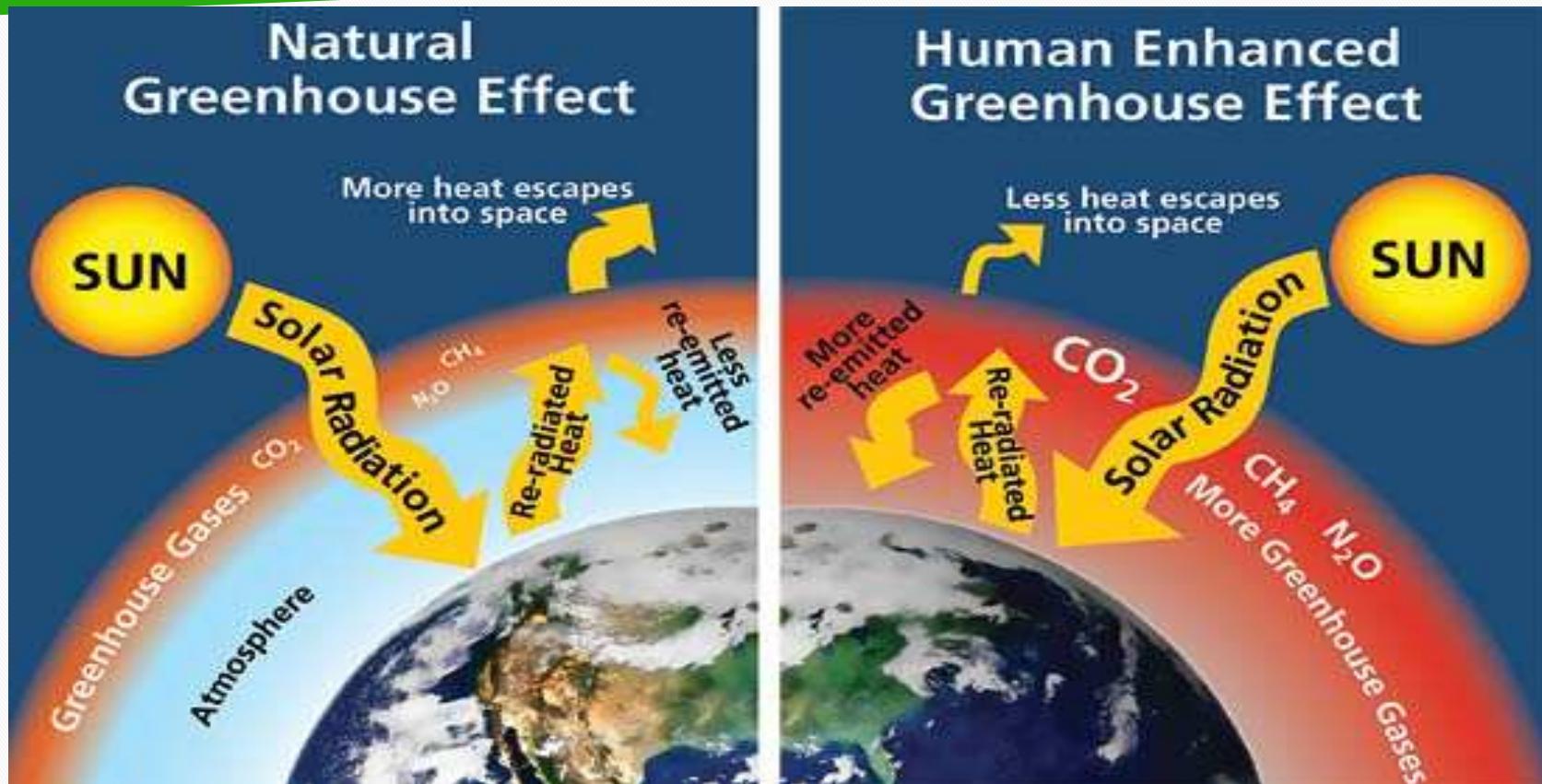


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# “The Greenhouse effect”



Naturally occurring GHGs normally trap some of the sun's heat, keeping the planet from freezing

Human activities, e.g. burning of fossil fuels, are increasing GHG levels, leading to an enhanced greenhouse effect



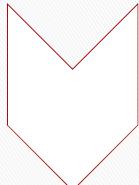
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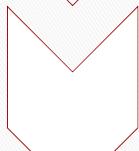
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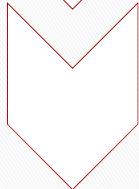
# Impact of climate change



- Increase of average annual T



- Sea lever rise
- (Melting of Polar Ice)



- Frequent storms and floods

## Measurements

## Reduction of greenhouse gas emissions



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# Greenhouse Gases

$\text{CO}_2$

- **Natural sources:** Plant and Animal breath, decay of organic matter, volcano
- **Human Activity:** Fossil fuel use in transportation, building heating and cooling and the manufacture of cement and other goods

$\text{CH}_4$

- **Natural sources:** Wetlands, oceans
- **Human Activity:** agriculture, livestock, natural gas distribution and landfills.

