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

DIMITRIOS SAVVAS, VALENTINI PAPPA, DIONISIOS YFANTOPOULOS, ANESTIS KARKANIS*, ILIAS TRAVLOS, PENELOPE BEBELI, GEORGIA NTATSI, DIMITRIOS BILALIS

AGRICULTURAL UNIVERSITY OF ATHENS
*UNIVERSITY OF THESSALY

ISHS BioGreenhouse COST EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

3rd INTERNATIONAL SYMPOSIUM ON ORGANIC GREENHOUSE HORTICULTURE
11 - 14 APRIL 2016 / IZMIR, TURKEY

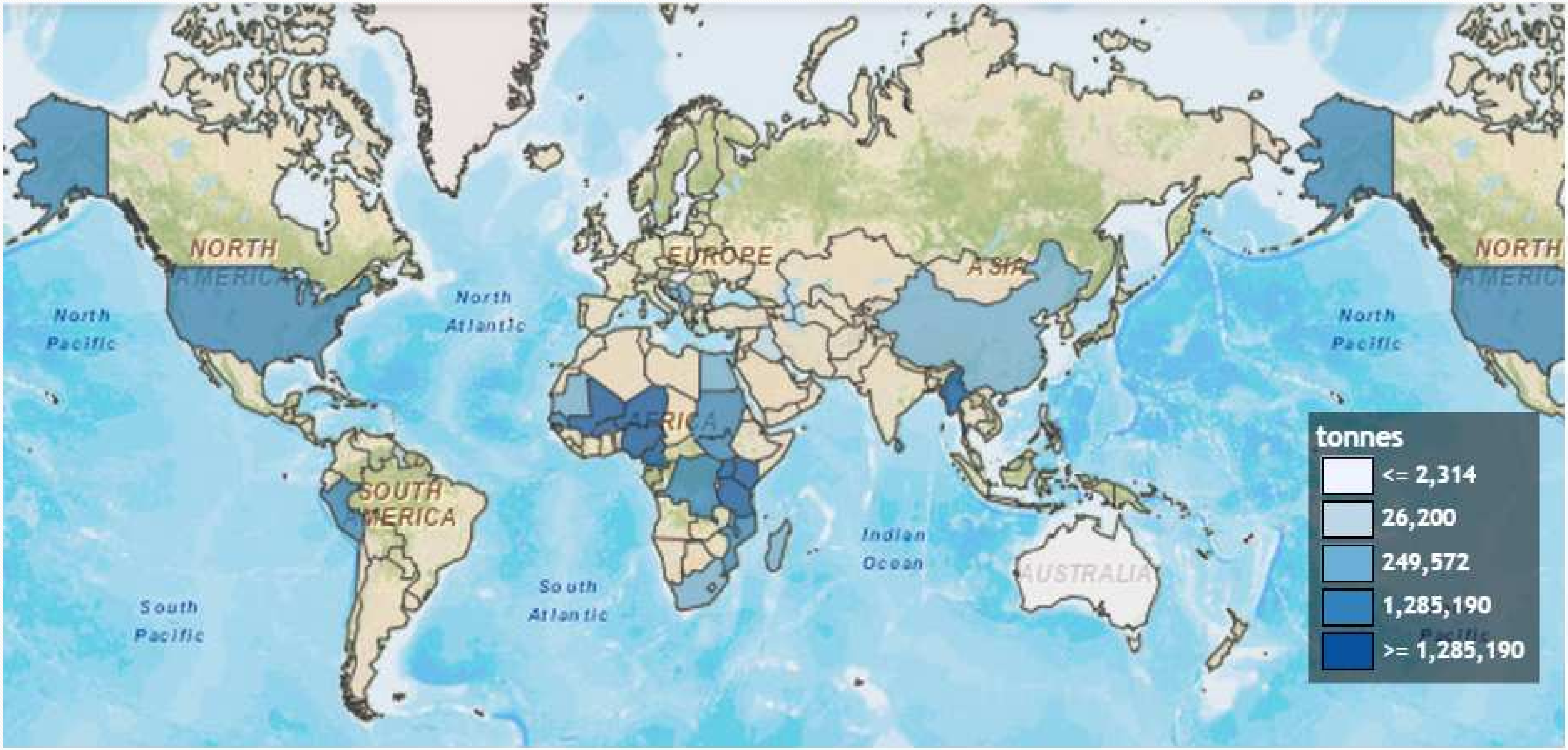
Legume Production

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

Global Legume Production



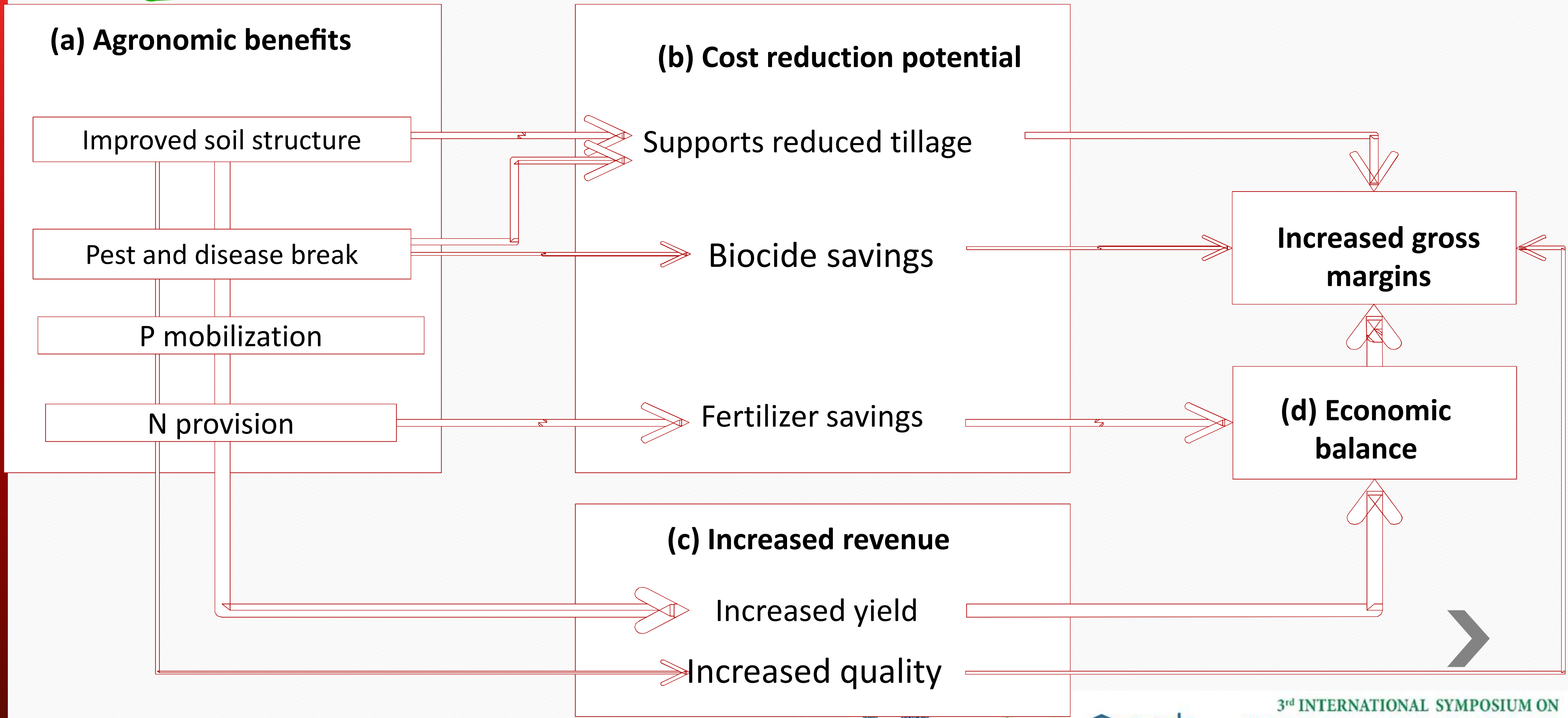
Main grain legumes


- soybean
- peas
- common bean
- faba bean
- cowpea
- spring vetch
- lupine
- peanuts
- lentils






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



Preissel et al., 2015. Field Crops Research, 175, 64-79

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

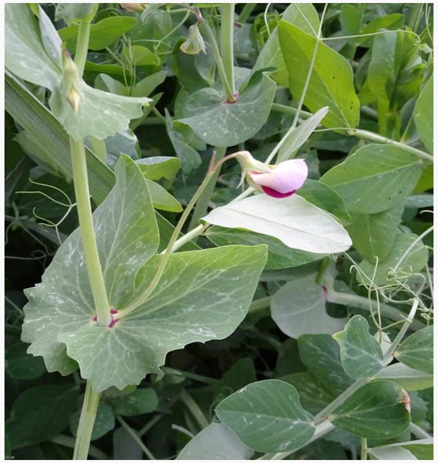
They have the tendency to keep a dynamic balance

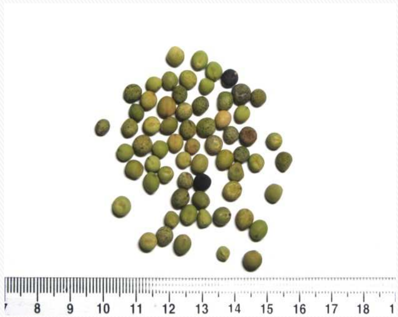
They are an evolving material

Landraces

(Stehfest and Bouwman, 2006)

Pea (*Pisum sativum*) Landraces

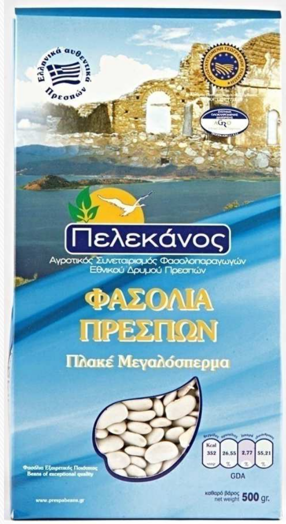


