TRansition paths to sUstainable legume-based systems in Europe

An overview of legume supported food and feed chains in Europe

Pietro Iannetta,
James Hutton Institute

20th April 2018, Athens, Greece

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The James Hutton Institute:

is situated along the east coast of Scotland

ca. ~600 staff

http://www.hutton.ac.uk

The James Hutton Institute has five main sites

Craigiebuckler, Aberdeen
Laboratories

Invergowrie, Dundee
Laboratories, glasshouses and arable land (300 ha)

Balruddery Farm, Angus
Arable farm 350 ha
Site of the Centre for Sustainable Cropping

Hartwood Research Station, Lanarkshire
350ha rotational and permanent grassland, moor and woodland

Glensaugh, Kincardineshire
865ha rotational grassland, permanent pasture, heather moor and peat

Legumes: what is not to like?

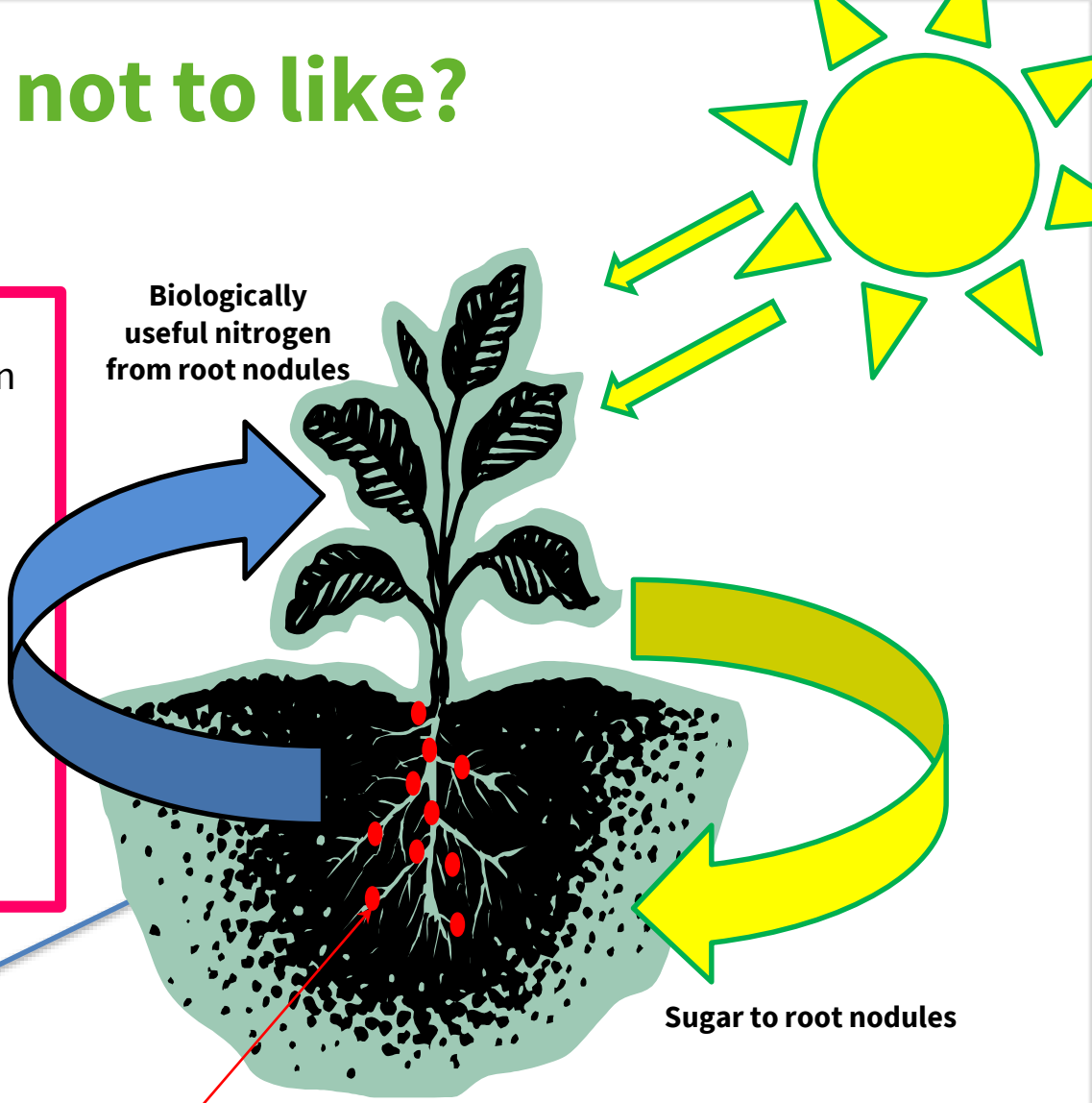
LEGUME FACTS

legumes fix nitrogen from air into protein

legumes need no nitrogen fertiliser

Legumes also:

rich in protein and energy
source of healthy food starches,
human food and animal feed
improve soil qualities
liberate soil phosphorous
reduce pesticide use
supports pollinators




Soybean root nodules

RHIZOBIA in root nodules fix nitrogen gas from air into biologically useful nitrogen

Pietro Iannetta, Project Coordinator, JHI

There are two main legume types

GRAINS

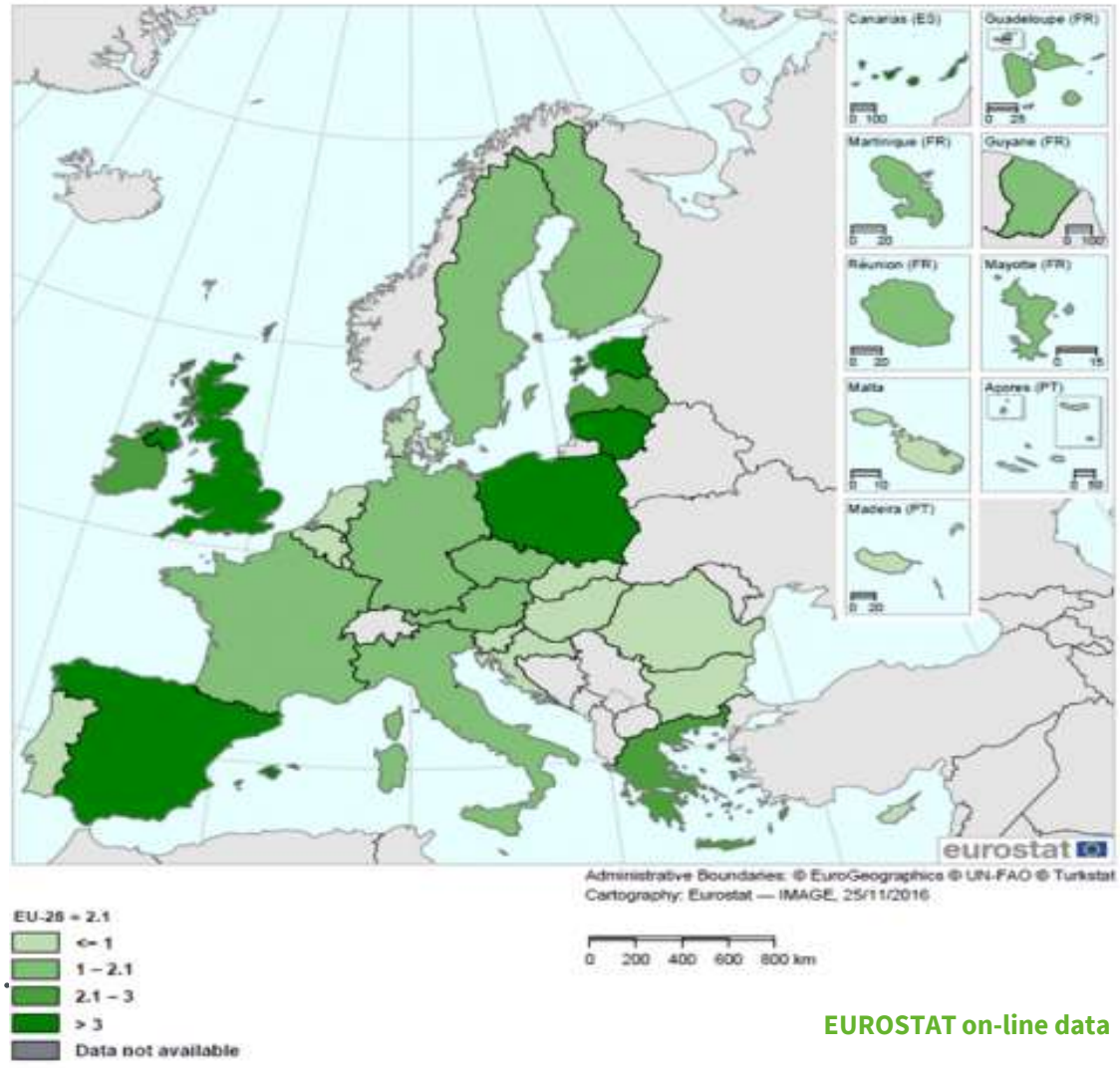
- for feed and food

FORAGES

- feed, green=manures, soil-cover

Examining the scale of legume cultivation across EU countries

% share of land area cultivated for dry pulses

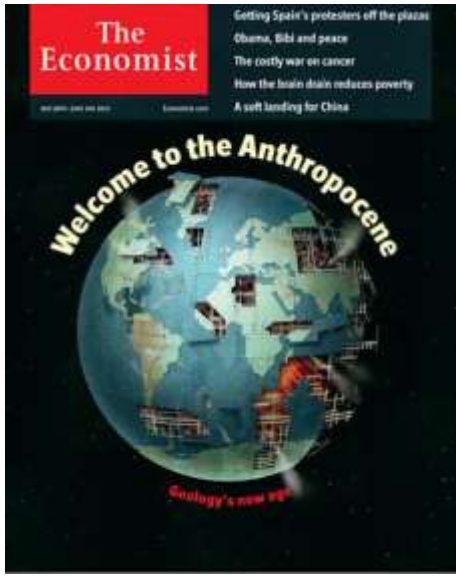


So, why is the % of legume cultivation so low in Europe?

