TRansition paths to sUstainable legume-based systems in Europe

Leaflet: attributional LCA for legumes and legume-based products

Work Package: 5

Deliverable: 5.2 (D30)

Lead author: David Styles, Bangor University

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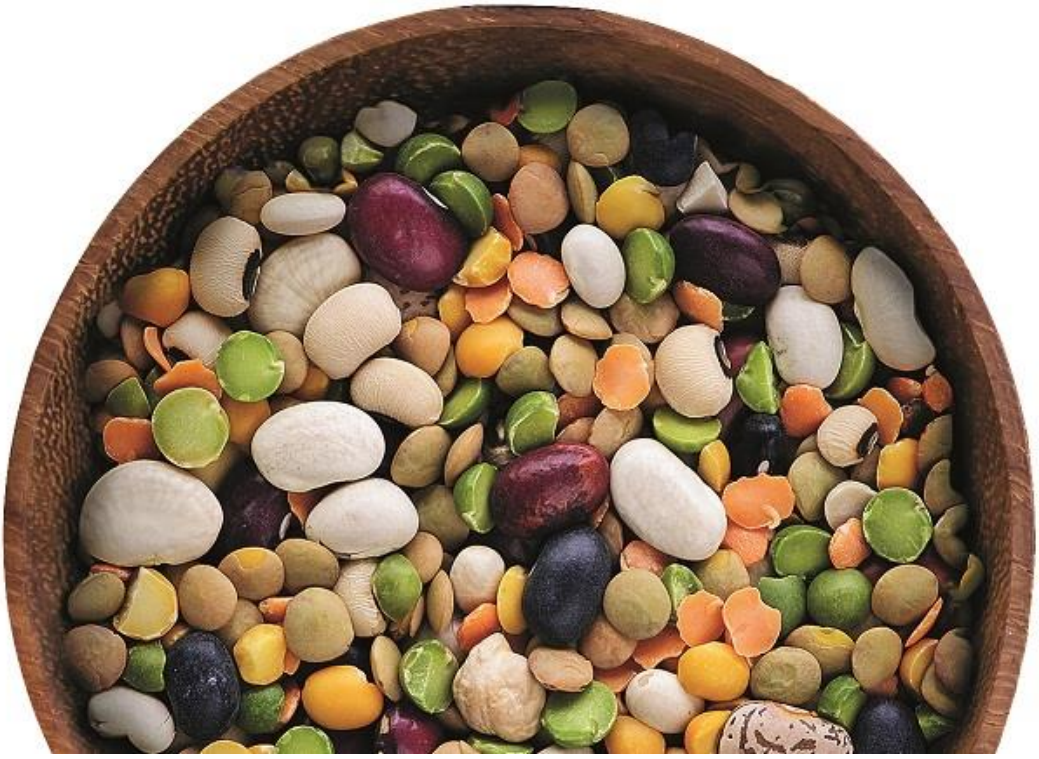

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Deliverable Description & Contributors

- **Due date**: 31st March 2020
- **Actual submission date**: 6th March 2020
- **Project start date**: April 1st 2017
- **Duration**: 48 months
- **Work Package**: WP5
- **Work Package Leader**: Michael Williams
- **Deliverable (D) Title**: D5.2, Summary Leaflet: attributional Life Cycle Assessment (LCA) to assess the sustainability of legume-based products
- **Nature of deliverable**: Information leaflet
- **Dissemination level**: Public

- **Deliverable Description:** The leaflet described in this project Deliverable highlights key methodology and footprint results for legume food and feed products. It summarises some key findings on legume environmental footprints from an attributional Life Cycle Assessment (LCA) undertaken in WP5. Carbon footprint results are presented for beans, chickpeas, soybean, lupins and peas across the three European biogeographical regions – Atlantic/Boreal, Continental and Mediterranean. Key results for pea-gin, pea protein balls and chickpea pasta are also highlighted as example case studies.