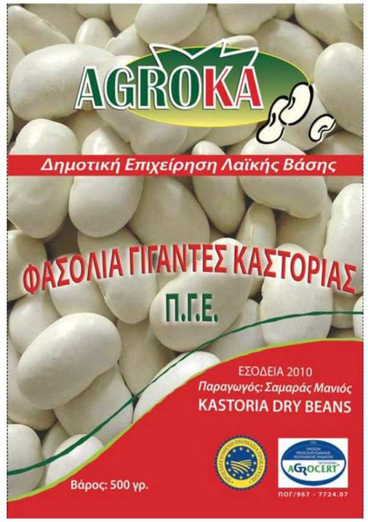


Faba Bean (*Vicia faba*) Landraces from Mani

Santorini Fava (PDO)
(*Lathyrus clymenum*)

Protected Geographical Indication (PGI) for Beans



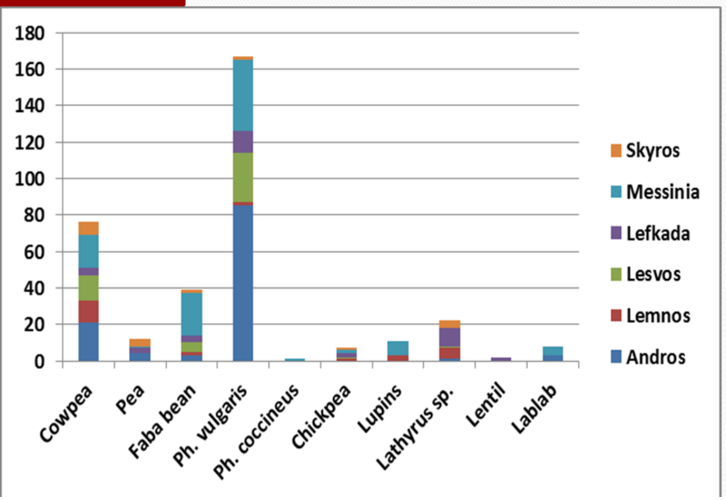


"Englouvi" Lentils
(*Lens culinaris*)

BioGreenhouse

3rd INTERNATIONAL SYMPOSIUM ON ORGANIC GREENHOUSE HORTICULTURE
11 - 14 APRIL 2016 / IZMIR, TURKEY

Collected Greek Crop Landraces Populations



ISHS BioGreenhouse COST EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

3rd INTERNATIONAL SYMPOSIUM ON ORGANIC GREENHOUSE HORTICULTURE
11 - 14 APRIL 2016 / IZMIR, TURKEY

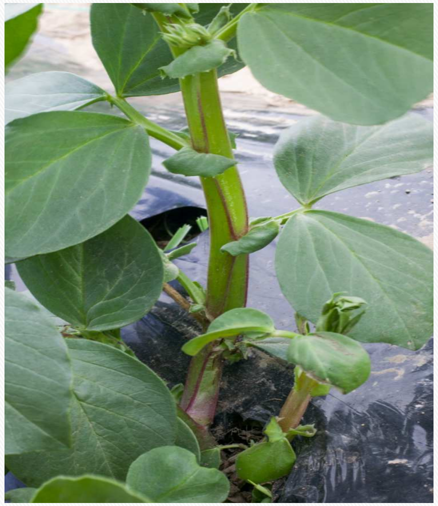
Characterizing Pea Landraces







Characterizing faba bean and cowpea landraces







ISHS BioGreenhouse cost EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY
3rd INTERNATIONAL SYMPOSIUM ON ORGANIC GREENHOUSE HORTICULTURE
11 - 14 APRIL 2016 / IZMIR, TURKEY

Direct environmental impacts of biological N_2 fixation

Biological N_2-fixation by rhizobia takes place at

- ambient T
- ambient atmospheric pressure

Industrial N fixation (Haber process):

- 400 - 600 ºC
- 200 At

Benefits of biological N_2-fixation:

- Strong reduction of energy input
- Strong reduction of CO_2 emissions

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

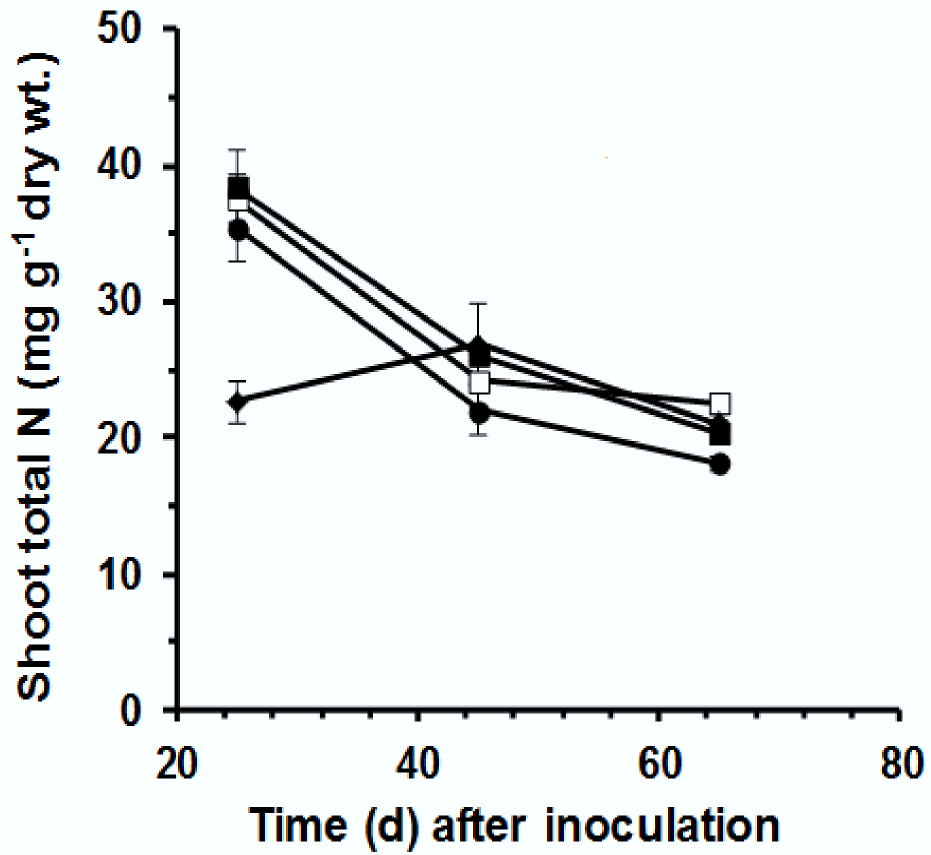
NS Treatment	$\delta^{15}N$ (‰)	Ndfa (%)	Total plant N content (kg ha^{-1})	Biologically-fixed N (kg ha^{-1})
Full N, -Rt	0.09 - 0.93	-4.8 c	212.2 a	-7.9 b
Full N, +Rt	0.23 – 0.85	-2.6 c	188.4 a	-6.2 b
1/3 of full-N, +Rt	(-1.15) - (-0.51)	58.1 b	93.0 b	54.3 a
Zero N, +Rt	(-1.93) - (-1.39)	100.0 a	48.7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

Restriction in N supply (1/3 of full N) stimulates biological N_2-fixation in bean crops grown on inert media, when the plants are inoculated with R. tropici.

$\delta^{15}N$: Differences between the abundance of ^{15}N in plant and atmospheric N
Ndfa: proportion of plant N derived from atmospheric N_2-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



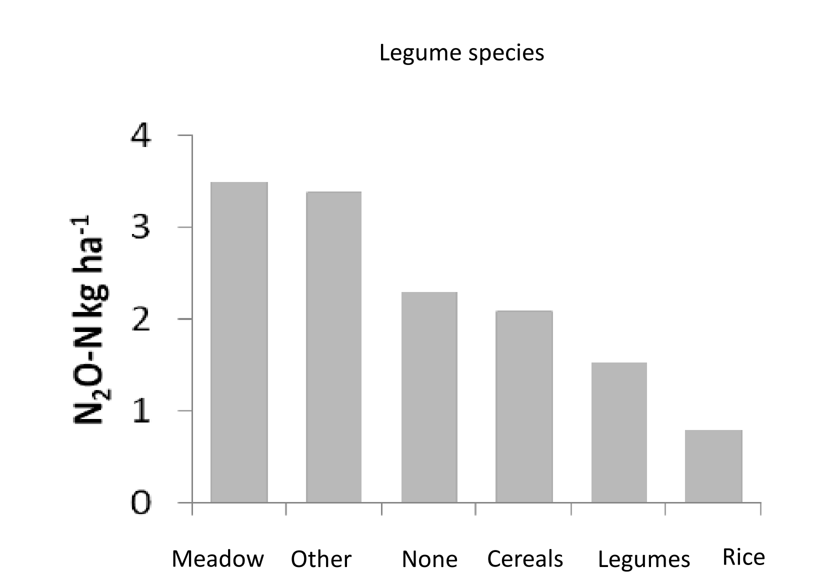
Similar shoot N levels in plants treated with full or restricted (1/3 of the full) N supply and inoculated with Rt