EUROSTAT on-line data

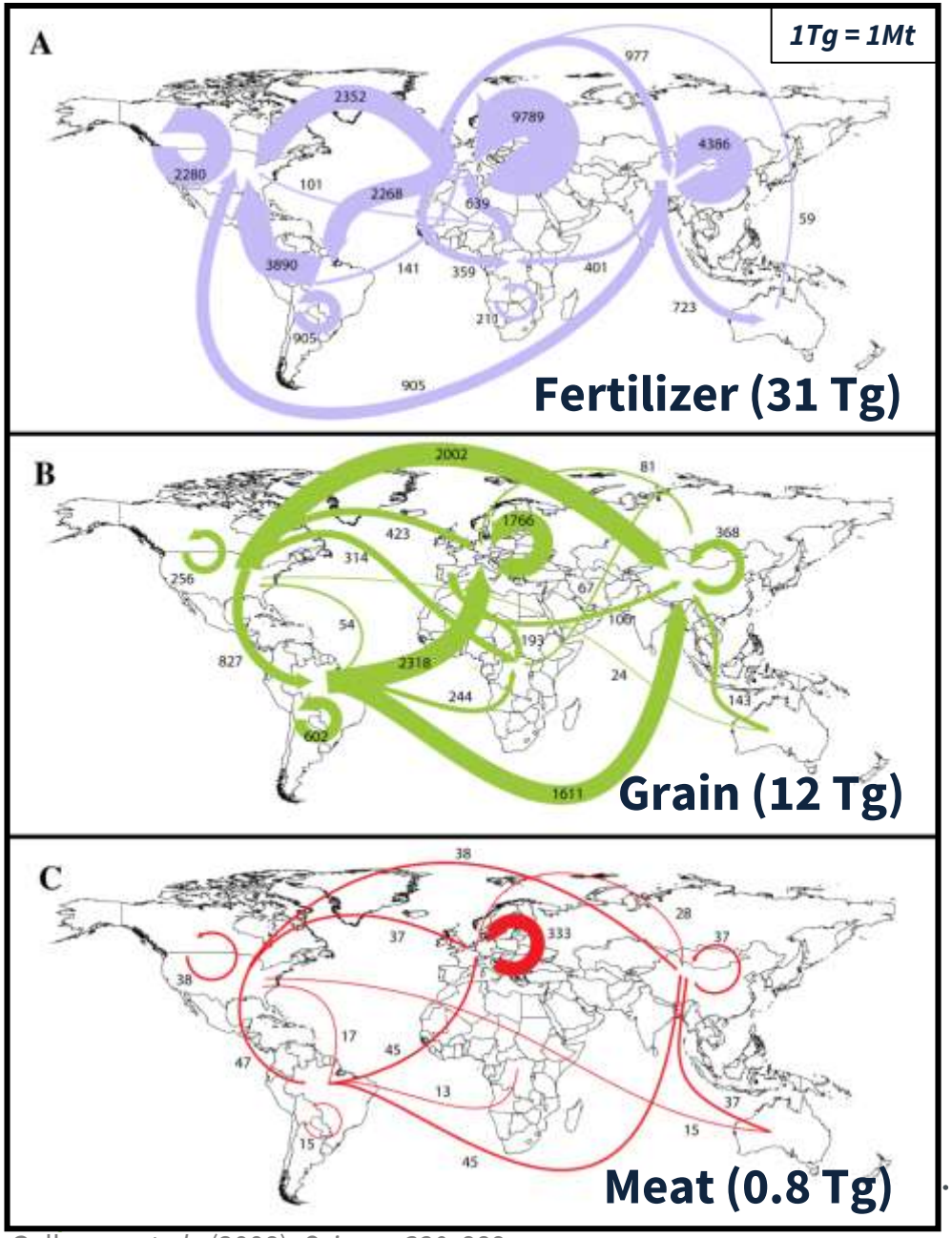
The ANTHROPCENE

- **An new epoch proposed by Prof. Paul Jozef Crutzen**
  - Atmospheric chemist, Nobel Prize Winner
- Based on negative impact of humans on the Earth's geology, including
  - biodiversity loss and species extinction
  - biogeography (species distributions/evolution)
  - climate change
  - geomorphology (drainage patterns)
  - stratigraphy (sedimentological record)
    - fossil record (techno-fossils)
    - trace elements
- Suggested periods for initiation include
  - **the industrial revolution / Haber-Bosch 1909**
  - **neolithic times and rise of agriculture**



Waters *et al.,* (2016) *Science* **351**.

International trade in reactive nitrogen



Galloway *et al.*, (2008). *Science 320*, 889.

The nitrogen crisis is food system crisis

Un-healthy EU28 dependencies

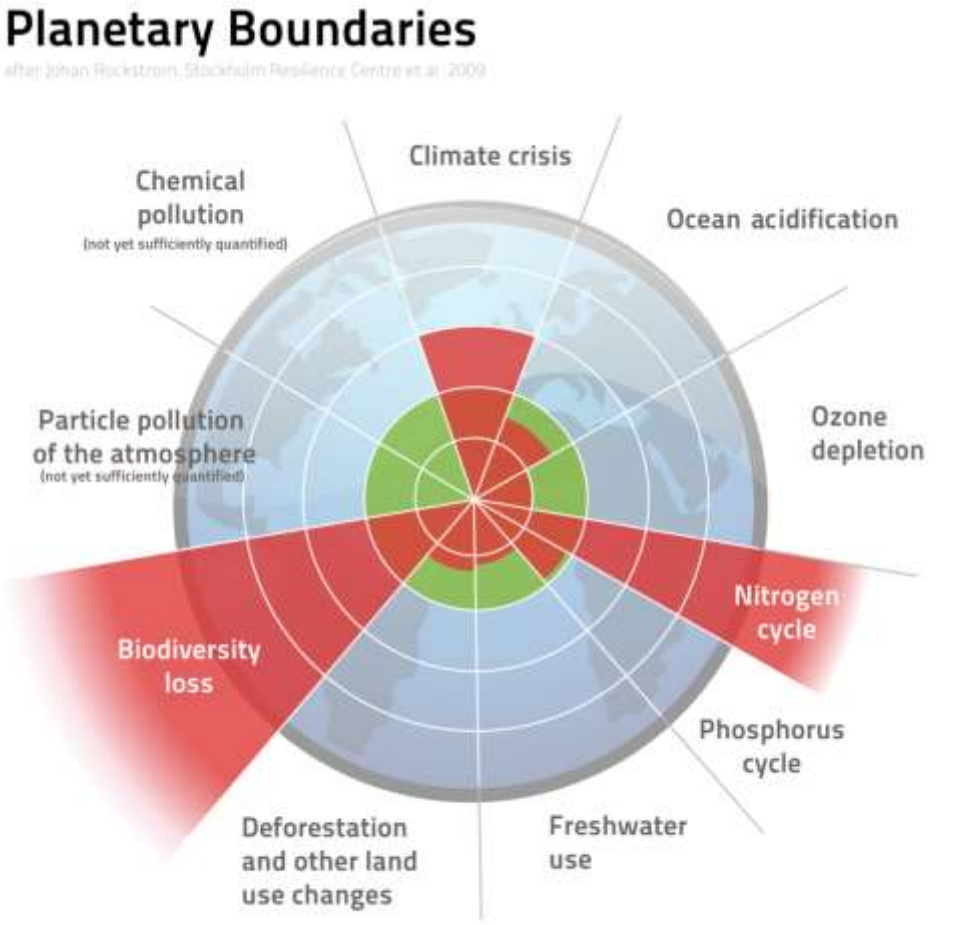
- High N fertiliser use = 10m t y^{-1}
- 23% of N fertiliser is imported
- **70% of protein is imported (42Mt, '09)**

Yet there is a solution:

- **LEGUME supported cropped systems**

Erisman *et al.,* (2008). *Nature Geosci.* **1**, 636.
Seufert et al., (2012) *Nature* **485**, 229.

