TRansition paths to sUstainable legume-based systems in Europe

Practice Abstracts II

Work Package: 1

Deliverable: 1.10 (D9)

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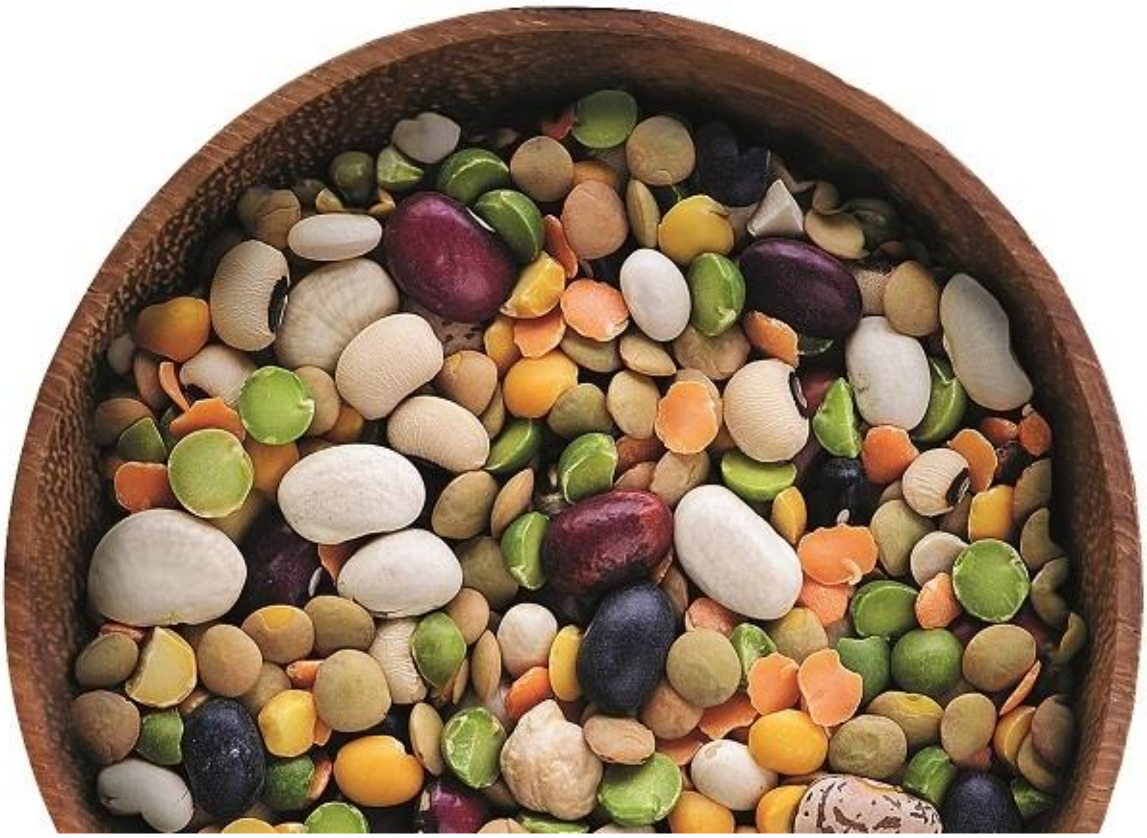

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Deliverable Description & Contributors

- **Due date:** 30th June 2021
- **Actual submission date:** 28th June 2021
- **Project start date:** 1st April 2017
- **Duration:** 48 months
- **Work package:** Knowledge Exchange and Communication (WP1)
- **Work package leader:** Carolin Callenius (UHOH)
- **Deliverable Title:** Practice Abstracts II
- **Nature of deliverable:** Report
- **Dissemination level:** PU: Public

- **Deliverable description:** As a requirement of multi-actor approach, this Deliverable formalises a second batch of 'Practice Abstracts'. These will also be delivered in the EIP Common Format (ExcelTM file) and present innovative and practical insights from project activities in accessible easy-to-use material for end-users. This knowledge is described in simple terms, easily understood by lay-persons and/or specific stakeholders. Including the final 21 Practice Abstracts presented here, 40 have been provided in total.