- **Contributors:**

- David Styles, Marcela Porto Costa (BU)
- Michael Williams, Sophie Saget (TCD)
- Beate Zimmermann (UHOH)
- Eleonora Barilli (SOL)
- Kirsty Black, (ADL)
- Uwe Lehrack, Nora Löhrich (IGV)
- Damian Bienkowski, Pietro Iannetta (JHI)

- **Key words:** legumes, environmental footprints, crop rotations, protein, alcohol.

Contents

Executive Summary

This deliverable report for D5.2 briefly describes the content and target audience of the information leaflet on legume sustainability. The leaflet is attached in Annex I, and presents key attributional Life Cycle Assessment (LCA) results described in detail in the associated D5.3 (open access LCA database) report. For simplicity, the leaflet focusses on carbon footprint results, expressed as kg CO_2 equivalent per unit of energy and protein in legume crops, benchmarked against conventional grain crops (wheat, barley and maize). Carbon footprints are also summarised for gin and protein balls made from peas, and pasta made from chickpeas, compared with conventional wheat-gin, beef meatballs and durum-wheat pasta, respectively. The leaflet demonstrates with model examples how the attributional LCA is approach is applied to ascertain the sustainability credentials (i.e. sustainability) of legumes crops and legume-based products and highlights the important contribution that wider cultivation of legumes could make to sustainable farm systems, and value chains.

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1. Introduction

The leaflet produced for D5.2 presents key life cycle assessment (LCA) results taken from the open access database (D5.3). Readers are referred to the comprehensive D5.3 report for more details on methodology, etc (Porto Costa et al., 2020).

2. Methodological background

2.1 Life Cycle Assessment

LCA is the quantitative evaluation of inputs, outputs and environmental impacts arising during the production, use and disposal of a product or service (ISO 14040, 2006). The leaflet produced for this deliverable presents results from LCA described in detail in an accompanying report for D5.3. A copy of the leaflet (Appendix I) includes a system diagram summarising main processes considered. All results are based on attributional LCA, most with allocation to "cut-off" system boundaries for co-products. For simplicity, the leaflet focusses on carbon footprints, expressed as kg CO_2 equivalents. Crop LCAs were based on a 'cradle to farm-gate' scope, and expressed per kg protein or 0.1 GJ digestible energy content basis, according to nutritional data from Feedipedia (INRA, CIRAD and FAO, 2019). In order to contextualise results, footprints were benchmarked against carbon footprints for protein and energy in conventional cereal crops, i.e. wheat, barley and maize grains.

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2.2 Target audiences

The leaflet is intended for all stakeholders with an interest to develop prospective legume value chains. It highlights the environmental credentials of legumes, especially when footprints are expressed per unit of nutrition (e.g. energy or protein in "fresh" crop harvests, or nutritional density units (van Dooren *et al.*, 2017) in final food products). The information has powerful marketing potential and can be used justify behaviour change, whether on-farm and extending to include *via* implementation strategies for new policy and governance.

2.3 Crops represented and data sources

The leaflet summarises carbon footprint results for the following legumes crops across European biogeographical regions:

- beans, cultivated in Germany, Romania, Italy, United Kingdom;
- beans, cultivated in Germany, Scotland, United Kingdom;
- soybeans, cultivated in Germany and Romania;
- chickpeas, cultivated in Spain and Bulgaria; and,
- lupin, cultivated in Germany.

Management values for beans, peas, soybean and lupine in Bayern, Germany were generated using data from the Ministry of Agriculture in Bavaria (LfL, 2020). Inputs and dry yields for peas and soybeans for Baden-Württemberg in Germany calculated using data from the Ministry of Agriculture for that region (LEL, 2020). Information for soybean and common bean in Sud-Muntenia, Romania, fava beans in Calabria, Italy and peas from East Scotland was obtained from Reckling *et al*. (2016). Data for the cultivation of peas and beans from United Kingdom was calculated from the data of Redman (2018).

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3. Results

See summary presented in leaflet, contained in Appendix I, and associated D5.3 report Open Access Database.