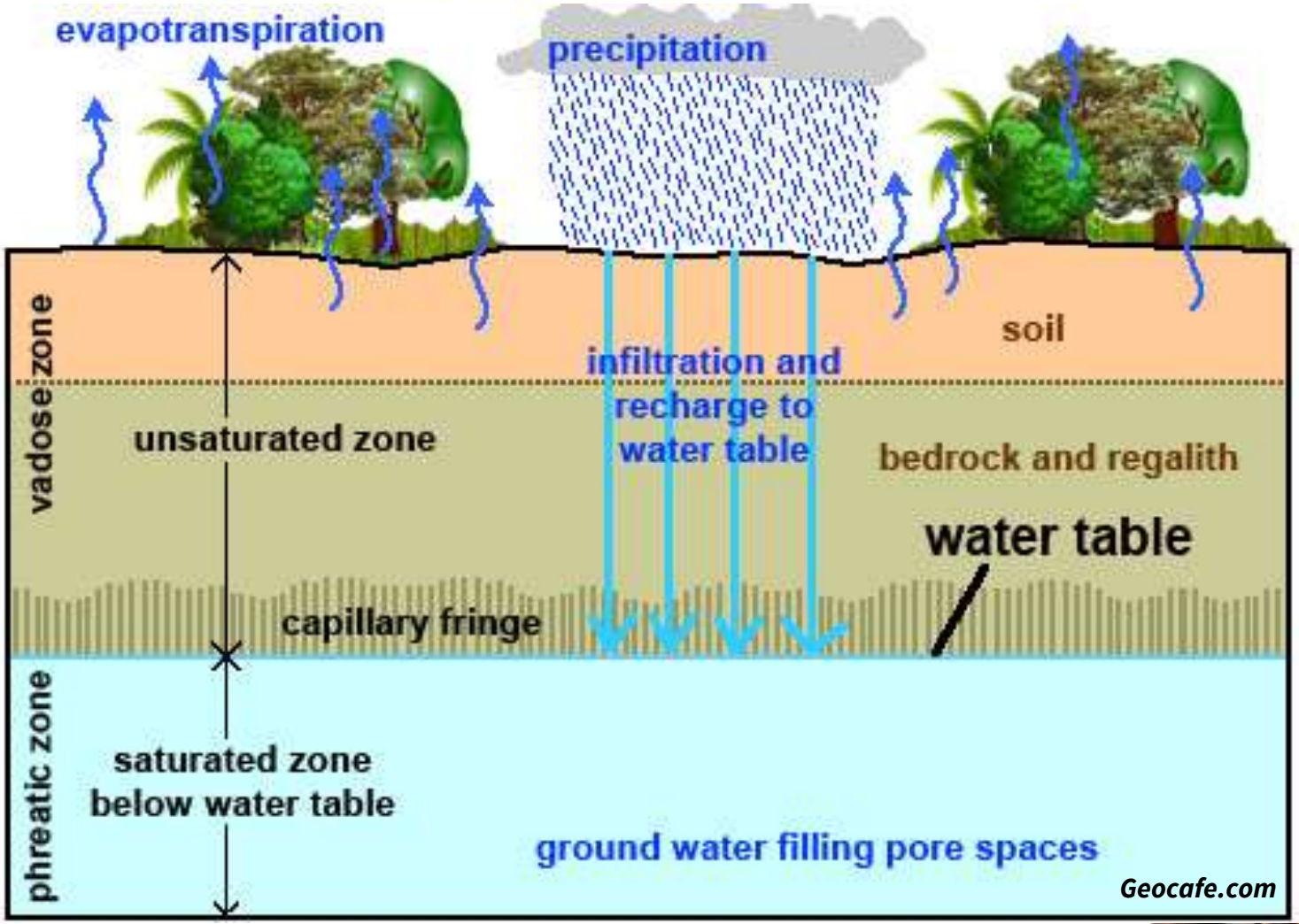
The impacts of discouraging natural chemical cycling



"Planetary Boundaries" are exceeded

Rockström et al., (2009). A safe operating space for humanity. *Nature* **461**, 472.

The nitrate “time-bomb”



TRUE tests the role of legumes to address economic-, environment- *and human*-health issues

- Major global health issues prevalent:
  - 1980 – 2017 obesity doubled (30% of global population)
    - heart disease / diabetes
  - 30% of global population suffer nutrient deficiencies (≠ same 30% obese)
- Global agriculture ~25 % of GHGs: nitrogen pollution
- **5th Assessment Report IPCC highlighted potential of consumption shifts to combat GHG (https://ipcc.ch/report/ar5/)**

Food system indicators:

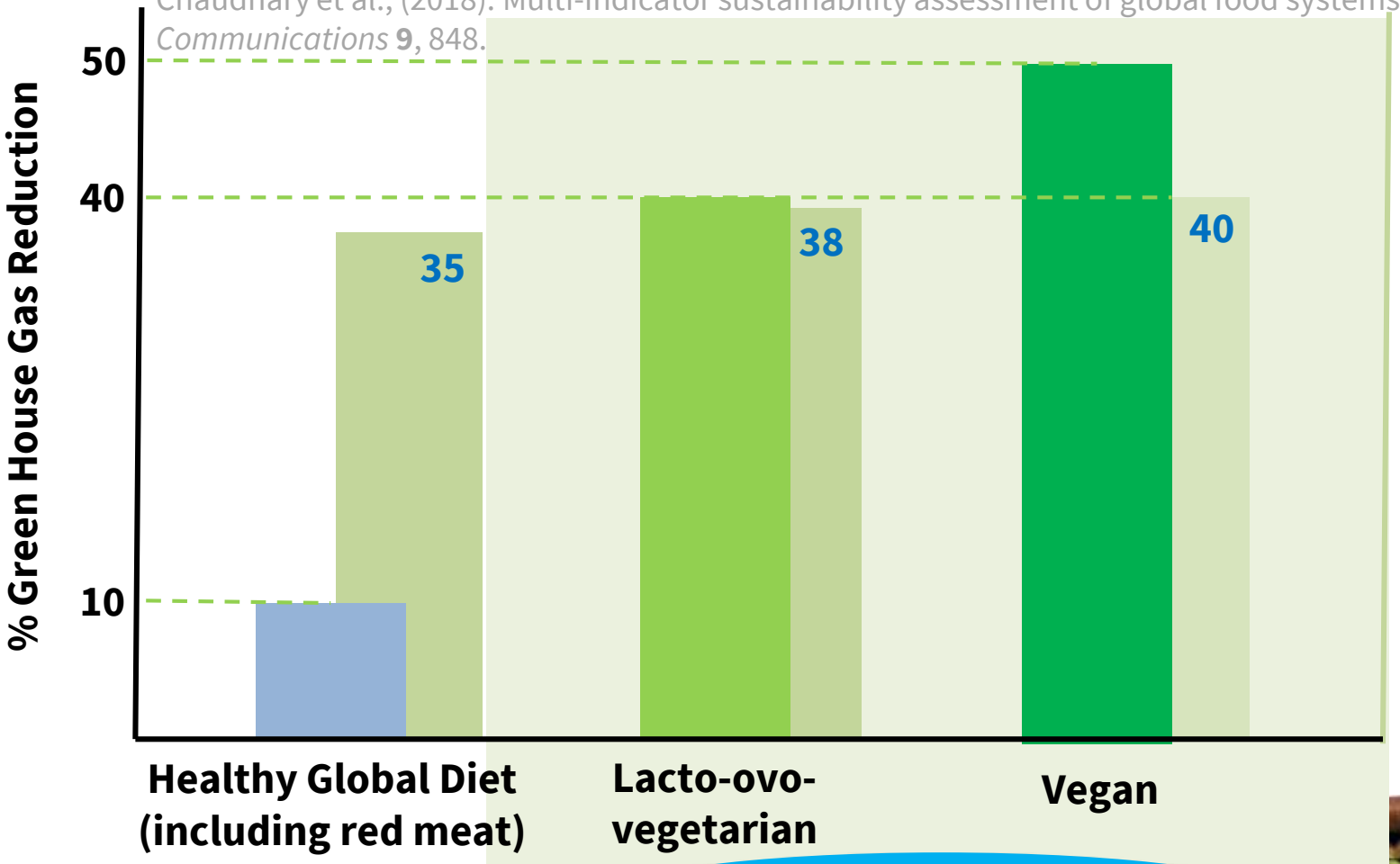
for countries with high relative GDP

Chaudhary et al., (2018). Multi-indicator sustainability assessment of global food systems. *Nature Communications* **9**, 848.

Impact of dietary change:

as facilitated by crop & diet diversification

Chaudhary et al., (2018). Multi-indicator sustainability assessment of global food systems. *Nature Communications* **9**, 848.

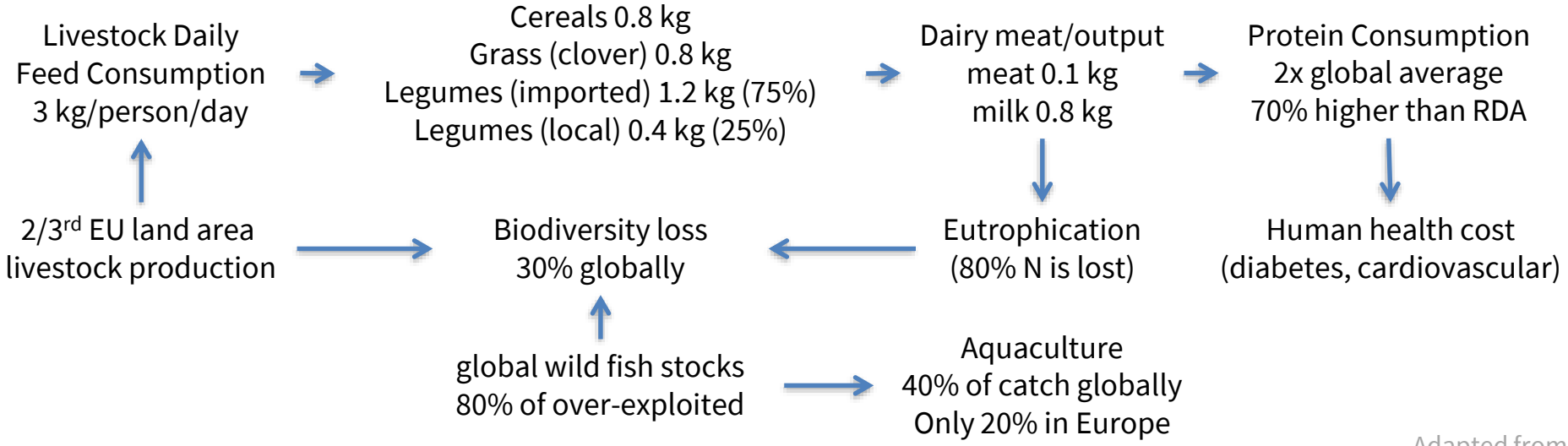


Nutrient shortages - Fish (farmed) to alleviate → Low B12 | Low B12, Se

Nutrient benefits: folate, Mg, Vit C - due to high fruit & veg

Legume Puzzle in the EU:

legumes are demanded but not grown



Adapted from:
Westhoek et al., (2011). The protein puzzle. Netherlands Environmental Assessment Agency.,