$\text{N}_2\text{O}$

- **Natural sources:** Oceans, virgin forests, soil bacteria
- **Human Activity:** N fertilizers, fossil fuel combustion, industrial production using N (wastewater)



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# Comparative impact of CO<sub>2</sub>, CH<sub>4</sub> & N<sub>2</sub>O to the greenhouse effect

GHG	GWP (100 yrs)	GHG concentration in the air per year (ppm )				
		1800	1900	1950	1995	2008
CO <sub>2</sub>	1	280	297	311	361	385
CH <sub>4</sub>	21	0.80	0.87	1.15	1.73	1.80
N <sub>2</sub> O	298	0.28	0.28	0.29	0.31	0.32

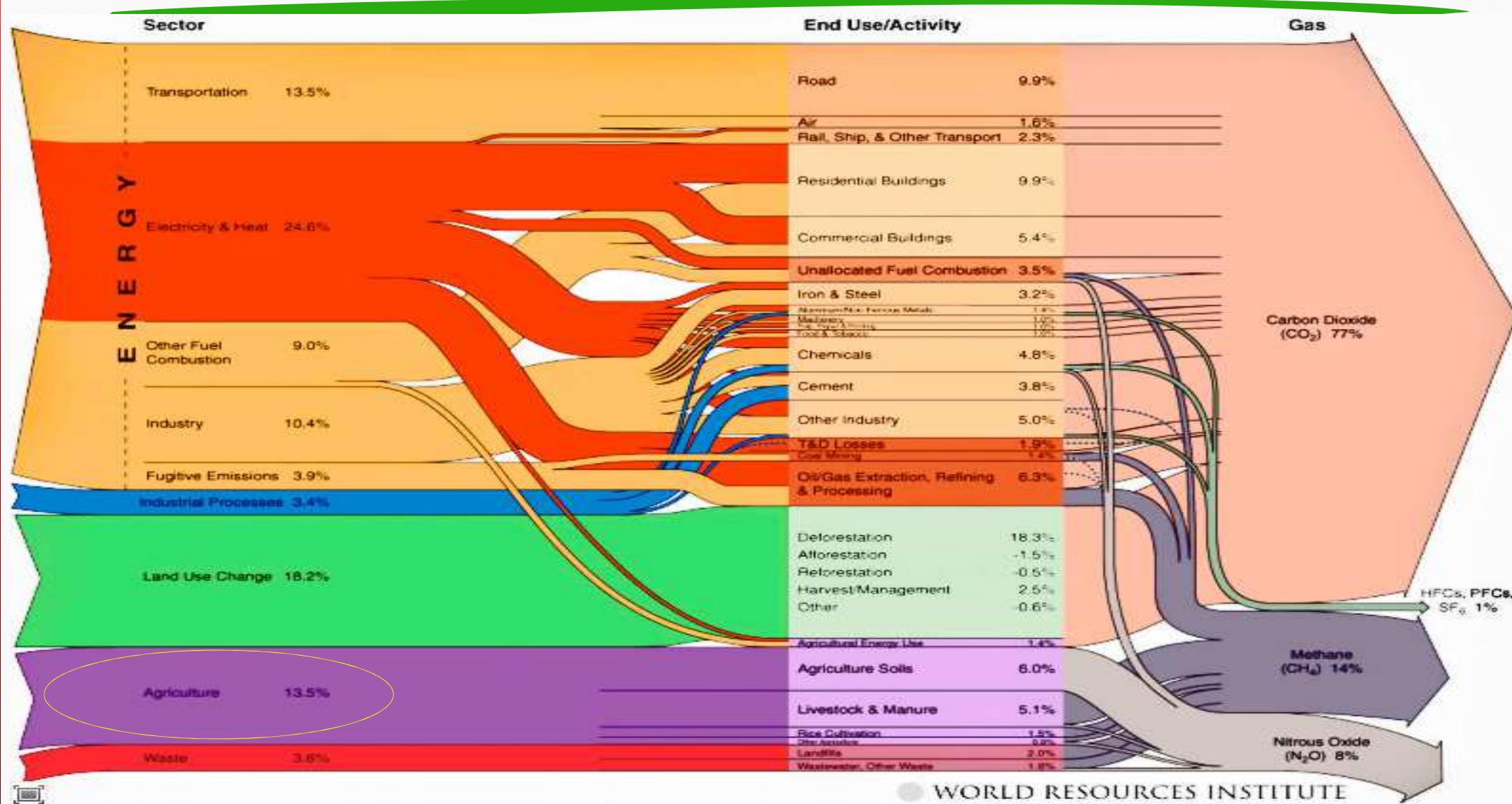
Equal amounts of emissions of GHGs have different contribution to the greenhouse effect