4. Final Considerations

The leaflet will be issued to communicate interim attributional LCA results to key stakeholders in the TRUE project. Ongoing research is incorporating rotation effects such as nitrogen carry-over to following crops and nutritional output from rotations into the 'LCA-of-diet' methodology. This will generate new footprint results that encompass more-fully the impacts of legume cultivation. In addition, consequential LCA of large-scale rotation and diet transitions will be undertaken. Nonetheless, existing results already indicate a compelling sustainability case for expansion of legume cultivation and consumption in Europe.

5. Acknowledgements

We are grateful to the following collaborators for the provision of data required to calculate product footprints: Dr Beate Zimmermann from University of Hohenheim; Dr Moritz Reckling from the Leibniz Centre for Agricultural Landscape Research, Germany; Variva Food, Bulgaria; Dr Eleonora Barilli Solintagro S.A.S. Spain; and Kirsty Black, Manager of Arbikie Distillery, Scotland.

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Annex I: Information Leaflet

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TRUE

Trinity College Dublin
The University of Dublin

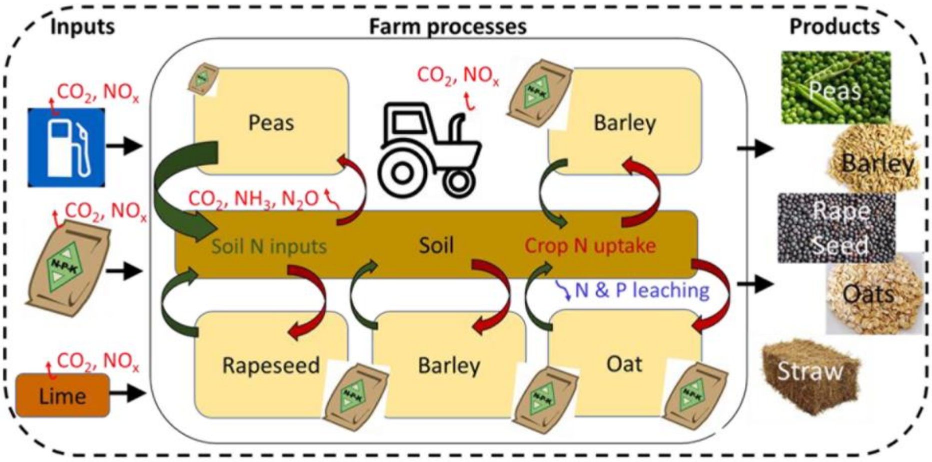
Objective "*TR*ansition paths to s*U*stainable legume based systems in *E*urope" (*TRUE*) is a practice-research partnership of 24 institutions, which aims to identify the best routes, or "transition paths" to increase sustainable legume cultivation and consumption across Europe. Just 2% of European farmland is planted with legumes; integrating legumes into cropping systems and pastures could help to make farming more sustainable. This leaflet summarises research that shows why introducing legumes into farm systems can be environmentally and economically beneficial, for farmers and wider

What is a legume? Legumes are plants that biologically fix nitrogen (N) from the air, reducing our dependence on synthetic N fertilisers. Whilst such fertilisers have played a vital role in delivering food security, they also contribute to N pollution that causes up to €320 billion of damages to the environment and health across Europe annually[1]. Common legume crops include: *peas, chickpeas, field beans, fava beans, soybeans, lentils, lupines, red clover* and *white clover*.

Benefits of legumes

- ✓ Reduce need for synthetic fertilizers – for themselves & following crops
- ✓ Break pest & disease cycles in cereal rotations
- ✓ Improve soil quality
- ✓ Increase biodiversity
- ✓ Deliver nutritious food & feed products (high in protein & fiber)

Environmental footprints represent the environmental impact arising from the production of food & feeds, including on-farm emissions from soils and tractors as well as off-farm emissions from fertilizer manufacture and downstream processing of commodities into food & feed (see diagram below). Legumes such as peas require less fertiliser input than other crops, though do produce smaller yields than cereals. Legumes also contribute substantially to soil N, reducing fertilizer inputs for other crops in the rotation, but also contributing to emissions and nutrient leaching from soils. Overall, legumes can reduce the environmental footprint of harvested crops, and derived food & feed products.