BNF was able to fully cover the plant nitrogen requirements

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

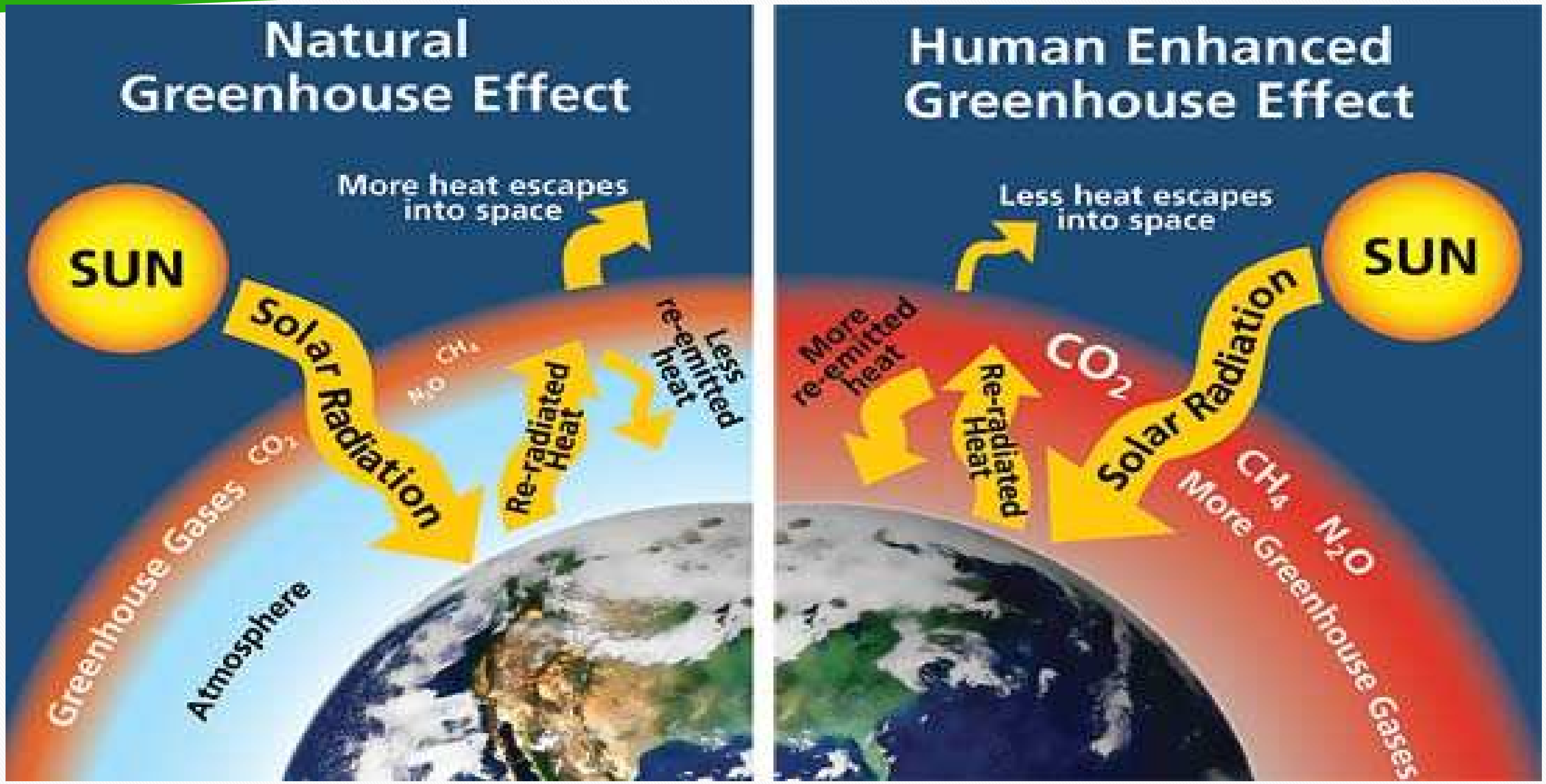
Direct environmental impacts of biological N_2 fixation

- 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_2O), which contributes to the greenhouse effect



(Stehfest and Bouwman, 2006)

"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

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

Greenhouse Gases

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
CH_4	•**Natural sources:** Wetlands, oceans •**Human Activity:** agriculture, livestock, natural gas distribution and landfills.
N_2O	•**Natural sources:** Oceans, virgin forests, soil bacteria •**Human Activity:** N fertilizers, fossil fuel combustion, industrial production using N (wastewater)

Comparative impact of CO_2, CH_4 & N_2O to the greenhouse effect

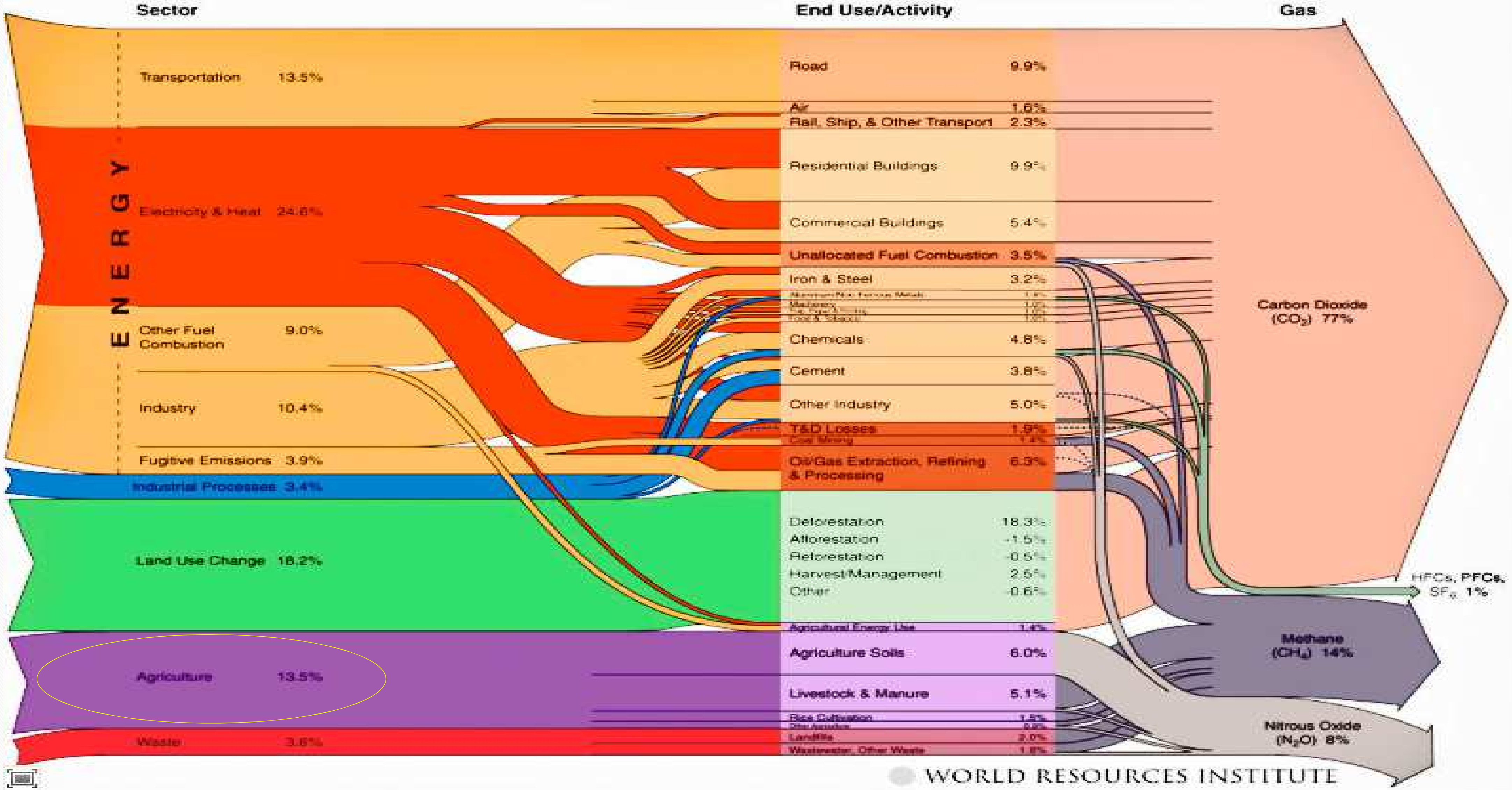
GHG	GWP (100 yrs)	GHG concentration in the air per year (ppm)				
		1800	1900	1950	1995	2008
CO_2	1	280	297	311	361	385
CH_4	21	0.80	0.87	1.15	1.73	1.80
N_2O	298	0.28	0.28	0.29	0.31	0.32