\* GWP = Global Warming Potential

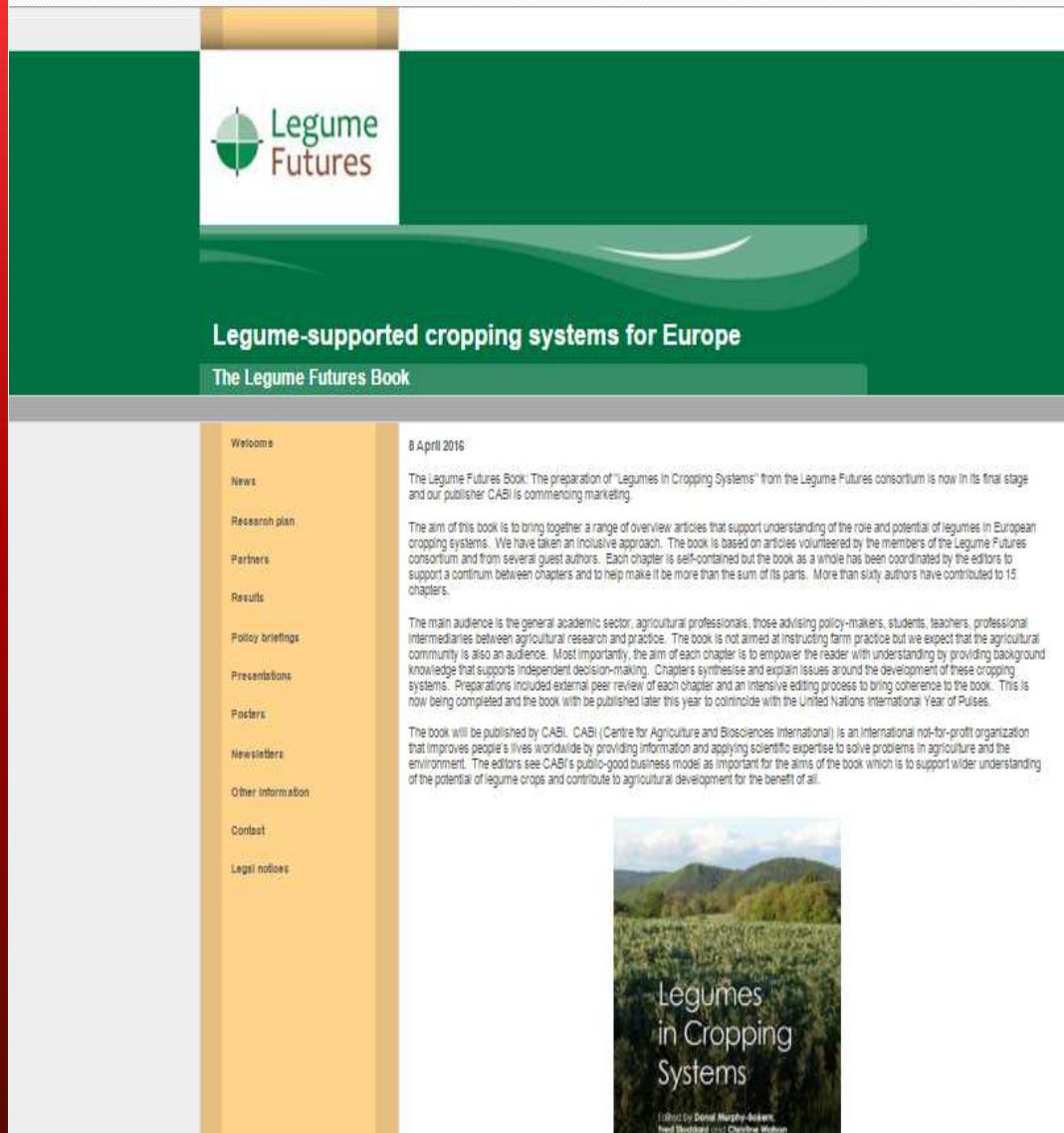


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Source : IPCC  
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# World GHG Emissions Flow Chart



<http://www.legumefutures.de/>



Legume-supported cropping systems for Europe

The Legume Futures Book

Welcome 8 April 2016

The Legume Futures Book: The preparation of "Legumes in Cropping Systems" from the Legume Futures consortium is now in its final stage and our publisher CABI is commencing marketing.

The aim of this book is to bring together a range of overview articles that support understanding of the role and potential of legumes in European cropping systems. We have taken an inclusive approach. The book is based on articles volunteered by the members of the Legume Futures consortium and from several guest authors. Each chapter is self-contained but the book as a whole has been coordinated by the editors to support a continuum between chapters and to help make it be more than the sum of its parts. More than sixty authors have contributed to 15 chapters.