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Visit: https://www.true-project.eu/

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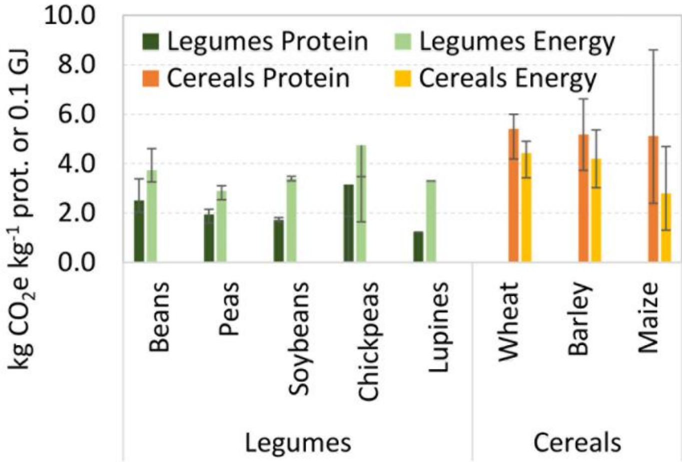
The University of Dublin

Legume footprints



Data sources: Reckling et al. (2016)[2], Ecoinvent v3.6[3], TRUE project[4]

The graph to the left displays carbon footprints per kg protein and per 0.1 GJ digestible energy contained in five legume crops and three cereal crops. Footprints vary considerably depending on management practices, and per kg of yield are similar between legumes and cereals. However, low inputs coupled with a high nutritional density mean that legumes deliver nutrition (protein & energy) at lower environmental cost (smaller carbon footprint) than cereals.

Legume product footprints

Advances in food processing coupled with demand for healthy and sustainable products by both business and consumers is driving innovative use of legumes in place of cereals. Researchers on the *TRUE* project are calculating the environmental footprints of exciting new legume products.

The starch from peas can be used to produce alcohol, leaving protein-rich coproducts that provide an excellent animal feed. Producing one liter of gin from peas (pictured right) instead of wheat can avoid up to 4.2 kg CO_2e of greenhouse gas emissions that cause climate change (equivalent to driving 25 km). Pea gin has a smaller footprint than wheat gin across 12 of 14 environmental impacts studied[3].

Peas can also substitute beef in meatballs, producing "protein balls" with a per-serving carbon footprint 84% lower than for beef meatballs – whilst also delivering more fiber and less fat. Meanwhile, producing pasta from chickpeas rather than durum wheat increases the nutritional value of pasta, and reduces the carbon footprint per unit of nutrition by 75%.

What's the bottom line? Lower yields and lack of demand has constrained legume production across Europe. However, the health & sustainability credentials of legumes are receiving more attention, creating new opportunities for cultivating and marketing innovative legume products. In the context of depleted soils, high dependence on polluting inputs and plateauing cereal yields, the introduction of legumes in to short cycle rotations can reduce environmental impact, diversify farm outputs and enhance profitability. These benefits become apparent when a broad perspective and medium time-horizon is applied.

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Annex II: Background to the TRUE Project