The Legume Solution

Simple major shift are required:

1) more legumes, less meat (*i.e.* ***a Mediterranean diet***)
2) more aquaculture production of protein for human consumption

TRansition paths to sUstainable legume-based systems in Europe

24 partners - equally balanced academic and non-academic

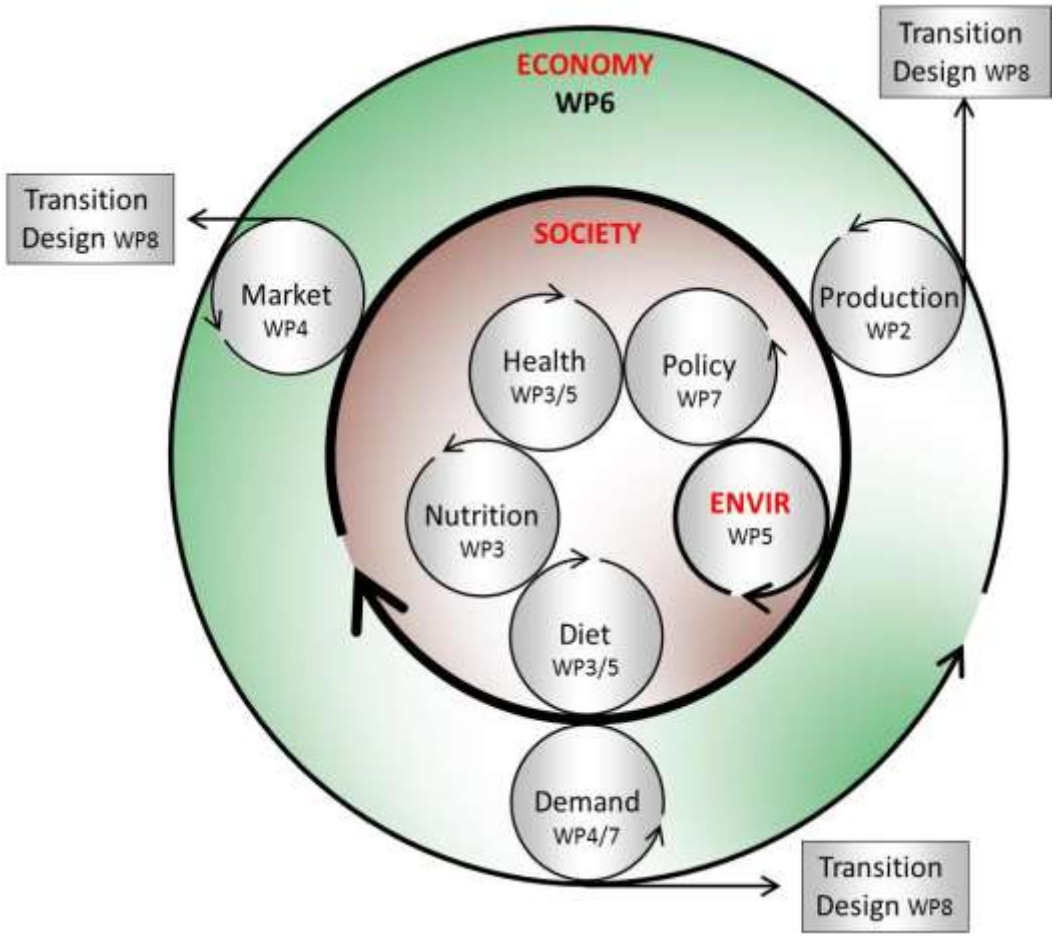
The TRUE approach is based on the 'Pillars of Sustainability'

A concept first developed by René Passet.

Passet, R. (1979). *L'économique et le vivant* [The economic and the living) **23**, Payot.

The 'TRUE Pillar' of Sustainability':

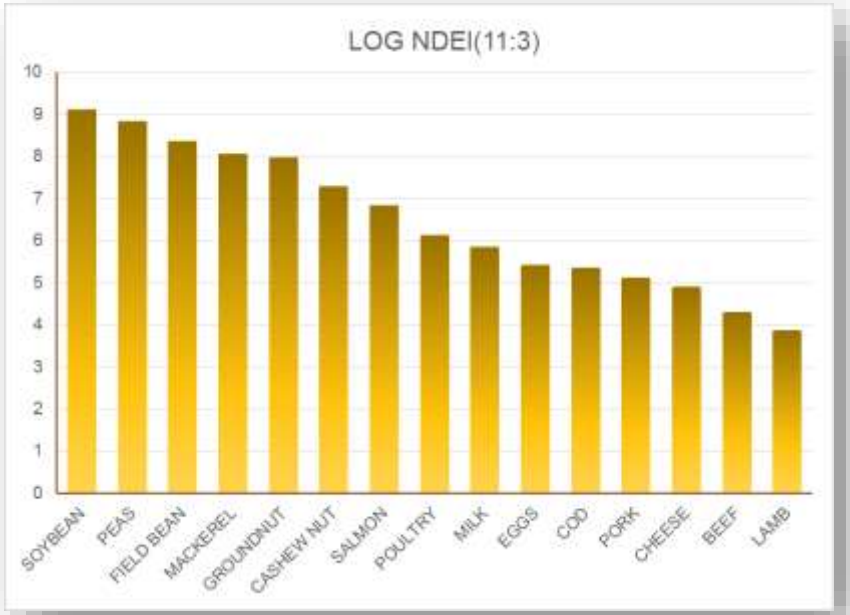
and work package (WP) structure



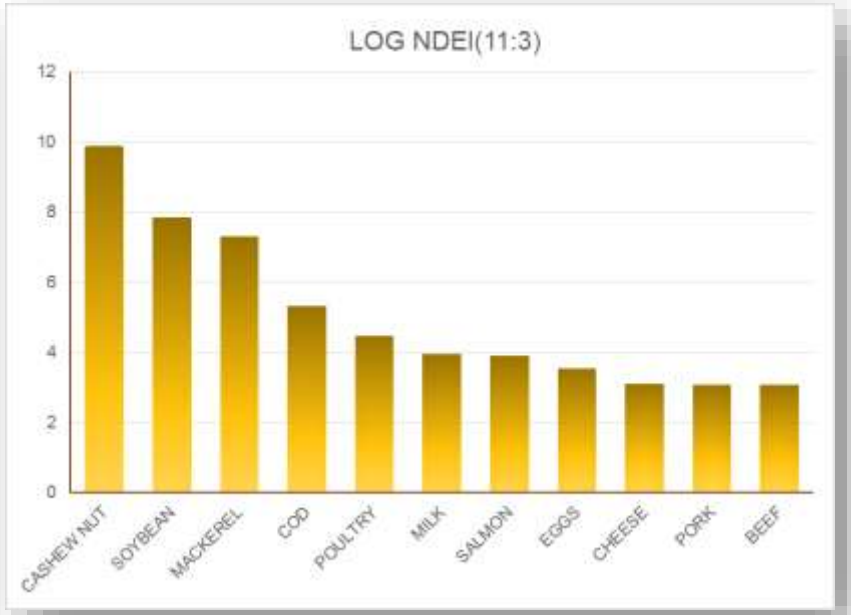
- **Assess the roles of "consumer citizen" and "sustainable consumption"**
- **Policy to reinforce the internal supports of the Society pillar**
- **Economy must also reinforce Society pillar, and struts therein**

Extensive food quality analysis of existing and new legume-based products

Mike Williams & Sadhbh Sheeran



Nutrient Density:
Environmental Impact Ratio (GHG)

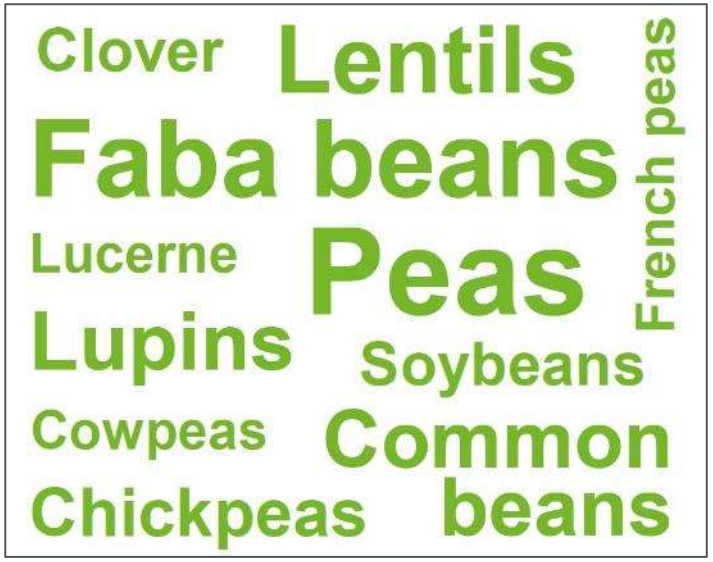


Nutrient Density:
Environmental Impact Ratio
(Eutrophication)