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Content

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Summary

Practice abstracts (PAs) are presented in a Common Format for all EU multiactor projects, to provide recommendations to end-users. These are uploaded to the data base of the EIP Agri Service Point, which imposes the strict criteria for each PAs. The summary should contain at least the following information:

- main results/outcomes of the activity (expected or final); and,
- main practical recommendation(s): what would be the main added value/benefit/opportunities to the end-user if the generated knowledge is implemented? How can the practitioner make use of the results?

The summary should be as interesting as possible for farmers/end-users, using simple and easy understandable language, highlighting entrepreneurial elements which are particularly relevant for practitioners (*e.g.,* related to cost, productivity *etc*.). Research oriented aspects which do not help the understanding of the practice itself should be avoided. The PAs are written in the native language of project partner as well as translated into English.

In addition, all PAs have been transferred into the TRUE PA layout and uploaded at the project website.

This deliverable report features 21 PAs, written by 13 different project partners. These are arranged by their focus with respect to the use of legumes within the supply chain. This leads to the following sections:

- "Production of legumes for food and feed" (9 PAs);
- "Legumes used as green manure" (5 PAs);
- "Processing of legumes for food" (1 PAs);
- "Marketing of legumes for food" (2 PAs); and,
- "Legume supply chains" (4 PAs).

The targeted end-users are growers, aquaculturists, processors (*e.g.* brewer), chefs and consumers. For 13 PAs, the native language is not English, so there are translations in DE (3), GR (3), DK (3), PT (2), SLO (1), and HU (1) (Table 1).

Table 1. Practice Abstract titles categorised according to their target 'supply chain sector', legume 'use', intended 'end-user', TRUE-Case Study ('CS') number, -Work Package ('WP'), and languages ('Language')

Supply chain sector	Use	Title	End-User	CS	WP	Partner	Language
production	food	Grafting technique in common bean cultivation	grower	21	2	AUA	EN,GR
	feed	Faba bean in salmon diets instead of fishmeal and GMO soy	aquaculturists	15	2	AWI	EN,DE
		Organic diets with home-grown feed sources for lactating sows and fattenings pigs - Denmark	grower	10	2,4	IFAU	EN,DK
	food and feed	New rhizobia strains for common bean	grower	22	2	AUA	EN,GR
		New rhizobia for Tephrosia and common beans	grower	24	2	KEFRI	EN
		Developing elite-rhizobia inoculants to enhance legume crop performance and yield	grower	NA	2	JHI	EN
		Intercropping pea and barley for improved cereal mineral nutrition	Grower/consumer	NA	2,3	UCP, JHI	EN,PT
		Benefits and constraints for the introduction of lentils in rotations in temperate regions	grower	13	2	UHOH	EN,DE
		How to use legumes to benefit pollinators	grower	7	2	CU	EN
	manure	Sustainable crop rotations for soybean production in Southern Germany	grower	12	2	UHOH	EN,DE
		Intercropping legumes with cereals to improve pest and weed control	grower	5	2	JHI	EN
		How can legumes help in biomass production?	grower	5	2	JHI	EN
		Selection of clovers for living mulches	grower	6	2	STC	EN
		Crop rotation schemes for organic common bean production under mild-winter climatic conditions	grower	22	2	AUA	EN,GR

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processing	**food**	Update to brewing abstract - Pulses as an adjunct in beer production	brewers	3	2	ADI	EN
		Organizing a PGI/PDO labelled product (dried pulses)	processors, market	9	2,4	IFAU	EN,DK
		Nordic consumers' preferences for meat alternatives	processors, market	9	2,4	IFAU	EN,DK
entire supply chain	**food**	Pulse consumption: potential drivers and barriers towards a sustainable diet	consumers	NA	3	UCP	EN,PT
		Guidance to the small-scale grwoing/cultivation of selected legume species	growers, chefs, consumers	17	2	AgriKulti	EN,HU
		Decision support syste Path Finder promotes sustainable legume path from farm to fork	all	NA	8	JSI	EN,SLO
		Legumes and uptake – producers and consumers	all	NA	6	SRUC	EN