Executive Summary

TRUE's perspective is that the scientific knowledge, capacities and societal desire for legume supported systems exist, but that practical co-innovation to realise transition paths have yet to be achieved. TRUE presents 9 Work Packages (WPs), supported by an *Intercontinental Scientific Advisory Board*. Collectively, these elements present a strategic and gender-balanced work-plan through which the role of legumes in determining '*three pillars of sustainabilit*y' – '*environment*', '*economics'* and '*society'* - may be best resolved. TRUE realises a genuine multi-actor approach, the basis for which are three *Regional Clusters* managed by WP1 ('*Knowledge Exchange and Communication',* University of Hohenheim, Germany), that span the main pedo-climatic regions of Europe, designated here as *Continental*, *Mediterranean* and *Atlantic,* and facilitate the alignment of stakeholders' knowledge across a suite of 24 Case Studies. The Case Studies are managed by partners within WPs 2-4 comprising '*Case Studies'* (incorporating the project database and *Data Management Plan*), '*Nutrition and Product Development'*, and '*Markets and Consumers'.* These are led by the Agricultural University of Athens (Greece), Universidade Catolica Portuguesa (Portugal) and the Institute for Food Studies & Agro-Industrial Development (Denmark), respectively. This combination of reflective dialogue (WP1), and novel legume-based approaches (WP2-4) will supplies hitherto unparalleled datasets for the '*sustainability WPs*', WPs 5-7 for '*Environment*', '*Economics'* and '*Policy and Governance'.* These are led by greenhouse gas specialists at Trinity College Dublin (Ireland; in close partnership with Life Cycle Analysis specialists at Bangor University, UK), Scotland's Rural College (in close partnership with University of Hohenheim), and the Environmental and Social Science Research Group (Hungary), in association with Coventry University, UK), respectively. These *Pillar WPs* use progressive statistical, mathematical and policy modelling approaches to characterise current legume supported systems and identify those management strategies which may achieve sustainable states. *A key feature* is that TRUE will identify key *Sustainable Development Indicators* (SDIs) for legume-supported systems, and thresholds (or goals) to which each SDI should aim. Data from the *foundation WPs* (1-4), to and between the *Pillar WPs* (5-7), will be resolved by WP8, '*Transition Design',* using machine-learning approaches (*e.g. Knowledge Discovery in Databases*), allied with *DEX* (*Decision Expert*) methodology to enable the mapping of existing knowledge and experiences. Co-ordination is managed by a team of highly experienced senior staff and project managers based in The Agroecology Group, a Sub-group of Ecological Sciences within The James Hutton Institute.

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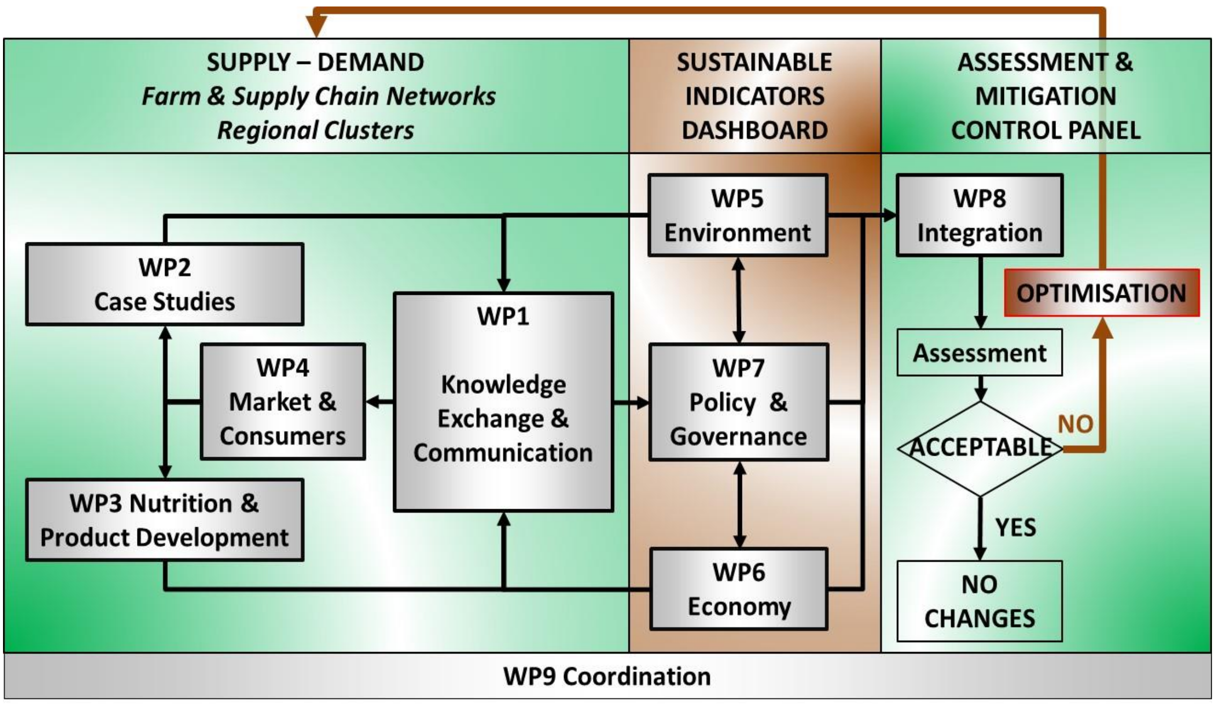
Work-package structure