The main audience is the general academic sector, agricultural professionals, those advising policy-makers, students, teachers, professional intermediaries between agricultural research and practice. The book is not aimed at instructing farm practice but we expect that the agricultural community is also an audience. Most importantly, the aim of each chapter is to empower the reader with understanding by providing background knowledge that supports independent decision-making. Chapters synthesise and explain issues around the development of these cropping systems. Preparations included external peer review of each chapter and an intensive editing process to bring coherence to the book. This is now being completed and the book will be published later this year to coincide with the United Nations International Year of Pulses.

The book will be published by CABI. CABI (Centre for Agriculture and Biosciences International) is an international not-for-profit organization that improves people's lives worldwide by providing information and applying scientific expertise to solve problems in agriculture and the environment. The editors see CABI's public-good business model as important for the aims of the book which is to support wider understanding of the potential of legume crops and contribute to agricultural development for the benefit of all.

**Legumes in Cropping Systems**

<http://www.eurolegume.com>



**EUROLEGUME**

**EUROLEGUME** (Enhancing of legumes growing in Europe through sustainable cropping for protein supply for food and feed) is an international research project funded by the 7th Research Framework Programme of the European Union.

In agreement with the tight relation between genotype and environment, root system architecture (RSA) and development has received an increased amount of attention due to advances in phenotyping capabilities. However, low focus on belowground characteristics of leguminous plants in plant breeding and limited number of high-yielding cultivars with good resistance to abiotic and biotic stresses has been obtained. Currently, broad diversity of Rhizobia and arbuscular mycorrhizal fungi is referred, although there is a lack of genotypic evaluation as well as of efficiency of particular strains in biological nitrogen fixation in diverse agro-ecological conditions. This situation has allowed to develop a research project aimed to deliver an updated biochemical, nutritional and morphological description of valuable genotypes, as well as biological methods to enhance the nutritive value of the residual biomass and the development of new feed and food products. New formulations for microbial inoculants, nitrogen availability to crops and elaborated growing technologies for sustainable use of legumes will be also assessed.

The relevance of the present venture is based on the role of legumes in the human diet and nutrition of animals and farming systems, which is increasingly important. Nowadays, a significant number of accessions of local pea, faba bean and cowpea germplasm are available across the Europe, even though the collections are not fully evaluated in terms of geno- and phenotyping as well as concerning their nutritional value. National traditions and climate conditions are influencing legume crop consumption and cultivation and there are available local genotypes not collected, evaluated and included in breeding programmes.

**PARTNERS**

# Can organic cultivation of legumes further reduce greenhouse gas emissions?

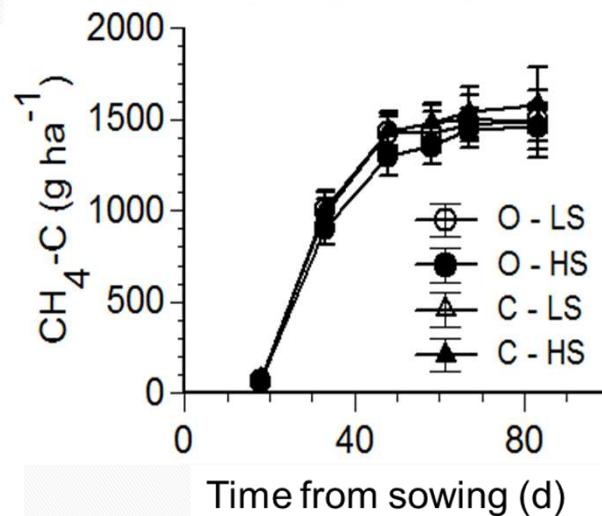
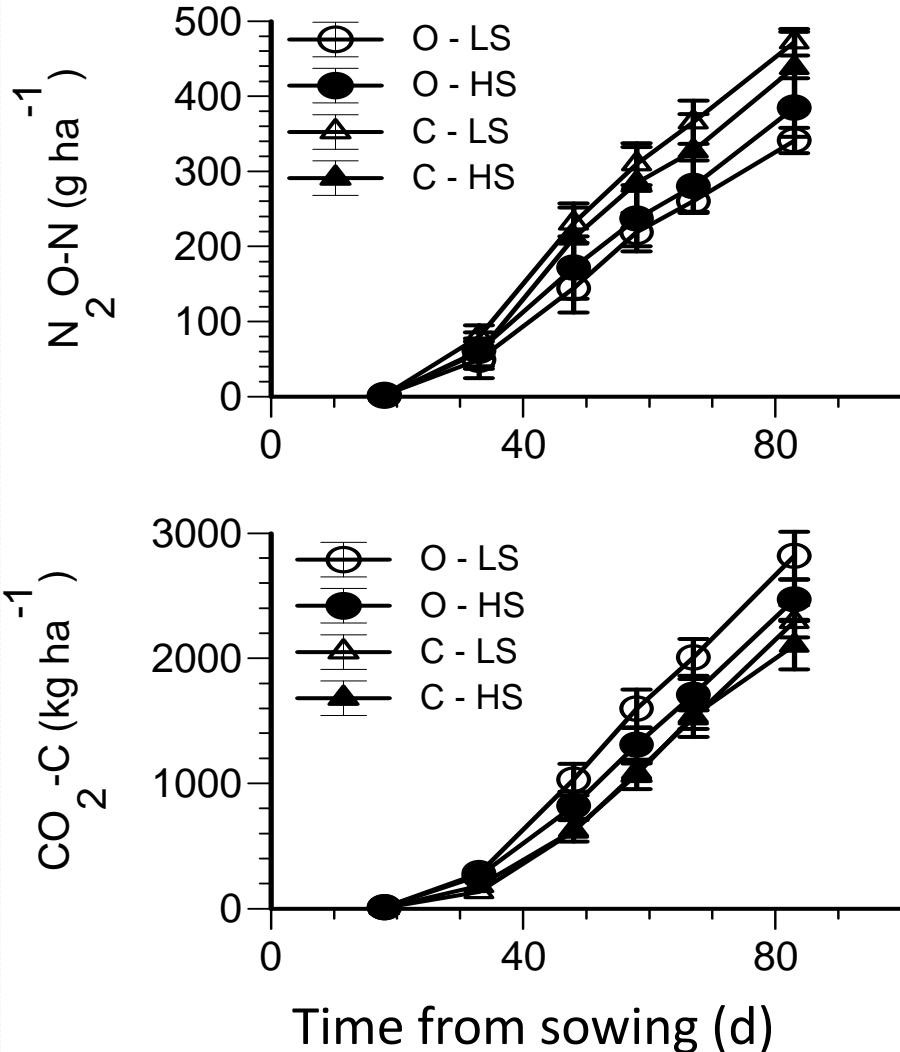