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

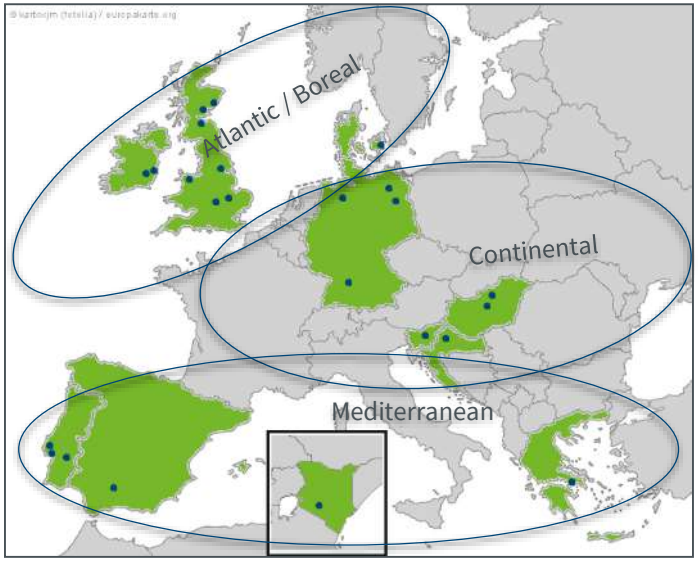
Pietro Iannetta, Project Coordinator, JHI

Case Studies &
Legume Innovation Networks



Legume text size ~ number of Case Studies

24 Case Studies



3 Legume Innovation Networks

One for each major EU pedoclimate

The main impacts of TRUE

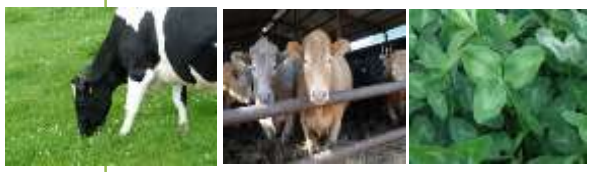
Main Impacts
1. Enable sustainable legume-based cropping systems and agri-food and feed chains
2. Increase the commercial competitiveness of legume crops
3. Reduce the environmental impact of food- & feed-production and processing
4. Integrated support for EU policies: CAP, Water Framework, IPCC, *etc*
5. Strengthen co-innovation: help build multi-stakeholders (transdisciplinary) community

Case Study 1: Carbon Footprint reduction of dairy systems

Teagasc, Ireland

Objective: Implementing best practices to

- **Reduce the Carbon Footprint of milk production**
- **Maintain output & profitability**

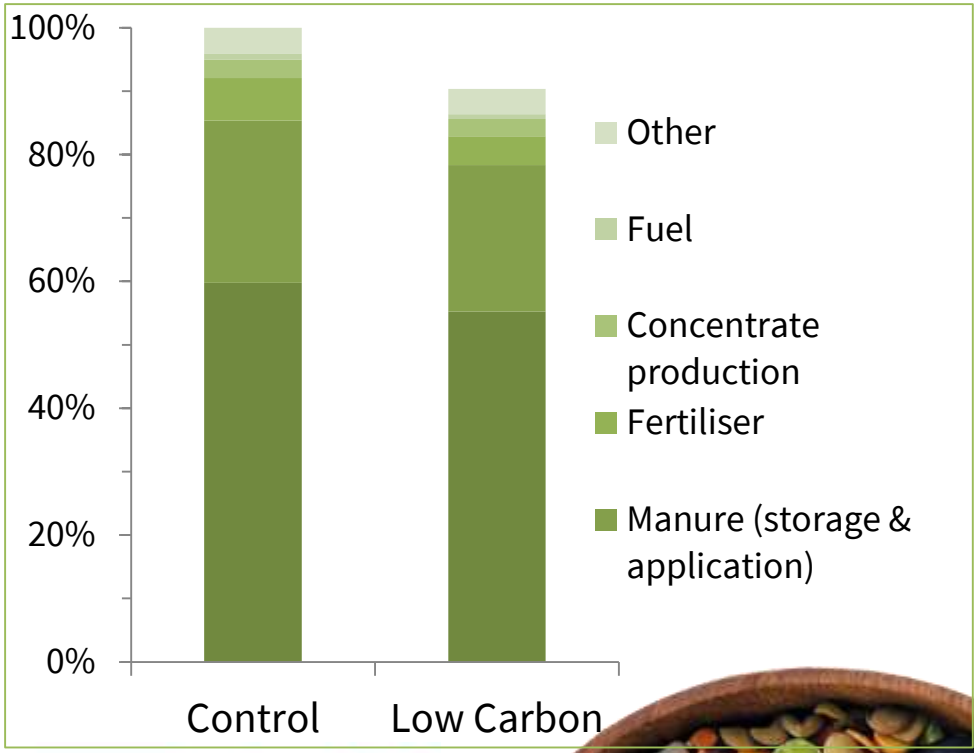


Low Carbon 24 cows	Control 24 cows
White clover N-fixation	-
Fertiliser: 150 kg/ha	Fertiliser: 280 kg/ha
NBPT-urea	CAN
High breeding index	Average breeding index

Low Carbon system:

- **Carbon Footprint reduction of 10% compared to control group**

Fig 1: Contribution to CF per impact category



Agriculture and Food Development Authority

Case Study 2: Clover-sward reliant organic

Teagasc, Ireland

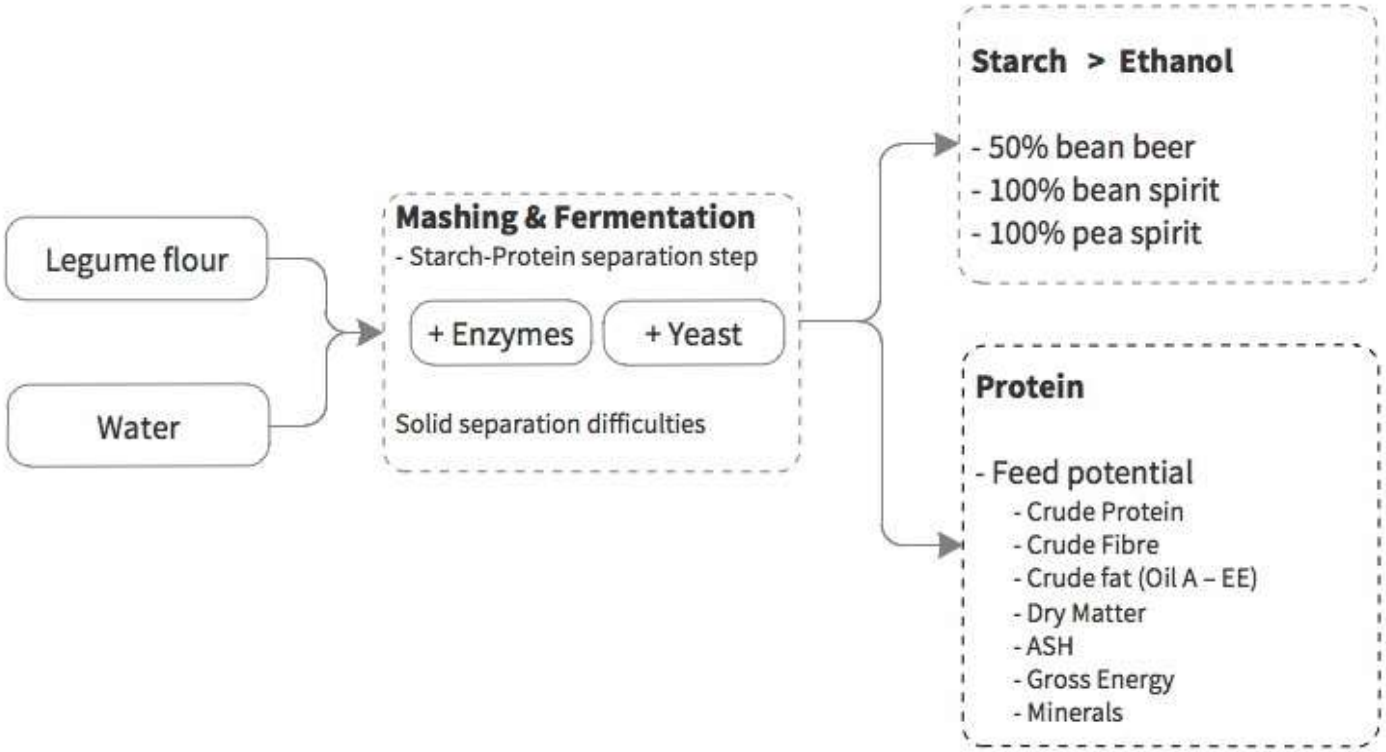
The challenge: There is lack of knowledge regarding best on-farm management practices and economic benefits of legumes on pasture based cattle and dairy farms.