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

** GWP = Global Warming Potential*

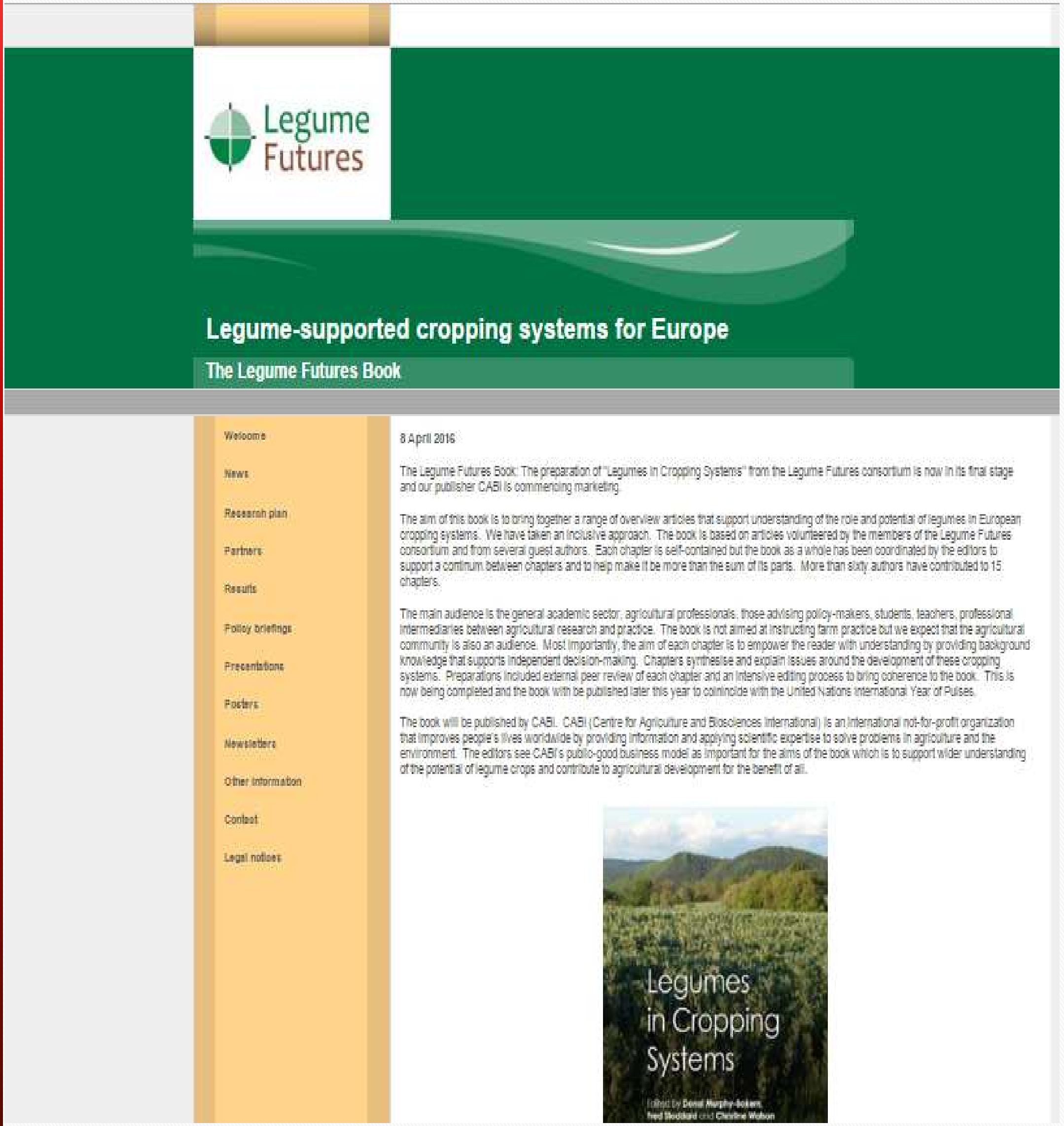
Source : IPCC

World GHG Emissions Flow Chart



http://www.legumefutures.de/

http://www.eurolegume.com

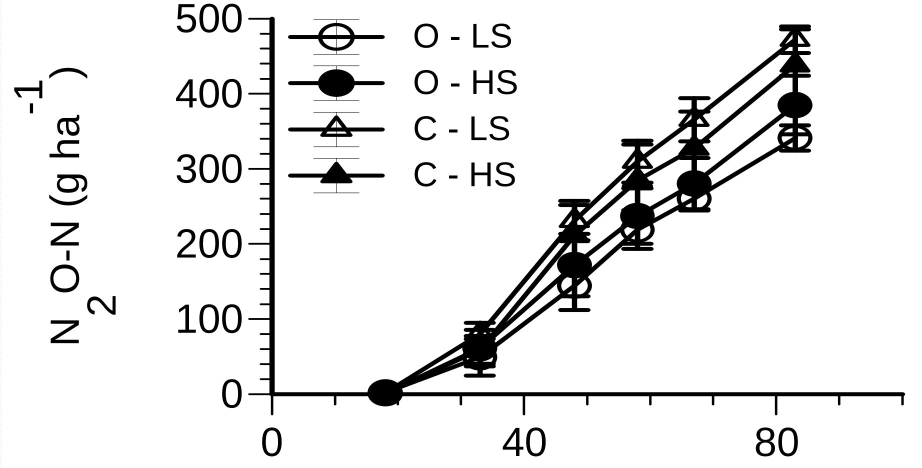


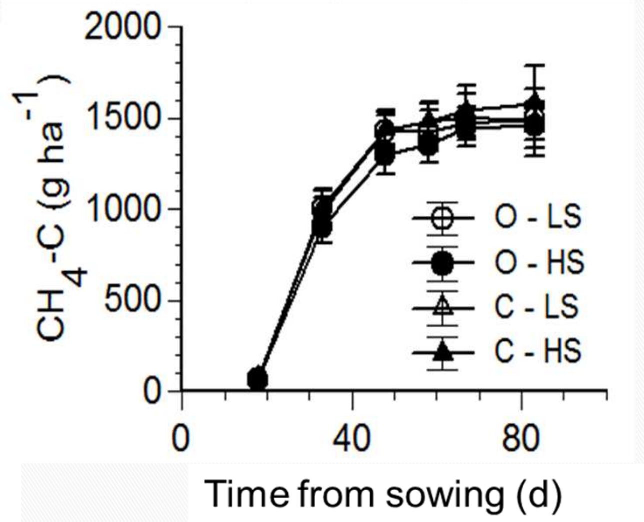
Can organic cultivation of legumes further reduce greenhouse gas emissions?