The flow of information and knowledge in TRUE, from the definition of the 24 case studies (left), quantification of sustainability (centre) and synthesis and decision support (right).



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Project partners

No	Participant organisation name (and acronym)	Country	Organisation Type
1 (C*)	The James Hutton Institute (JHI)	UK	RTO
2	Coventry University (CU)	UK	University
3	Stockbridge Technology Centre (STC)	UK	SME
4	Scotland's Rural College (SRUC)	UK	HEI
5	Kenya Forestry Research Institute (KEFRI)	Kenya	RTO
6	Universidade Catolica Portuguesa (UCP)	Portugal	University
7	Universität Hohenheim (UHOH)	Germany	University
8	Agricultural University of Athens (AUA)	Greece	University
9	IFAU APS (IFAU)	Denmark	SME
10	Regionalna Razvojna Agencija Medimurje (REDEA)	Croatia	Development Agency
11	Bangor University (BU)	UK	University
12	Trinity College Dublin (TCD)	Ireland	University
13	Processors and Growers Research Organisation (PGRO)	UK	SME
14	Institut Jozef Stefan (JSI)	Slovenia	HEI
15	IGV Institut Fur Getreideverarbeitung GmbH (IGV)	Germany	Commercial SME
16	ESSRG Kft (ESSRG)	Hungary	SME
17	Agri Kulti Kft (AK)	Hungary	SME
18	Alfred-Wegener-Institut (AWI)	Germany	RTO
19	Slow Food Deutschland e.V. (SF)	Germany	Social Enterprise
20	Arbikie Distilling Ltd (ADL)	UK	SME
21	Agriculture And Food Development Authority (TEAG)	Ireland	RTO
22	Sociedade Agrícola do Freixo do Meio, Lda (FDM)	Portugal	SME
23	Eurest -Sociedade Europeia De Restaurantes Lda (EUR)	Portugal	Commercial Enterprise
24	Solintagro SL (SOL)	Spain	SME
25	Public Institution Development of the Međimurje County (PIRED)	Croatia	Development Agency

*Coordinating institution

Objectives

Objective 1: Facilitate knowledge exchange (UHOH, WP1)

- *Develop a blueprint for co-production of knowledge*

Objective 2: Identify factors that contribute to successful transitions (AUA, WP2)

- *Relevant and meaningful Sustainable Development Indicators (SDIs)*

Objective 3: Develop novel food and non-food uses (UCP, WP3)

- *Develop appropriate food and feed products for regions/cropping systems*

Objective 4: Investigate international markets and trade (IFAU, WP4)

- *Publish guidelines of legume consumption for employment and economic growth*
- *EU infrastructure-map for processing and trading*

Objective 5: Inventory data on the environmental intensity of production (TCD, WP5)

- Life Cycle Analyses (LCA) -novel legumes rotations and diet change

Objective 6: Economic performance - different cropping systems (SRUC & UHOH, WP6)

- *Accounting yield and price risks of legume-based cropping systems*

Objective 7: Enable policies, legislation and regulatory systems (ESSRG, WP7)

- *EU-policy linkages (on nutrition) to inform product development/uptake*

Objective 8: Develop decision support tools: growers to policymakers (JSI, WP8)