The Teagasc Clover Group = regional demonstration farms and local discussion groups

Agriculture and Food Development Authority
Pietro Iannetta, Project Coordinator, JHI

Case Study 3: Pulse Premiumisation

Arbikie Distilling Ltd./Barney's Beer, UK



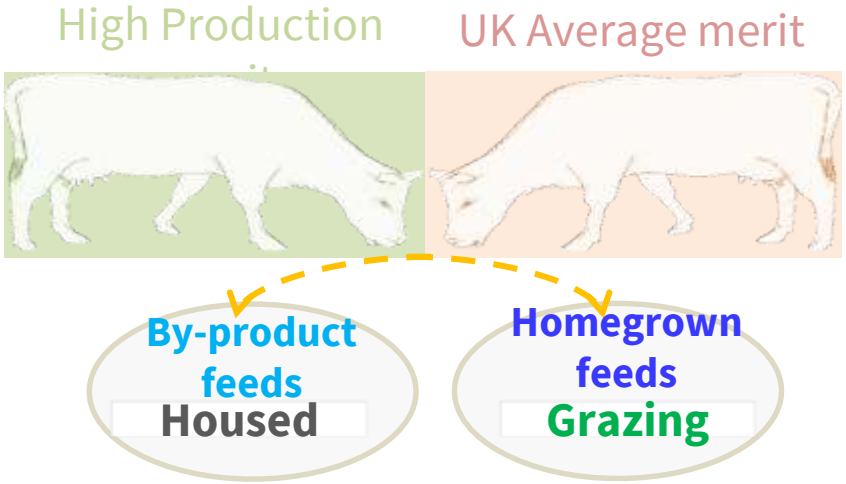
Now making bean beer & spirit alcohol

- with coproducts or waste material processed for uses uses for food and feed for animal and fish

ARBIKIE
HIGHLAND ESTATE

Case Study 4: Legumes and leguminous by-products within dairy farming systems

Scotland's Rural College, UK

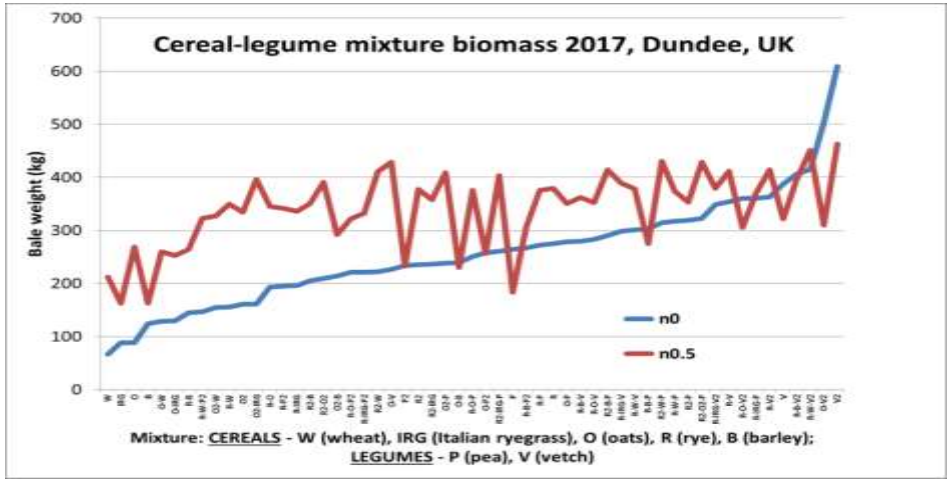


Parameters	Units	
On and off farm land use	ha	ha /LSU
Harvest	tonnes/ha	DM %
Milk yield	litres/cow	litres/ha
Protein & Butterfat	%	
Dry matter intake	kg / cow	
Live-weight	kg / cow	
Sprays & Fertilisers	kg / ha	litres/ha
Purchased feed & bedding	tonnes FW	Dry matter %
Nitrogen surplus	kg/litre	kg/litre ECM
Carbon footprint	kg CO2 e / kg output	

- By-product system feed components are imported onto the farm
- Home-grown system feeds are provided by crops grown on the farm
- Leguminous products represent 10% of the by-product ration and include soya bean meal.
- Legumes grown include spring beans, red clover and lucerne (alfalfa), accounting for up to 15% of the ration.

Case Study 5: Intercropping for high productivity low input systems

James Hutton Institute, UK



- Experimental system of winter-sown cereals with legumes for biomass for use in low-input arable systems in a northern UK context
- Comparisons with spring-sown cereal-legume cropping for biomass and for seed production in trial and on-farm
- Rye, oat, pea and vetch combinations promising for biomass quantity and quality
- Variety choice and proportions can be problematic and need optimising
- Fertiliser rates other agronomic compromises need careful consideration

Case Study 6: Precision Agriculture Technologies: living mulches for cereal production

STC/Manterra, UK

Development of Precision Agriculture Technology (PAT) led agronomy for strip-sown barley- & wheat-forage legume combination, with the forage legume managed as a living-manure

Year 1 activities

- Case Study activity and approach defined:
  - Small-scale PAT solutions, as these are also applicable to large-scale systems.
  - Across a range of crop platforms (e.g. maize, wheat, oilseed rape and sugar beet).
- Have secured PAT system and machinery expertise to collaborate on project.

Planned Year 2 activities:

- Begin to establish field platform (maize and spring barley).
- Commence data collection.
- Formulate novel machinery development plan with PAT collaborator; begin design with consideration of field requirements and engineering limitations

Case Study 7: Heritage Varieties for enhanced human and beneficial insect nutrition

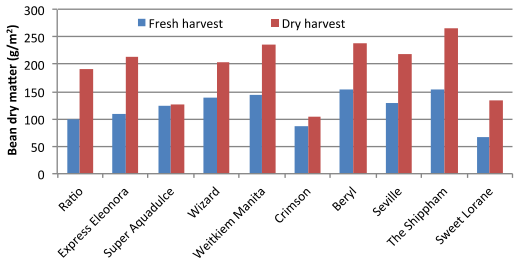
Coventry University, UK

Barbara Smith and Francis Rayns, Coventry University

It has been suggested that heritage varieties of legumes may provide enhanced benefits for human and insect nutrition but there has been no research to confirm this. We are investigating:

1) Five heritage varieties and five modern varieties of both *Vicia faba* (broad bean and field bean types) and *Phaseolus vulgaris* (climbing French bean type) will be grown.
2) The nutritional content of the crops (protein and carbohydrate content, vitamins and minerals in the beans) will be analysed.
3) Pollinating insect visitation will be quantified and related to the production of floral volatile chemicals that may be responsible for attracting them. The quality of floral resources that are provided in return (e.g. amino acid profiles of pollen and the sugar content of nectar) will be analysed.

Heritage variety: Crimson flowered *Vicia faba*



Preliminary results from 2017 pilot study using *Vicia faba*

THE PRACTICAL WORK FOR THIS CASE STUDY WILL BE DONE IN YEARS 2 AND 3 OF THE PROJECT. In 2017 a pilot project was run to test the methodology.

Case study 8: Using legumes as a source of fertility in organic protected cropping systems

Coventry University, UK

Francis Rayns, Coventry University

The use of fertility building crops in polytunnels can be problematic and feeding plants with animal by-products (blood, bone etc. is controversial). We are investigating:

1) A range of fast growing leguminous green manures grown in situ in polytunnels
2) Green manures grown outside are the material used in a polytunnel as a mulch or a liquid feed after anaerobic digestion.
3) Legume seed meal incorporated in growing media or added to the soil.

THE PRACTICAL ASPECTS OF THIS CASE STUDY WILL BE DONE IN YEARS 2 AND 3 OF THE PROJECT. We are working closely with commercial producers to identify and overcome existing technological and practical barriers.

Development of sustainable legume-based models for

- Retailer-producer quality chains (Case Study 9)
- organic pig production (Case Study 10)
- pocurement by public and private food services (Case Study 10)
- business models for pea supply chains (Case Study 11)

IFAU, Denmark

Case study 13: Why is lentil (*Lens culinaris*) cultivation a success story in south-west Germany?

University of Hohenheim, Germany

- Status quo analysis of lentil cultivation as a reintroduced traditional food crop in the region
  - Questionnaires about crop management of lentils (site conditions, crop rotation, tillage, varieties, companion crops, yield, marketing etc.)
  - Semi-structured interviews with farmers about their motivation and obstacles regarding lentil cultivation
- Sample size: 21 organic and 4 conventional farmers
  - Progress status:
    - Data collection: ✓
    - Data entry: *work in progress*
    - Data analysis: *work in progress*

Case study 14: Why is soybean (*Glycine max*) cultivation a success story in south-west Germany?