ISHS BioGreenhouse COST EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

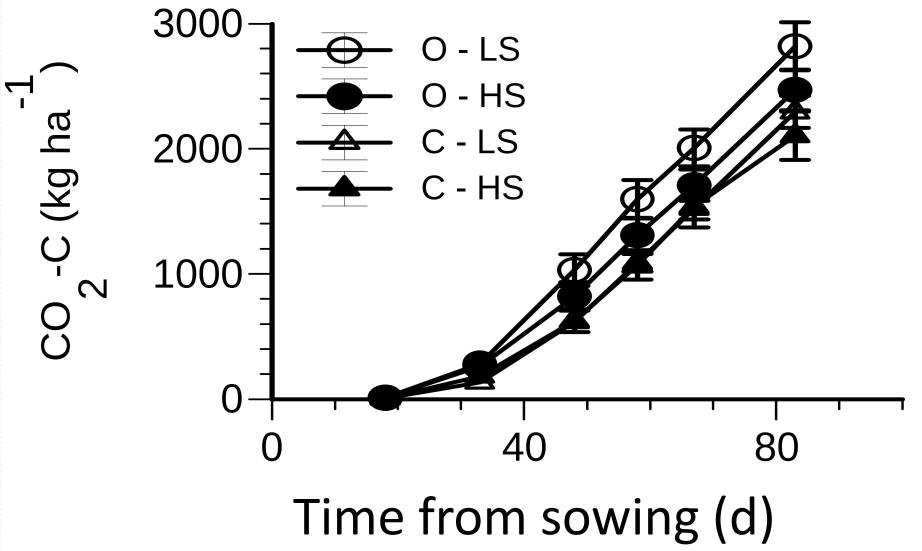
3rd INTERNATIONAL SYMPOSIUM ON ORGANIC GREENHOUSE HORTICULTURE
11 - 14 APRIL 2016 / IZMIR, TURKEY

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





Maximizing yield within organic systems to benefit from the reduced N_2O 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

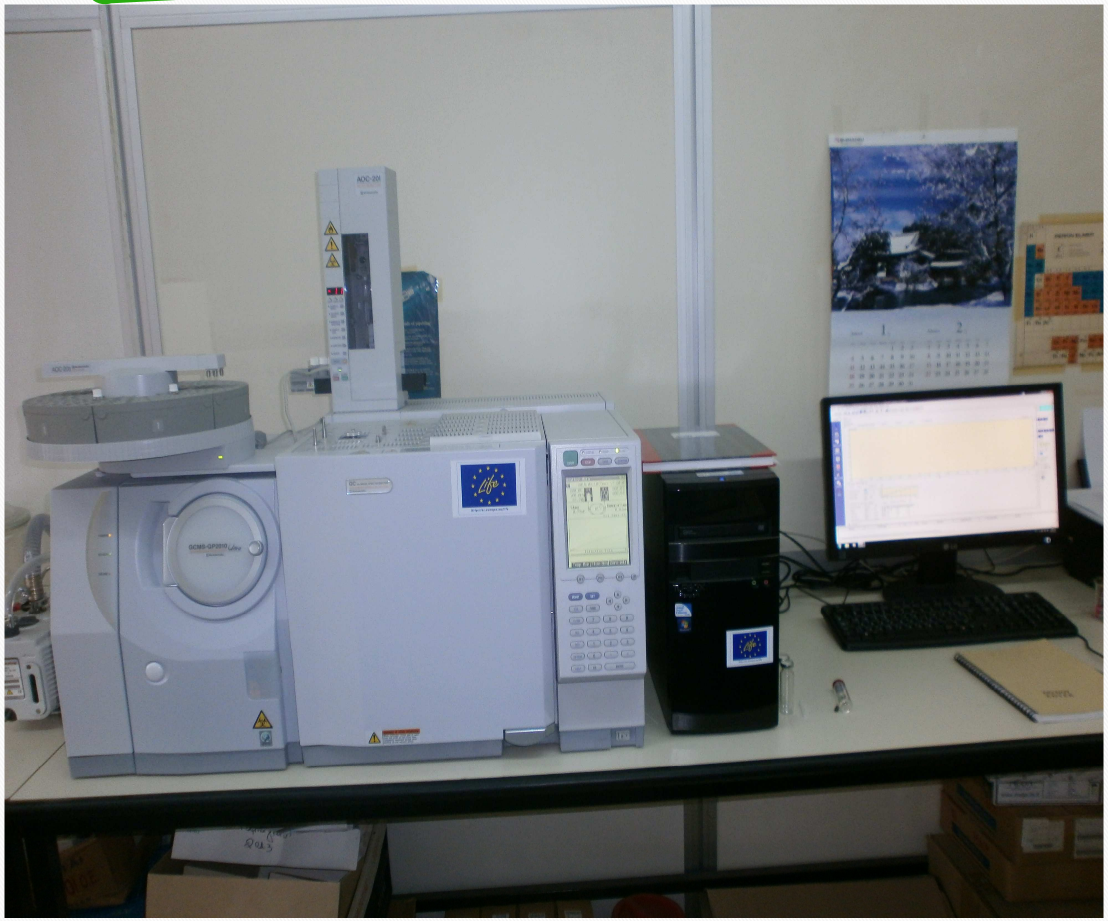
Measurements

1. Yield
2. Biological N_2 Fixation (Natural abundance method ^{15}N)
3. Molecular characterization of Indigenous Rhizobium strains
4. Variations in soil nitrogen over a 3-years rotation experiment
5. N_2O, CO_2 and CH_4 emissions over a 3-year rotation experiment