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# Greenhouse gas emissions per cultivated area unit in a field crop of common bean



Maximizing yield  
within organic  
systems to benefit  
from the reduced  
 $\text{N}_2\text{O}$  emissions

O: Organic	LS: Low salinity
C: Conventional	HS: high salinity

Kontopoulou et al, 2015. *Scientia Horticulturae* 183, 48-57

## Impact of the use of local legume varieties in crop rotation with vegetables on greenhouse gas emissions

### Measurements

- 1. Yield**
- 2. Biological N<sub>2</sub> Fixation (Natural abundance method <sup>15</sup>N)**
- 3. Molecular characterization of Indigenous Rhizobium strains**
- 4. Variations in soil nitrogen over a 3-years rotation experiment**
- 5. N<sub>2</sub>O, CO<sub>2</sub> and CH<sub>4</sub> emissions over a 3-year rotation experiment**



# Pictures from EUROLEGUME experiments





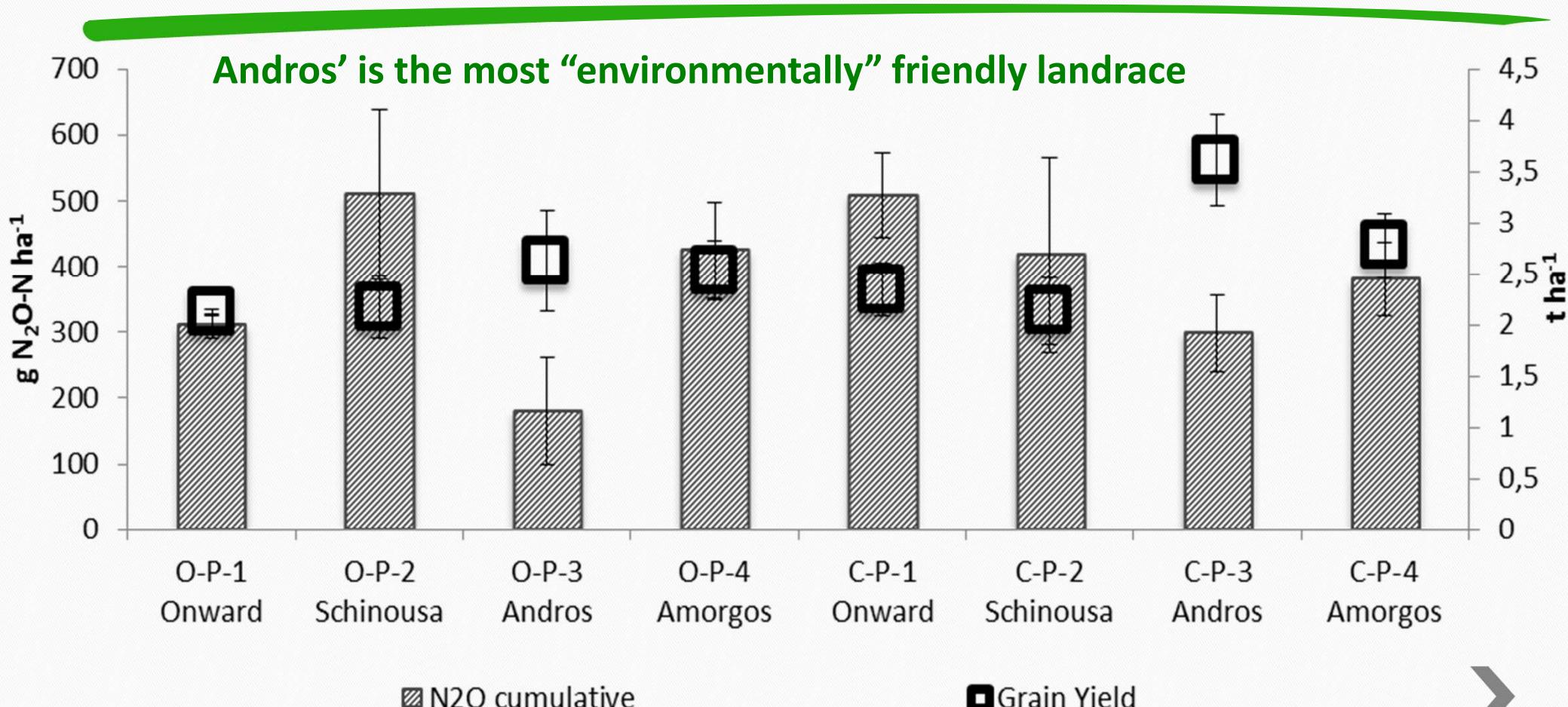
## Pictures from EUROLEGUME experiments



# Determination of soil emissions of $\text{N}_2\text{O}$ , $\text{CO}_2$ and $\text{CH}_4$ using static chambers by Gas Chromatography