University of Hohenheim, Germany

- Status quo analysis of soybean cultivation as newly introduced crop in the region
  - Questionnaires about crop management of soybean (site conditions, crop rotation, tillage, varieties, inoculation, yield, marketing etc.)
  - Semi-structured interviews with farmers about their motivation and obstacles regarding soybean cultivation
- Sample size: 8 organic and 9 conventional farmers
- Soybean for feed (on-farm or for sale) and food


Photo: Jonas Weber


Photo: Sascha Dauphin


Photo: Sabine Zikeli


Photo: Sabine Zikeli

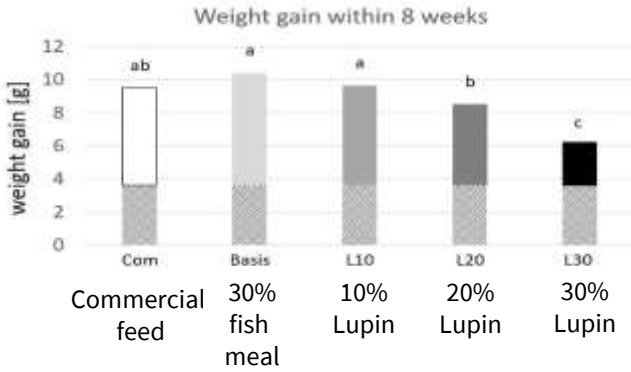
- Progress status:
  - Data collection: ✓
  - Data entry: *work in progress*
  - Data analysis: *work in progress*

Case study 15: Novel feed formulation for Aquaculture

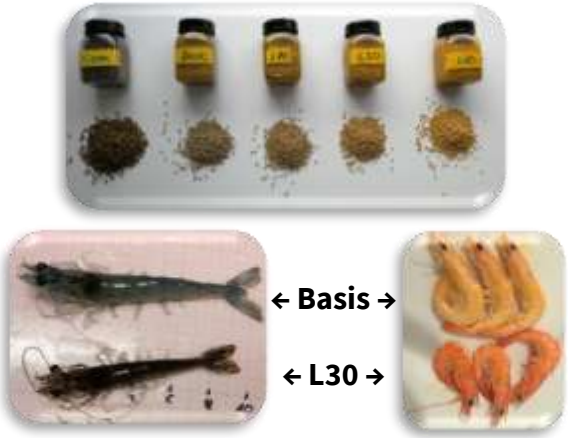
Alfred-Wegener-Institut, Germany

We are testing legume products from Lupin and Fava bean to replace the expensive and unsustainable protein source fish meal in aquafeeds for different important aquaculture species .

- Tasks:
  - Feed formulation to meet all requirements of the species
  - Feeding experiments to test growth performance
  - Analysis to exclude negative impact of legumes on animal health
- Results from first feeding experiments
  - Feeding experiments with Shrimps successful
  - 20% of fishmeal can be replaced by lupin kernel meal
  - Hints to elevated immune capacity at 10% replacement

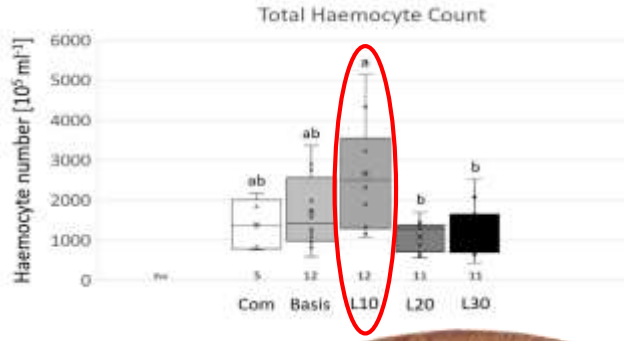


Hannoversche Allgemeine 17.10.17



L. vannamei from experiments alive

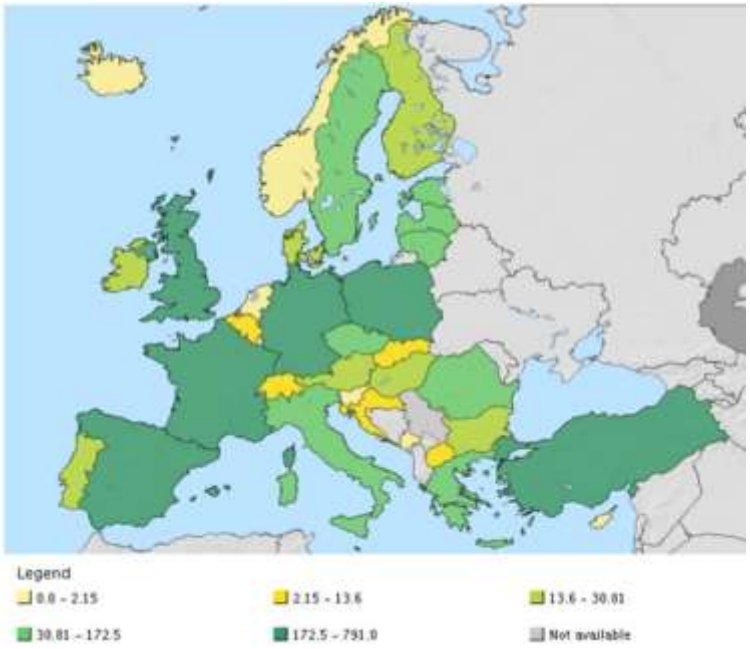
cooked



Case Study 16: Policy for sustainable development

Regionalna Razvojna Agencija Medimurje, Croatia

- **Croatian Case study and Legume Innovation Network**
- **Regional Development Agency Međimurje REDEA Ltd**. will focus the **Case Study** on the research of current state of legume production in agri food sector and also on defining which are the most important factors that affect the development of legume production process in Croatia.
- The general aim is to encourage and stimulate farmers to increase cultivation and production of these important crops and for consumers to raise awareness of their importance in a healthy diet.
- This aim will be also achieved through development of policy recommendation framework for sustainable development and also creating the prerequisites for setting up the first **Croatian Legume Innovation Network**.



Case study:

Identification of legume producers and processors

Types of legumes produced

Legume products and quantities

Monitoring the increase of legume producers and processors

Monitoring trends regarding types and quantities of legumes produced and processed

Added value in legume production and diversification of legume based products

Case study:

Number of initiatives connected to enhancing legume production and consumption

Number of educated farmers, retailers and consumers about benefits of legume production

Raised a public awareness about the nutritional content of all kinds of legumes

Increased a daily consumption of legumes

Regional Development Agency Međimurje REDEA Ltd.
Valentina Hažić, Head of Rural Development Department
Jurka Topol, Expert Associate in Rural Development Department

Case Study 17 - Pulses in Short Food Supply Chains

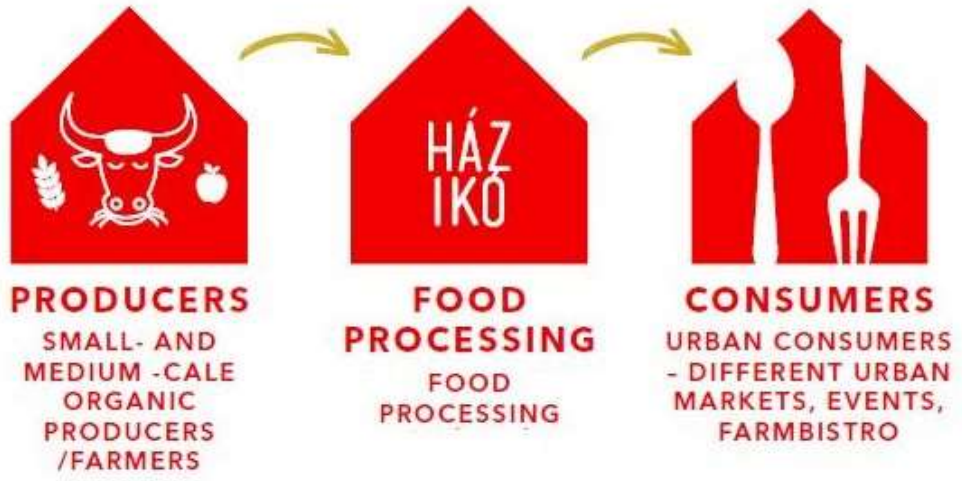
Overall goal : Test Hungarian traditional/local legume varieties from small-scale production to quality gastronomy along a short food supply chain.

I. Selection of genetic resources

II. Cultivation experiments

III. Processing and product development

IV. Consumers' feedback



agRi KulTi

Urban Gastronomy: high-end legume based meals

I. Analysis of nutritional content

II. Evaluation of gastronomic potential

III. Processing, recipe and product development




Case Study 18: Ancient & heritage variety screening for higher nutritive value

Sociedade Agrícola do Freixo do Meio, Portugal

Ancient & heritage variety screening for higher nutritive value	• **Main Products: Greenpods, grain, grain products** • **Legume Crop: Common bean, Lupin, Lentil, Chickpea**
Aim	• Analyse the new strategies that recreate the multifunctional montado traditional system, and adapt it to new economic, social and environmental challenges
Adding Value	• **Showcasing a successful and personalized short supply chain** • **Understand the new forces and dynamics that intercross and may result in facilitation, or blockage, in the development of farm multifunctionality, with the inclusion of legume grains.** • **Provide legume grains for novel food and feed development**

Case Study 19: Consumers - legume dishes

Eurest -Sociedade Europeia De Restaurantes Lda., Portugal

- **Main Products: Menu design & recipe books**
- **Legume Crop: Common bean, Faba bean, Soybean, Lentil**

Aim

- Educating Europe´s consumers on the benefits of legume grains
- Responsible for the foods services in 1155 units, serving over 113,000 meals per day.
- In a pilot project called “Choose Beans”, catering two of these units, Eurest was able to **increase legume consumption** frequency by 25% and **increased knowledge on the nutritional benefits of legume grains** by 28%. The preference for each of the legume grains showed that common bean was the preferred legume grain (39%), followed by chickpea (32%), green peas (10%), and fava beans (10%).
- 2016, Eurest established that in each meal plan, there was a daily inclusion of at least one legume grain. Ten marketing actions were undertaken (1890 consumers).