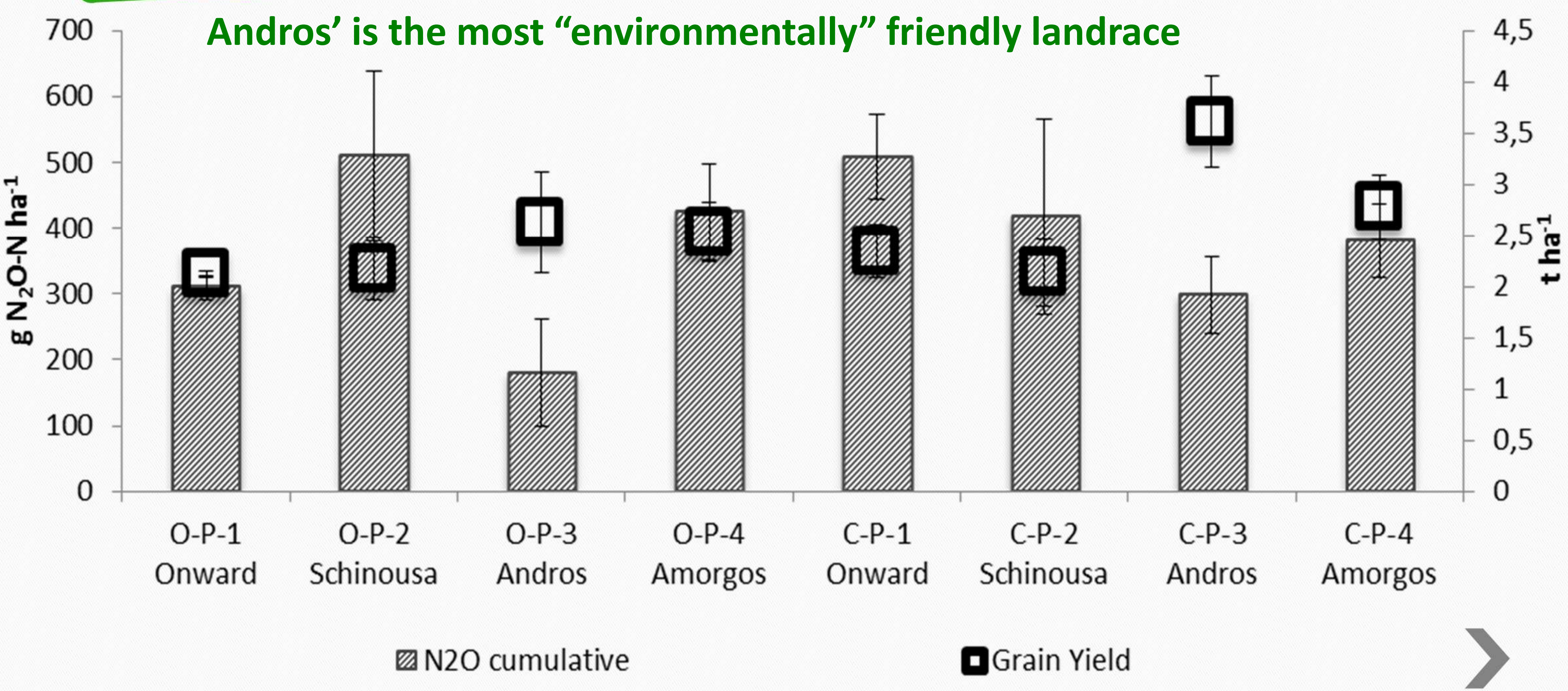
Pictures from EUROLEGUME experiments

Pictures from EUROLEGUME experiments

Determination of soil emissions of N_2O, CO_2 and CH_4 using static chambers by Gas Chromatography

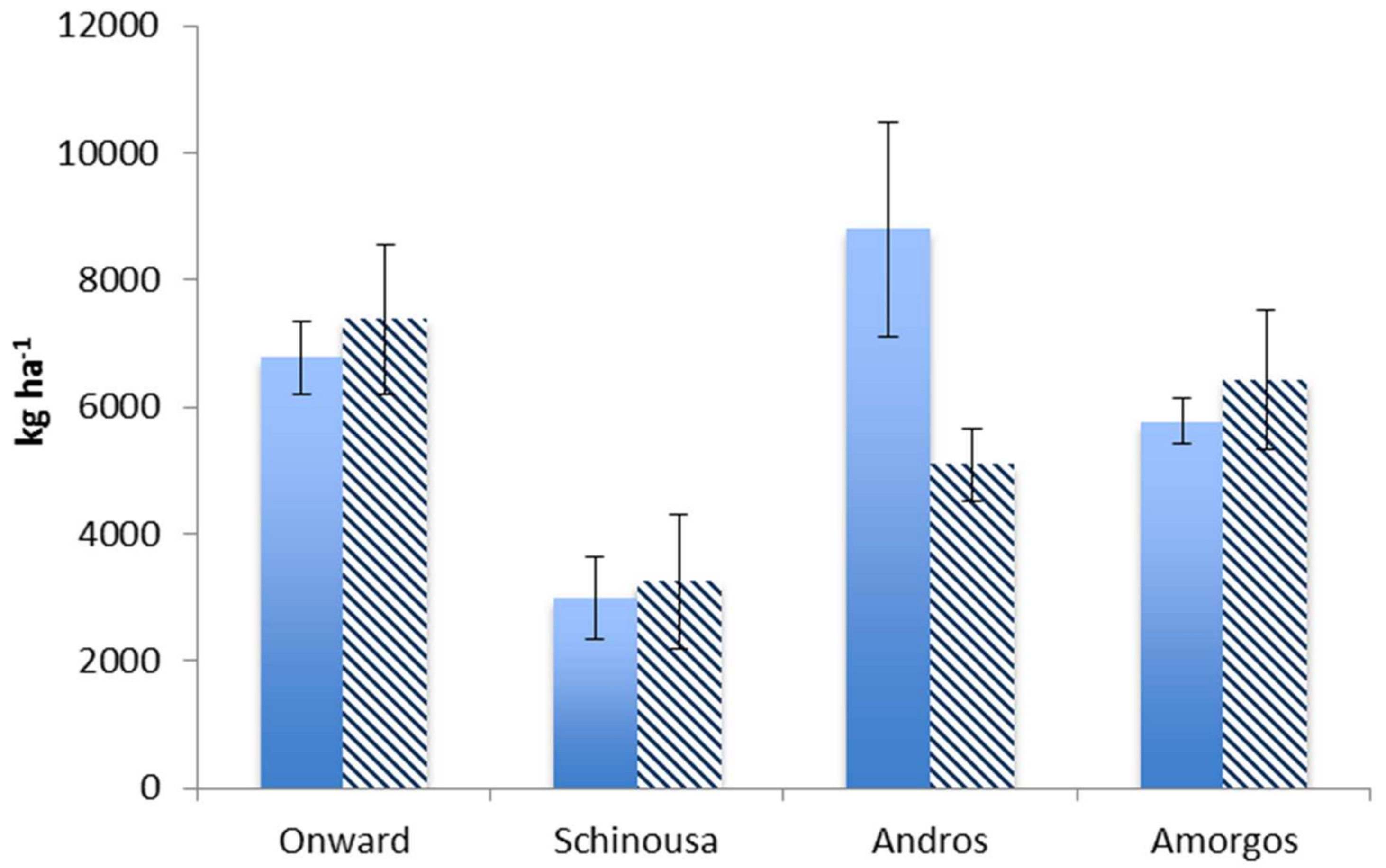


Cumulative N_2O emissions and production of fresh and dry seeds from local varieties of peas in organic and conventional farming systems



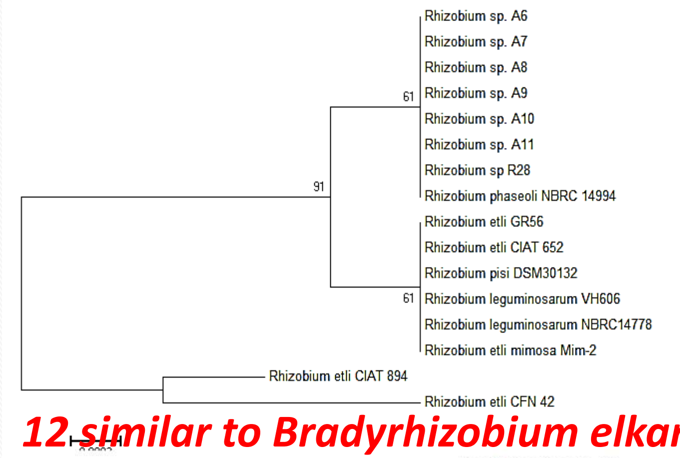
Intensities: g N_2O-N per ton of fresh yield