- *User-friendly decision support tools to harmonise sustainability pillars*

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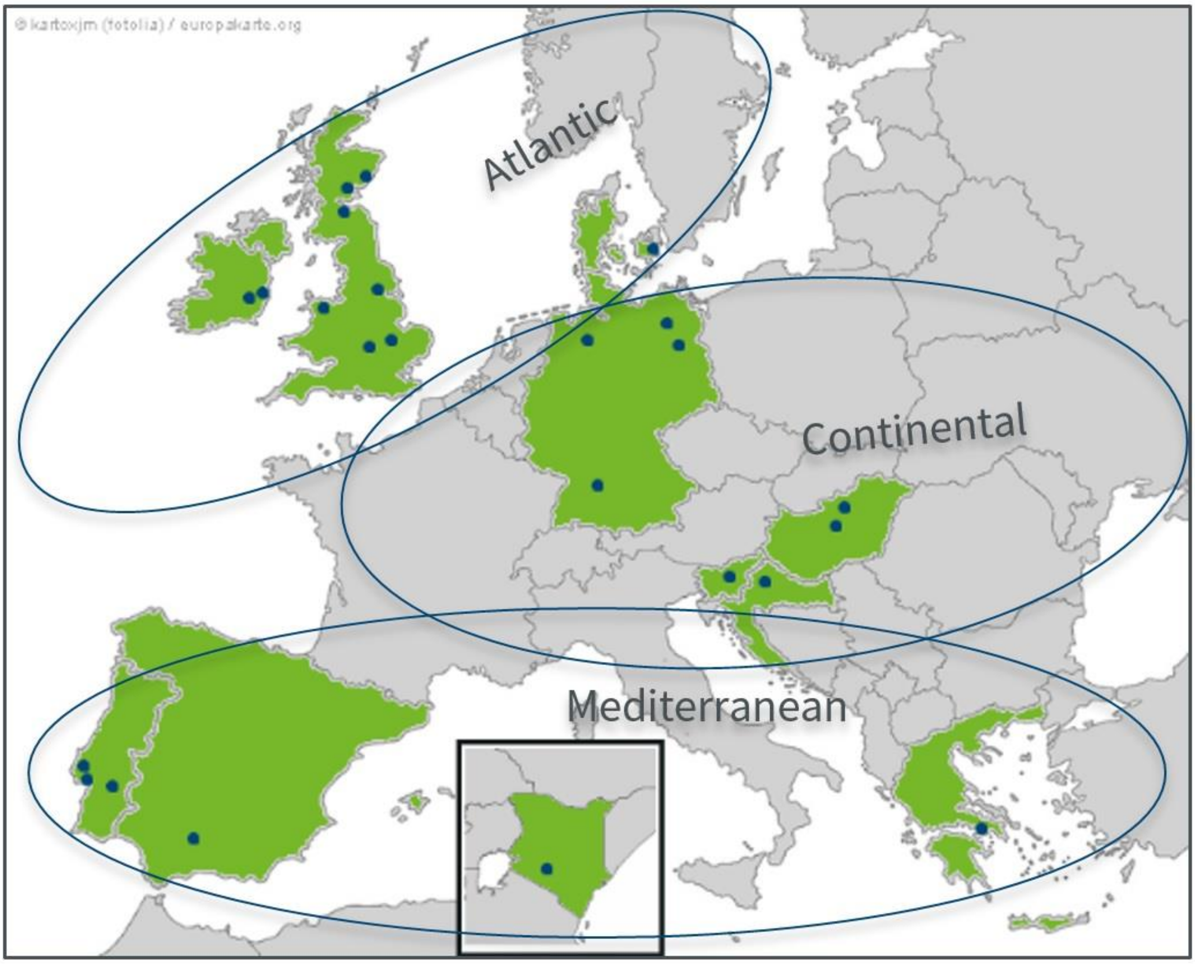
Legume Innovation Networks



Knowledge Exchange and Communication (WP1) events include three TRUE European Legume Innovation Networks (E-LINs), and these engage multi-stakeholders in a series of focused workshops. The E-LINs span three major pedoclimatic regions of Europe illustrated above within the ellipsoids for Continental, Mediterranean and Atlantic zones.

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