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List of new Practice Abstracts

Production of legumes for food and feed

Grafting technique in common bean cultivation

Common bean (*Phaseolus vulgaris* L.) is the most widely cultivated legume for human consumption as fresh pods or dried seeds. Its serves as an important nutritional source of proteins, vitamins, fibers and antioxidants. Grafting is a common technique used to protect plants against the adverse effects of biotic and abiotic stressors as well as to increase yield and fruit quality. A grafted plant is a combination of two different genotypes: the scion (upper) and the rootstock (lower). The factors for successful grafting are the compatibility of scion and rootstock, including the accurant alignment of upper and lower vascular systems, choice of appropriate growth stage, and the healing of the grafted plant afterwards. In common bean, grafting is conducted when the two primary leaves are partially expanded. The rootstock is excised below the primary leaves and a vertical slit is made on the stem. The scion (the apical part including the primary leaves) is taken from the donor plants by cutting the stem under the primary leaves. The lower part of the scion stem is cut in a V-shape and is inserted in the vertical slit of the rootstock. A grafting clip secures the union, and a stick keeps the grafted plant stable. The plants are then placed in a healing chamber at 26 °C and relative humidity of 90%. These conditions minimise foliar water loss and promote the survival rate of the plants. After the cut ends are permanently united, the relative humidity in the healing chamber is gradually reduced to acclimate the plants.

Characters: 1282

Native Language: Greek

Η τεχνική του εμβολιασμού στην καλλιέργεια φασολιού

Το κοινό φασόλι (*Phaseolus vulgaris* L.) είναι ένα ψυχανθές που καλλιεργείται ευρέως για τους φρέσκους λοβούς ή τους ξηρούς σπόρους του. Αποτελεί σημαντική πηγή πρωτεΐνών, βιταμινών, φυτικών ινών και αντιοξειδωτικών. Ο εμβολιασμός είναι μια καλλιεργητική τεχνική που χρησιμοποιείται για την προστασία των φυτών από βιοτικούς και αβιοτικούς παράγοντες καταπόνησης, καθώς και για να αύξηση της απόδοσης και την ποιότητα αυτής. Ένα εμβολιασμένο φυτό αποτελείται από δύο διαφορετικούς γονοτύπους: αυτόν του εμβολίου (ανώτερο) και αυτόν του υποκειμένου (κατώτερο). Οι παράγοντες που καθορίζουν την επιτυχία ενός εμβολιασμού είναι η συμβατότητα εμβολίου και υποκειμένου, η σύμπτωση των καμβίων τους, η εφαρμογή του εμβολιασμού στο κατάλληλο αναπτυξιακό στάδιο και η σκληραγώγηση του φυτού μετέπειτα. Στην περίπτωση του κοινού φασολιού, ο εμβολιασμός πραγματοποιείται στο στάδιο όπου τα πρώτα φύλλα έχουν μερικώς εκπτυχθεί. Στο φυτό που θα χρησιμοποιηθεί ως υποκείμενο αφαιρείται το ανώτερο μέρος στο σημείο κάτω από τα πρώτα φύλλα και γίνεται μια κάθετη τομή στον εναπομείναντα βλαστό. Το εμβόλιο (το ανώτερο μέρος συμπεριλαμβανομένων των πρώτων φύλλων) αποκόπτεται από το φυτό-δότη και στο βλαστό του δίνεται σχήμα V. Τοποθετείται στην τομή του υποκειμένου και σταθεροποιείται με ένα μανταλάκι εμβολιασμού. Στη συνέχεια, τα φυτά τοποθετούνται σε θάλαμο ανάνηψης με T=26 °C and RH= 90%. Υπό αυτές τις συνθήκες ελαχιστοποιείται η διαφυλλική απώλεια νερού και προάγεται η επιτυχία του εμβολιασμού. Όταν το σημείο τομής συγκολληθεί πλήρως, η σχετική υγρασία στο θάλαμο μειώνεται σταδιακά για να εγκλιματιστούν τα φυτά.