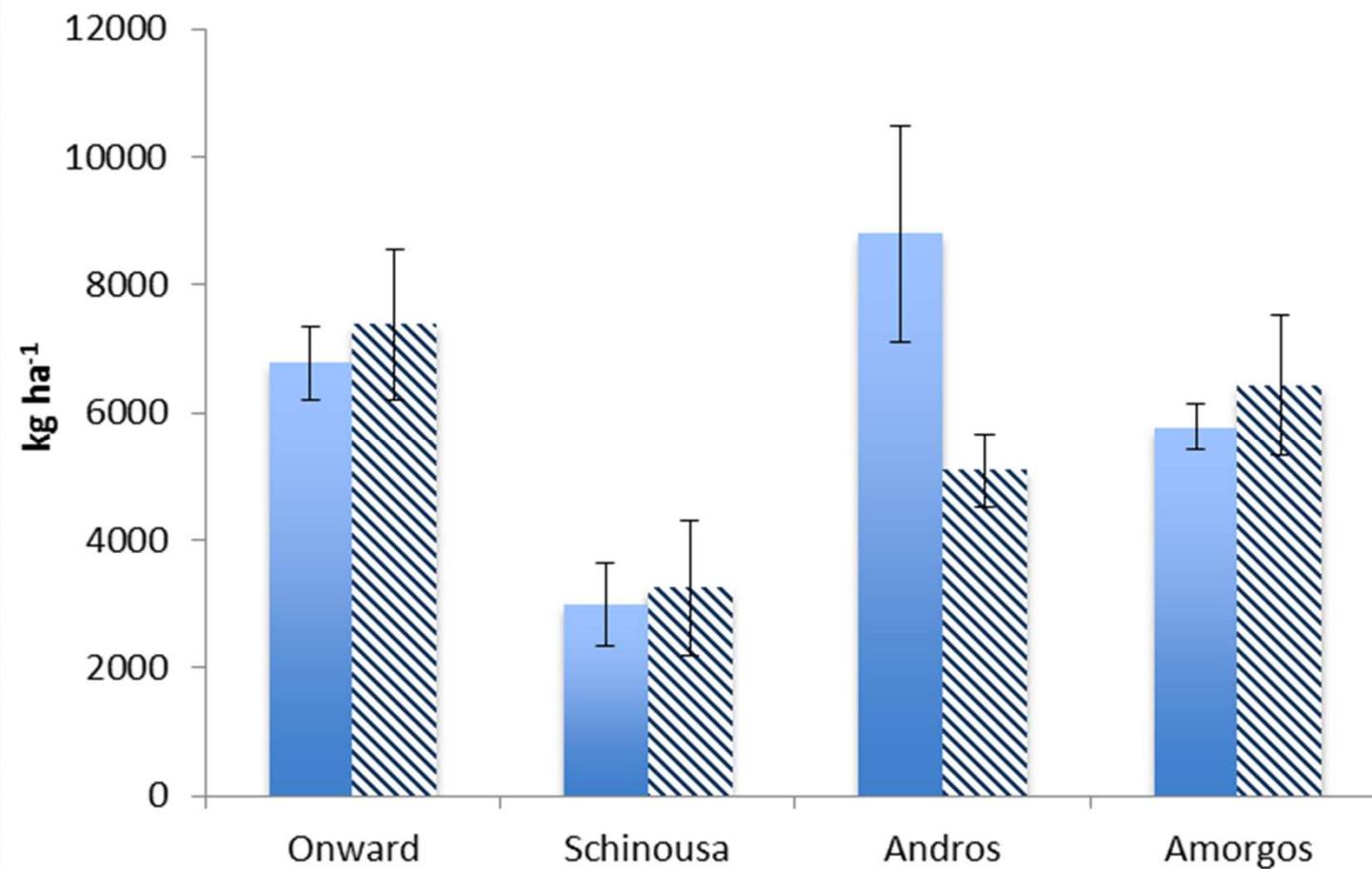


## Cumulative $\text{N}_2\text{O}$ emissions and production of fresh and dry seeds from local