Adding Value

- **Expanding these two initiatives to other units across Europe**
- **Test novel legume food products developed in TRUE in their catering units**

Case Study 20: Processors - snack and convenience foods

Universidade Catolica Portuguesa/Palmeiro Foods, Portugal

Processors - snack and convenience foods	• **Main Products: Inc. purees & symbiotic yogurts** • **Legume Crop: Common bean, Lentil, Chickpea, Pea** • Palmeiro Foods: dehydrated and lyophilized products, targeted to clinical nutrition • Bfood: Product line of PalmeiroFoods aimed at adult and senior individuals for different meals of the day (breakfast, lunch, dinner and snacks)
Aim	• Combined their knowledge with that of specialists in nutrition through partnerships; to draw a wide variety of products that are nutritionally rich and balanced, adapted to special dietary needs such as: mastication and ingestion problems, or dysphagia, hydration needs, neurological disorders, and others.
Adding Value	• **Expand their portfolio by inclusion of novel legume sources** • **Currently, they have special lines of products named "special diet anti-diarrheal" and "special diet rich in fibre“. Could consider inclusion of legume grains in these.** • **Experience in the preparation of flours could contribute for the development of other products, like breads, cakes or even the incorporation in yogurts and other food matrices.**

Case Study 21: The potential of plant growth promoting bacteria for production of beans

Agricultural University of Athens, Greece

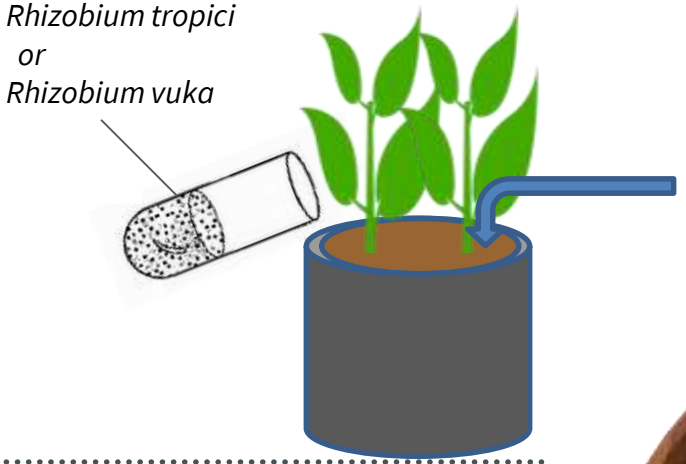
In soilless culture, how much nitrogen supply and which bacteria?

Inoculation of legumes with rhizobia can considerably reduce the input of inorganic nitrogen to the nutrient solutions. The practical application of this approach encounters some difficulties:

- The supply of plant available nitrogen is important at the early growth stage when the rhizobia are still not functional in terms of N2-fixation.
- Inorganic nitrogen and especially nitrate N inhibits rhizobia colonization.

To cope with these two contrasting issues, a fine tuning of the N supply is needed, when legumes grown in soilless culture are inoculated with relevant rhizobial strains.

Phaseolus vulgaris L.
Greek landrace: Zargana Chryssoupolis
Hydroponically cultivated



Case Study 22: Impact of legume-based green manures on soil fertility

Agricultural University of Athens, Greece

Aims:

- to identify wider environmental effects such as carbon sequestration and greenhouse gas emissions when legumes are used in rotation schemes.
- to improve Nitrogen (N) supply via alternative renewable organic sources in non-legume crops grown organically

Treatments:

- Broccoli organic
- Broccoli conventional
- Faba bean organic inoculated with Rhizobium leguminosarum bv. viciae
- Faba bean organic non inoculated
- Non-cultivated plot (control)

Measurements:

Plant biomass characteristics
N levels (total-N, NO3-N, NH4-N) } in plant tissues and soil
Mineral nutrients
Biological Nitrogen Fixation

Case Study 23: Breeding grains legumes yield and disease resistance

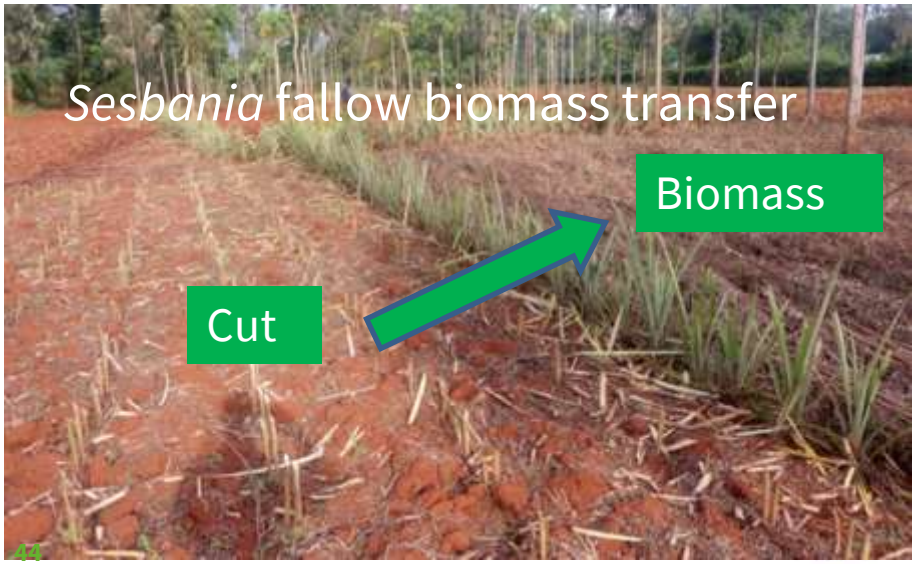
Solintagro SL, Spain

Experimental design and Crop management

- **69 legume accessions** (5 chickpea, 8 grass peas, 16 lentil s, 6 white lupins, 21 peas and and 13 faba bean accessions) established on 6-m2 plots in a completely randomized design, with three blocks each. **Three different locations** in a context of **zero or minimum external inputs**.
- Growing season: **November 2017-June 2018**
- **Climatic data**
- **Phenological, growth and nutritional characteristics** (Days to plant emergence, days to 50% flowering, days to 50% well formed pods, days to 50% mature pods, days to full ripening, plant height (cm), plant lodging, protein content (%))
- **Plant production** (Pod number(N° plant-1), fresh pod yield (t ha-1), fresh seeds number (N° pod-1), fresh seeds yield (t ha-1), dry seeds number (N° pod-1), dry seeds yield (t ha-1), mean weight for fresh pods (gr per seed), mean seed weight for fresh seeds number (gr per seed), mean seed weight for dry seeds number(gr per seed)
- **Fungal pathogens**: DS (% of full plant covered by the disease), AUDPC (Area Under the Disease Progress Curve) and IT (Infection type, when applicable)
- **Broomrape**: day of appearance, AUDPC and final broomrape N° plant-1
- **Synergy with WP3: Quality Analysis**

Solintagro SL

Case Study 24: Agroforestry in Kenya: developing the up-stream value chains characterisation



Kenya Forestry Research Institute, Kenya

- The study is located in Lake Victoria basin region, western Kenya, sub-Saharan Africa.
- Farm sizes average 0.3 to 3 hectares.
- A variety of legume-based cropping systems have been identified, namely maize-bean, maize-cowpea, maize-bean-cowpea, and fallow or relay intercropping with N_2-fixing trees & shrubs.
- Maize-bean intercropping predominate in the region.

Kenya Forestry Research Institute, Nairobi

Todays sessions in this workshop

WRITE-ON & STICK-IT POSTERS

We are interested in your ideas – FOUR opportunities

9:00	General Introductions
	1) TRUE QUESTIONNAIRE your conference bag (also on-line)
	2) Text ideas to TRUE PHONE - +447 598 153 753
10:30	Break
	3) WRITE-ON the "WHAT IS YOUR MARKET?" poster
11:00	**LEGUME MARKETS**
13:00	Lunch
	4) STICK-ITS on the "MARKETS & POLICY" poster
	- view detail of the Case Studies (posters)
14:00	**POLICY FOR LEGUMES**
15:30	Break
	4 again) – STICK-ITS on the "MARKETS & POLICY" poster
16:00	Round-up & General Discussion

During the first break - WHAT IS YOUR MARKET?

	Scale of operation			Farm operation type			Purpose		
	Local or regional	**National**	**International**	**Conventional**	**Organic**	**Integrated** (Conservation ag. *etc.*)	**Food**	**Feed**	**Other** (trade, tech. Research etc)
Peas									
Beans									
Soybeans									
Chickpeas									
Lentils									
Other grain legume									
Clover									
Alfalfa/ lucerne									
Other forages									

MARKETS & POLICY SESSIONS

- during lunch & afternoon break

	Supply Chain Sector	Barriers	Opportunities
Market session	Seed-supply & Legume Breeding		
	Agriculture Machinery		
	Production		
	Pre-processing		
	Food Technology		
	Marketing		
	Retailing		
	Consumers		
Policy session	Policy		

Questions on legume markets in the Mediterranean region

1) What are the most important legumes in Greece, for which market?
2) Why to consumers (in Greece) buyt legumes?
3) What are you most common products made with legumes?
4) What stops legumes being commercial successful?
5) What markets present the most commercial potential?
6) How could bugger market demand for legumes be created?
7) Is legume production profitable for farmers

Text ideas to the TRUE PHONE +447 598 153 753

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#TrueLINworkshop
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#LoveLegumes
#LegTechIsBioTech
#LegTech

Text ideas to the TRUE PHONE +447 598 153 753

Online Stakeholder Survey

Share your ideas and experiences on

- **Changes needed** for an increase of legume cultivation and consumption
- **Indicators to measure sustainability** of legume-based value chains

@ https://www.true-project.eu/lin-workshops/stakeholder-survey/

Follow @TrueLegumes

TRansition paths to sUstainable legume-based systems in Europe (TRUE) has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement number 727973

The James Hutton Institute is supported by the
Rural & Environment Science & Analytical Services (RESAS)
a division of the Scottish Government

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