Characters: 1378

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Figure 1. Grafting of a common bean plant. *Photo credits ©: Vasiliki Vougeleka*

Faba bean in salmon diets instead of fishmeal and GMO soy

Atlantic salmon *(Salmo salar*) is one of the most important farmed fish species in Europe with a production of 1.7 million tons and a value of 8.3 billion Euros in 2019. Fishmeal and fish oil still constitute traditional resources for feeds for fish and crustaceans kept in aquaculture. The fishmeal contains readily digested protein, a complete amino acid profile and provides all nutrients the animals, especially carnivores such as salmon, trout, seabass, seabream, shrimps, require. Demand for fishmeal has risen as the aquaculture sector has expanded, placing pressure on the marine food chain and increasing prices. Legumes are the main alternative to fishmeal, and soya has been the main ingredient in fish diets for more than 20 years. The use of other locally produced legumes like lupin or faba bean, which are more suitable in terms of digestibility and sustainability, is now a focus of research.

At the Alfred Wegener Institute, researchers tested faba bean protein concentrate, lupin meal, and lupin concentrate from local sources at inclusion rates of 35% in feeds formulated for Atlantic salmon. Results showed that with an inclusion rate of 35% faba bean protein concentrate, it is possible to replace all soy concentrate. Additionally, the use of fish meal can be reduced to less than half of what is currently used in a conventional diet. The use of regional resources is highly recommended, as neither the growth nor the health of the salmon is affected. Moreover, faba beans are considerably less expensive than soy and fishmeal.

Characters: 1300

Native Language: German

Faba-Bohne im Lachsfutter anstelle von Fischmehl und GVO-Soja

Der Atlantische Lachs (*Salmo salar*) ist eine der wichtigsten Zuchtfischarten in Europa mit einer Produktionsmenge von 1.7 Mio. t und einem Wert von 8.3 Mrd. € im Jahr 2019. Fischmehl und Fischöl sind nach wie vor die traditionellen Ressourcen für Futtermittel für Fische und Krustentiere, in Aquakulturen. Vor allem Fischmehl enthält leicht verdauliches Eiweiß und ein vollständiges Aminosäureprofil und liefert alle Nährstoffe, die die Tiere, insbesondere Fleischfresser wie Lachs, Forelle, Wolfsbarsch, Meerbrasse und Garnelen, benötigen. Die Nachfrage nach Fischmehl ist mit der Expansion des Aquakultursektors gestiegen und treibt auch die Preise für Fischmehl in die Höhe. Leguminosen sind die Hauptalternative für Fischmehl: Soja ist seit mehr als 20 Jahren neben Fischmehl einer der Hauptbestandteile im Fischfutter. Der Einsatz anderer heimischer Leguminosen wie Lupine oder Ackerbohne, die hinsichtlich der Verdaulichkeit und Nachhaltigkeit besser geeignet sind, steht nun im Fokus der Forschung. Am Alfred-Wegener-Institut testeten Forscher Ackerbohnenproteinkonzentrat, Lupinenmehl und Lupinenkonzentrat aus lokalen Ressourcen mit einer Beimischungsrate von 35 % in Futtermitteln, die für Atlantischen Lachs formuliert wurden. Die

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Ergebnisse zeigten, dass bei einer Einschlussrate von 35 % Ackerbohnenkonzentrat das gesamte Sojakonzentrat ersetzt, und zusätzlich der Einsatz von Fischmehl auf weniger als die Hälfte dessen reduziert werden kann, was in einem konventionellen Futtermittel verwendet wird. Der Einsatz der regionalen Ressource ist absolut empfehlenswert, da weder das Wachstum noch die Gesundheit der Lachse beeinträchtigt wird. Zudem sind Ackerbohnen deutlich preiswerter als Soja und Fischmehl.

Characters: 1492

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Organic diets with home-grown feed sources for lactating sows and fattening pigs – Denmark

In Denmark, the main protein source for organically farmed pigs is imported organic soya cakes. To mitigate climate impact and better accommodate the principles of organic farming, it is important to identify home-grown alternatives to these imported protein feed. Such alternatives could be fava beans, peas, lupines, or mixed crops (e.g., pea/barley or lupine/spring wheat).