varieties of peas in organic and conventional farming systems

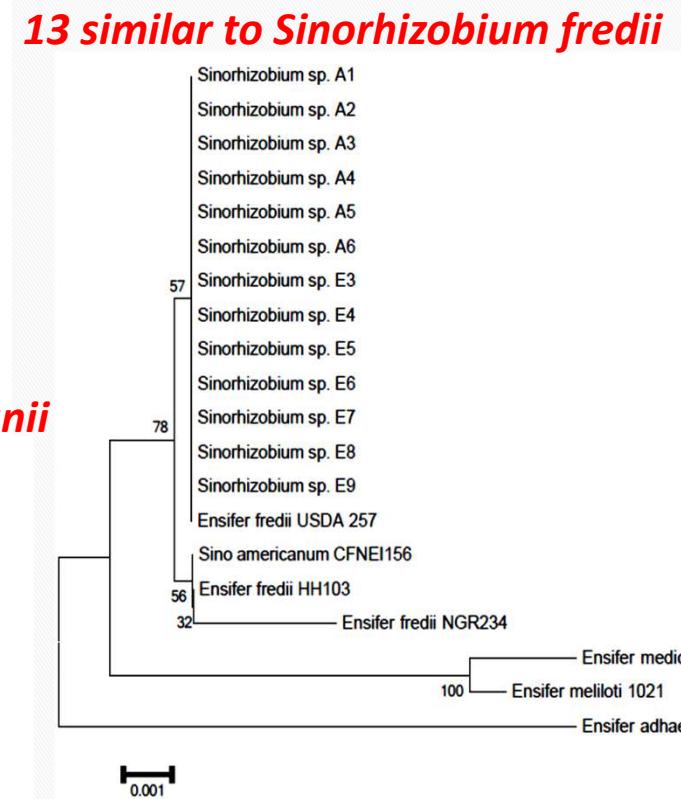
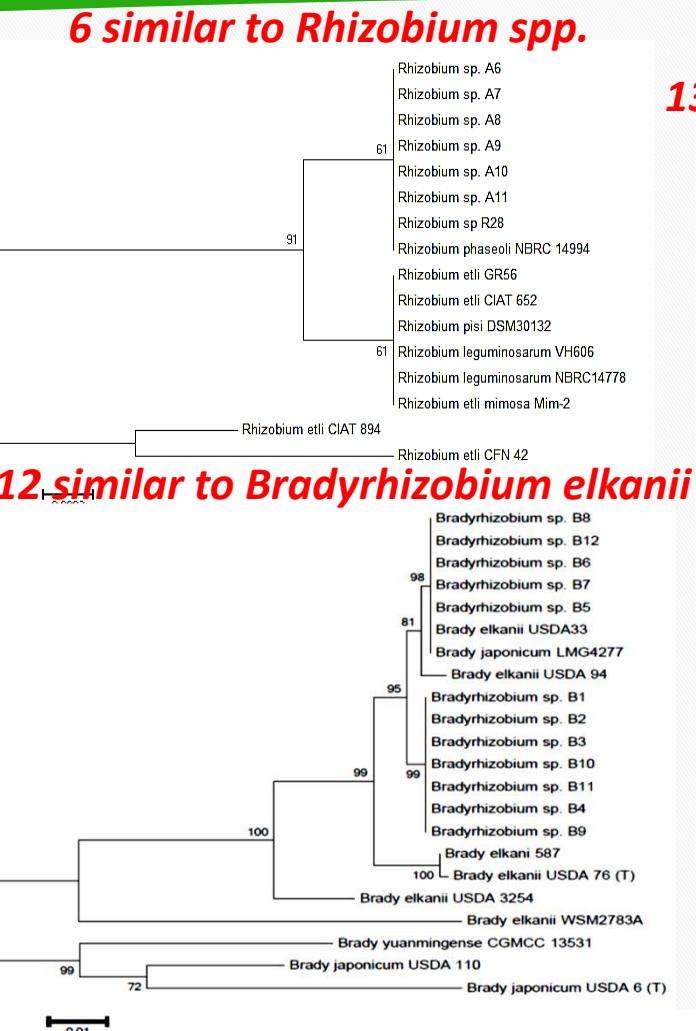