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

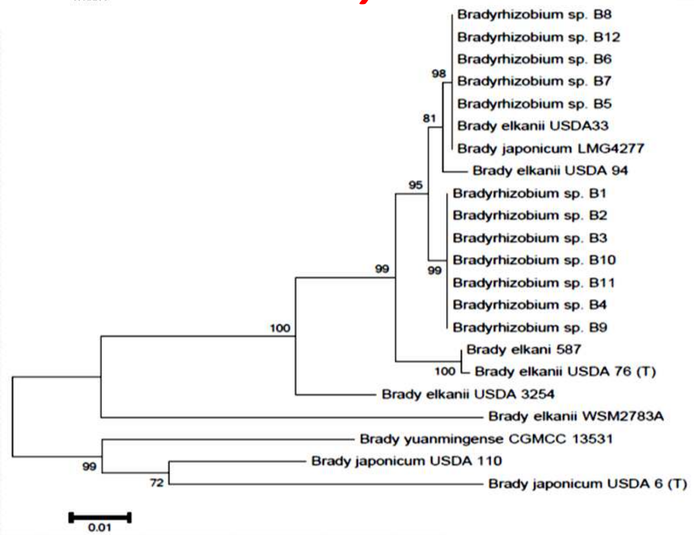


Nodules of Greek cowpea varieties with rhizobia isolates

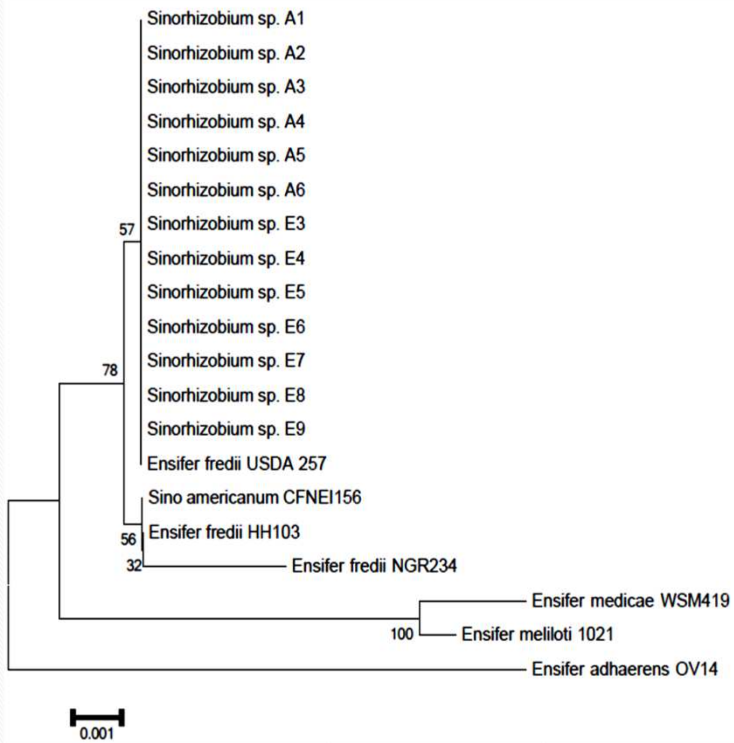
6 similar to Rhizobium spp.



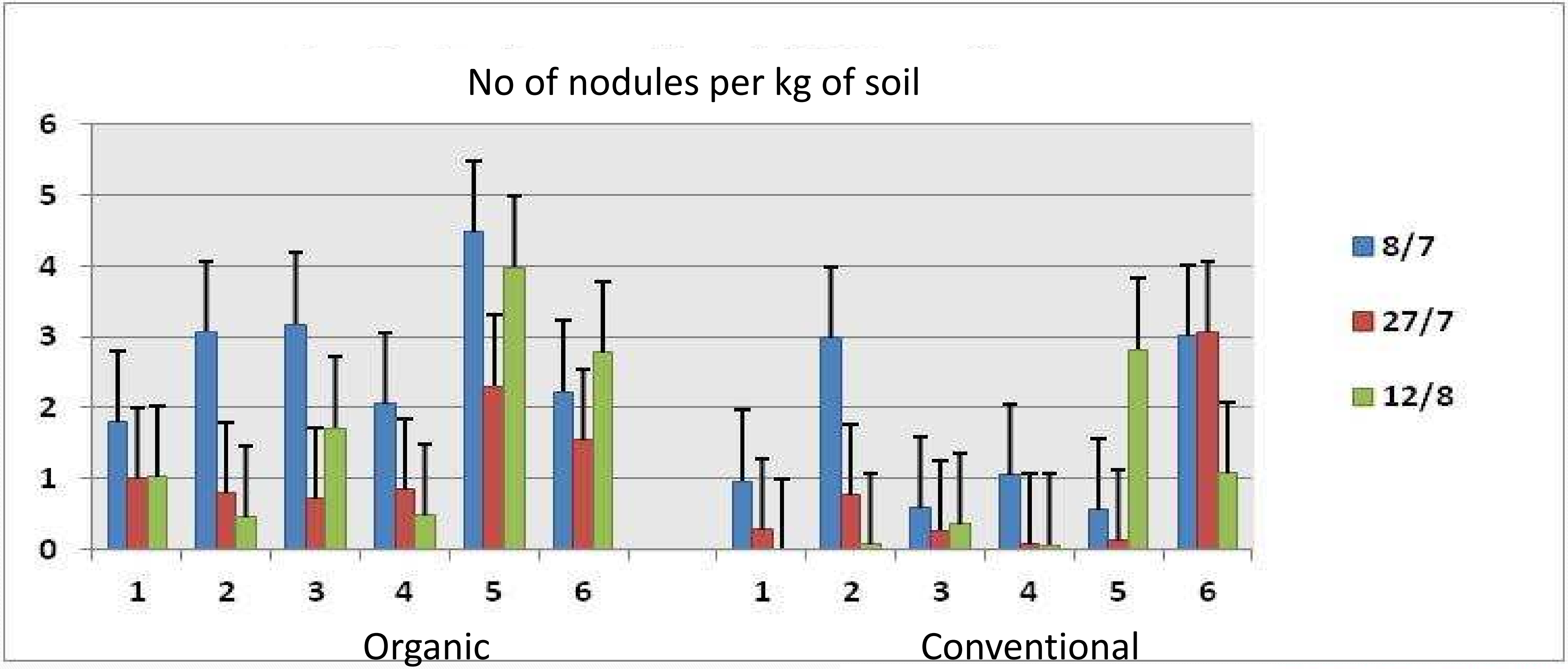
12 similar to Bradyrhizobium elkanii



13 similar to Sinorhizobium fredii



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

Take home message (2)

Different genotypes of the same crop species may exhibit considerable differences in their ability to fix N_2 and reduce GHG emissions

- Consequently, selection of cultivars and landraces characterized by high N_2-fixation efficiency is of paramount importance for maximizing benefits provided by legumes in legume-supported cropping systems

Take home message (3)

Organic farming results in significantly lower N_2O emissions than conventional farming in terms of the overall Global Warming Potential

- N_2O emission differences between organic and conventional systems, highlighting the importance of maximising yield within organic systems in order to reduce their environmental impact

EUROLEGUME 2014-2017

Enhancing of legumes growing in Europe through sustainable cropping for protein supply for food and feed

www.eurolegume.com

Research Project № 613781

Funded by the 7th Research Framework Programme of the European Union

ISHS BioGreenhouse COST EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

3rd INTERNATIONAL SYMPOSIUM ON ORGANIC GREENHOUSE HORTICULTURE

11 - 14 APRIL 2016 / IZMIR, TURKEY

Convener

Prof. Dr. Yüksel TÜZEL

Co-Convener

Assoc. Prof. Dr. Gölgen Bahar ÖZTEKİN

Thank you for your attention!