Organic farmers are keen to grow more legumes and mixed crops due to the nitrogen-fixating properties of leguminous plants and to improve self-sufficiency with feed protein. Fava beans are the most important protein crop in Danish organic pig farming, and the cultivation area of fava beans and other legumes has increased with the expanding organic sector.

The amino acid composition of legumes does not match that of soybeans and their protein content is also lower. However, nutritionally optimised diets can be formulated by using Danish crops only. Diets for organic pigs could be made from a combination of organic grains (wheat, oats, or barley), fava beans and other pulses, rapeseed cake, vitamins and minerals. Organic lactating sows can be fed a diet of 68 % organic grains, 13 % fava beans and 5 % lupines, resulting in a diet containing 15 % protein (130 g digestible protein per kg). Diets for fattening pigs could have 35 % organic grains, 29 % de-hulled oats, and 24 % fava beans, resulting in a diet containing 17.5 % protein (146 g digestible protein per kg).

Characters: 1218

Native Language: Danish

Økologiske foderblandinger med danske afgrøder til diegivende søer og slagtegrise

Importerede økologiske sojakager udgør den væsentligste proteinkilde i økologisk svinefoder i Danmark. For at modvirke klimaeffekten ved import og bedre imødekomme de økologiske principper er det vigtigt at finde alternative danske proteinkilder. Det kunne være økologiske hestebønner, ærter, lupin eller blandsæd (f.eks. ærte/byg eller vårhvede/lupin). Økologiske landmænd vil gerne dyrke flere bælgplanter p.g.a. planternes evne til at fiksere kvælstof og for at øge selvforsyningen med proteinfoder. Hestebønner er den vigtigste proteinafgrøde i økologisk svineproduktion i Danmark, og arealet med bælgsæd er øget i takt med økologiens fremgang.

Aminosyresammensætningen i bælgplanter er ikke på højde med den i sojabønner, og proteinindholdet i bælgplanterne er også lavere end i sojabønner. Alligevel er det muligt at sammensætte ernæringsrigtige foderrationer af udelukkende danske afgrøder. Foderblandinger til økologiske grise kan sammensættes af økologisk korn (hvede, byg eller havre), hestebønner og andre bælgfrugter, rapskager samt vitaminer og mineraler. En foderblanding til diegivende søer kan bestå af 68 % økologisk korn, 13 % hestebønner og 5 % lupin. Det giver et foder med 15 % protein (130 g fordøjeligt protein pr kg). En foderplan til slagtegrise kan bestå af 35 % økologisk korn, 29 %

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afskallet havre og 24 % hestebønner. Det giver en ration med 17.5 % protein (146 g fordøjeligt protein pr kg).

Characters: 1213

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New rhizobia strains for common bean

Rhizobia are beneficial soil microorganisms that promote the growth of legumes through biological nitrogen fixation (BNF), a process of converting atmospheric nitrogen into plant assimilable nitrogen such as ammonia. Rhizobial inoculants (applied to seed at sowing) have been used for many years in agricultural systems to improve productivity of legume crops, enhance soil fertility and reduce the use of synthetic chemical fertilisers. The utilisation of rhizobial inoculants under field conditions often produces inconsistent results around the world. Research aiming at isolating and characterizing indigenous rhizobia is of great importance for selecting novel strains adapted to the local crop varieties and environmental conditions.

Common bean is an important legume crop that is cultivated as a grain or vegetable crop in many parts of the tropics, subtropics, and temperate regions**.** Common bean can establish symbiotic relationships with a great number of rhizobial species, but it displays reduced BNF ability compared to other legumes and it is therefore considered a poor nitrogen fixer pulse. Hence, best common bean varieties or landrace need combined with the best rhizobia. The use of the best rhizobia is considered a sustainable agricultural practice to maximise nodulation, BNF and achieving optimal biofertilisation - regardless of soil, climatic and management conditions. To this end, the study of indigenous rhizobia nodulating common bean in Greece ascertained for first time their diversity and identified novel strains, while others were found for first time in European soils.