Intensities: g  $\text{N}_2\text{O-N}$  per ton of fresh yield

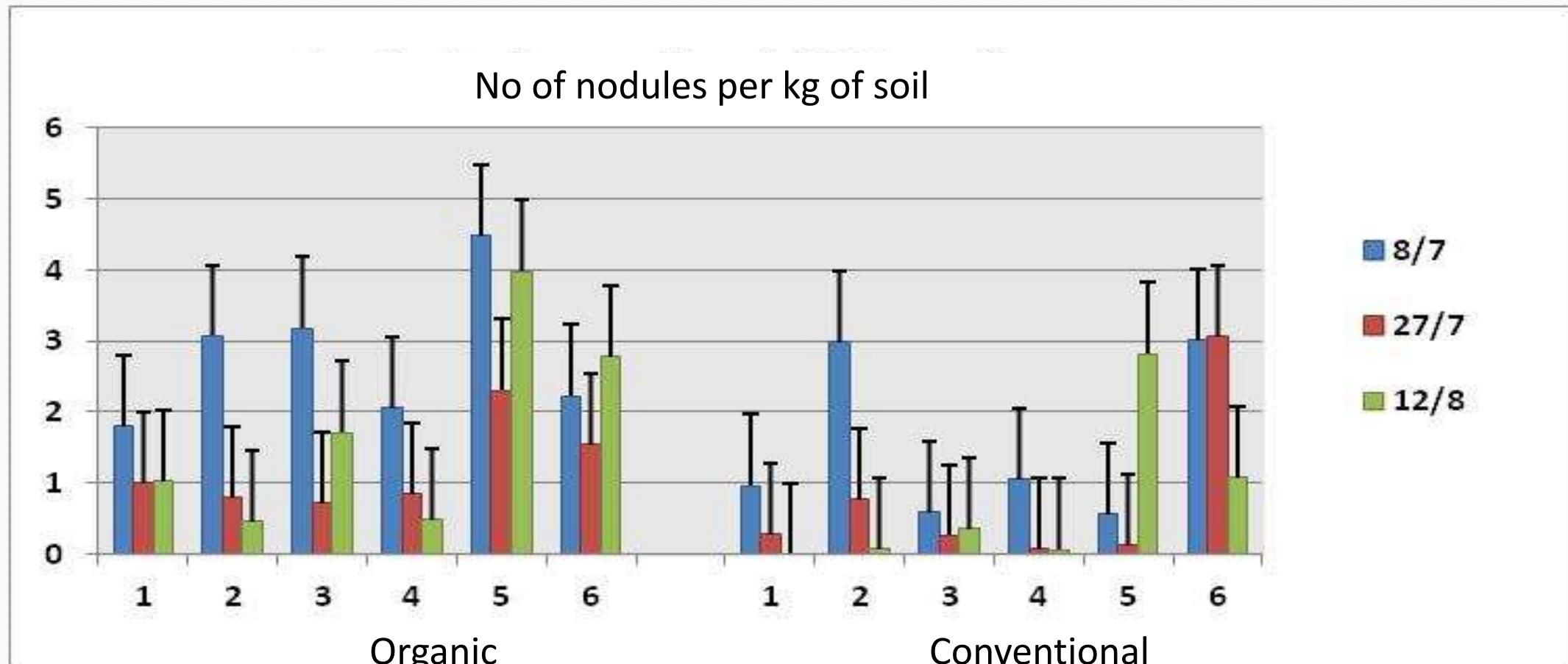
## Calculated BNF for pea landraces in organic (solid fill) and conventional (line fill) system



# Nodules of Greek cowpea varieties with rhizobia isolates



## Nodules on the roots of local cowpea varieties in organic or conventional farming systems



# Take home message (1)

**High rates of inorganic N supply restrict root nodulation and biological nitrogen fixation by rhizobia**

- Thus, root inoculation of legumes with efficient nodulating bacteria may enhance biological  $N_2$  fixation and increase crop yield and quality, provided that the inorganic N supply is accordingly low



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# Take home message (2)

**Different genotypes of the same crop species may exhibit considerable differences in their ability to fix N<sub>2</sub> and reduce GHG emissions**

- Consequently, selection of cultivars and landraces characterized by high N<sub>2</sub>-fixation efficiency is of paramount importance for maximizing benefits provided by legumes in legume-supported cropping systems



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# Take home message (3)

**Organic farming results in significantly lower N<sub>2</sub>O emissions than conventional farming in terms of the overall Global Warming Potential**

- N<sub>2</sub>O emission differences between organic and conventional systems, highlighting the importance of maximising yield within organic systems in order to reduce their environmental impact



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**Convener**  
**Prof. Dr. Yüksel TÜZEL**

**Co-Convener**  
**Assoc. Prof. Dr. Gölgen  
Bahar ÖZTEKİN**





**Thank you for  
your attention!**



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