Characters: 1370

Native Language: Greek

Νέα ριζοβιακά στελέχη για το κοινό φασόλι

Τα ριζόβια είναι ωφέλιμοι μικροοργανισμοί του εδάφους, που προωθούν την ανάπτυξη των ψυχανθών μέσω της Βιολογικής Αζωτοδέσμευσης, μια διαδικασία με την οποία το ατμοσφαιρικό άζωτο μετατρέπεται σε αμμωνία, αφομοιώσιμη μορφή αζώτου για τα φυτά. Τα ριζοβιακά εμβόλια έχουν χρησιμοποιηθεί για πολλά χρόνια στα γεωργικά συστήματα για τη βελτίωση της παραγωγικότητας των ψυχανθών, την ενίσχυση της γονιμότητας εδαφών και τη μείωση εφαρμογής συνθετικών χημικών λιπασμάτων. Τα αποτελέσματα από τη χρήση ριζοβιακών εμβολίων στο πεδίο ποικίλουν σε παγκόσμια κλίμακα για διάφορους λόγους. Οι έρευνες που στοχεύουν στην απομόνωση και στον χαρακτηρισμό γηγενών ριζοβίων έχουν μεγάλη σημασία για την επιλογή νέων στελεχών, προσαρμοσμένων στις τοπικές ποικιλίες και στις περιβαλλοντικές συνθήκες.
Η φασολιά είναι ένα σημαντικό ψυχανθές που καλλιεργείται παγκοσμίως είτε ως όσπριο ή ως λαχανικό σε πολλά μέρη των τροπικών, υποτροπικών και εύκρατων περιοχών. Παρότι, η φασολιά μπορεί να αναπτύσσει συμβιωτικές σχέσεις με μεγάλο αριθμό ριζοβίων, επιδεικνύει μειωμένη αζωτοδεσμευτική ικανότητα σε σχέση με άλλα ψυχανθή. Η επιλογή κατάλληλων ποικιλιών φασολιάς με μεγάλη ικανότητα αφομοίωσης αζώτου σε συνδυασμό με αποτελεσματικά, ανταγωνιστικά και καλά προσαρμοσμένα στελέχη ριζοβίων σε διαφορετικές εδαφοκλιματικές ζώνες θεωρείται η πιο βιώσιμη γεωργική πρακτική για τη μεγιστοποίηση της ικανότητας σχηματισμού φυματίων και της αφομοίωσης αζώτου στη φασολιά, επιτυγχάνοντας τελικά τη βελτιστοποίηση της βιολίπανσης. Για το σκοπό αυτό, η μελέτη γηγενών ριζοβίων που σχηματίζουν

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φυμάτια σε φασολιά στην Ελλάδα προσδιόρισε για πρώτη φορά την ποικιλομορφία τους και αποκάλυψε νέα στελέχη, ενώ κάποια άλλα βρέθηκαν για πρώτη φορά σε ευρωπαϊκά εδάφη.

Characters: 1490

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New rhizobia for tephrosia and common beans

One of the most important drivers of low agricultural productivity in smallholder farms in sub-Saharan Africa is the low use or lack of access to chemical fertilisers. Inoculating leguminous crops with effective rhizobia inoculants can significantly enhance biological nitrogen fixation (BNF), thus complementing or reducing the dependency on nitrogen-based chemical fertilisers. Identification and selection of indigenous rhizobia associated with leguminous crops can lead to the development of effective and affordable rhizobia inoculants that enhance BNF. In Western Kenya, the intercropping of fast-growing nitrogen-fixing leguminous species *Tephrosia* (*Tephrosia candida)* and common bean (*Phaseolus vulgaris*) in combination with maize (*Zea mays*) crop as part of a rotational agroforestry system, also known as 'improved fallow', is widely practised. To optimise BNF, the isolation, identification, and selection of common bean and *Tephrosia* rhizobia with varying morphological and genetic characteristics have been carried out and used to develop inoculants. These newly developed inoculants significantly improve grain yield and biomass production of common bean and *Tephrosia* in Western Kenya conditions. Due to the differences in compatibility and effectiveness of common bean and *Tephrosia* rhizobia, it is crucially important that each species be inoculated with specifically developed inoculants during planting.

Characters: 1229

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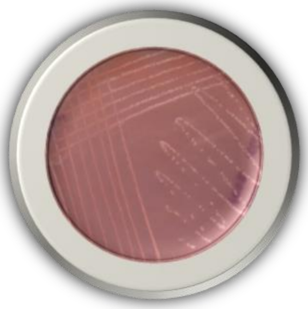

Tephrosia rhizobia

Common bean rhizobia

Inoculant packet

Inoculation of common bean seeds

Figure 2. Different types of rhizobia, inoculant packet, common bean inoculation at Nyabeda trial. *Photo credits ©: Emmanuel Makatiani*

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Developing elite-rhizobia inoculants to enhance legume crop performance and yield

Legumes are characterised by their capacity for Biological Nitrogen (N) Fixation (BNF), which is the ability to fix atmospheric di-N gas (N_2) into biologically useful forms. BNF is a function of a symbiotic relationship of the legume with a particular class of soil microbes, collectively referred to as rhizobia. Rhizobia that are compatible with the host infect its roots, and form outgrowths termed 'root nodules' within which they carry out BNF. Due to this unique ability legumes do not need synthetic N fertilisers to be productive, since BNF fulfils their N requirements.

The rhizobia normally reside as free-living soil microbes and present a wide variety of types which vary in ecologically important characteristics, such as their persistence in the soil, their ability to compete with other legume-compatible rhizobia to form root nodules, and their BNF capacity. In addition, legumes are often characterised as having unstable yields, and the sub-optimal nature of their rhizobia-legume symbiosis has been implicated as a factor in such instability.

Consequently, specific rhizobia strains have been isolated which allow more consistent and enhanced yields, and these are sold as commercial inoculants. The inoculants are applied to legume seeds just before sowing and comprise very high concentrations of rhizobia due to low on-seed survival.

To optimise the potential of commercial inoculants, TRUE partners have isolated 'elite' rhizobia from peas and beans which have both high BNF potential and high on-seed survival. This provision of elite rhizobia inoculants is allied to the availability of molecular tests for rhizobia population densities in soils, and identification of the genetic determinants underpinning their elite potential.

Characters: 1492

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Intercropping pea and barley for improved cereal mineral nutrition

Intercropping is the growing of two or more crop species simultaneously in the same field during a growing season. This technique can be applied to a mix of non-legume and legume crops, helping to improve crop yield while reducing chemical input costs and supporting sustainable agricultural practices.

In this study, pea and barley were intercropped to test the potential role of pea in improving barley's mineral nutrition. The field trial was repeated for two consecutive years and compared against a monocrop system and the application of fertilisers. In the first year, the provision of several mineral nutrients of barley was positively impacted by intercropping, namely, the concentrations of nickel (Ni), manganese (Mn), calcium (Ca), iron (Fe), zinc (Zn), magnesium (Mg), phosphorus (P) and potassium (K) was increased 90%, 50%, 49%, 39%, 24%, 16%, 13% and 9%, respectively. In the second year, only Ni concentration was significantly different (increased). Hence, barley mineral-nutrition qualities are not compromised and may even be greater when intercropped. Intercropping barley (with pea) therefore presents a more resource use-efficient strategy (as no fertiliser was added) to provide mineral nutrient provisions which are greater than those provided by monocrops.

Characters: 1091

Native Language: Portuguese

Crescimento de ervilha e cevada em consociação melhora a composição nutricional do cereal

O crescimento em consociação é, por definição, o cultivo de duas ou mais espécies de cultivo simultaneamente, no mesmo campo, durante ciclo de cultivo. Esta técnica pode ser aplicada a uma mistura de culturas não leguminosas e leguminosas, ajuda a melhorar o rendimento da colheita enquanto reduz os custos de aditivos químicos, apoiando deste modo práticas agrícolas sustentáveis.

Neste estudo, culturas de ervilha e cevada foram cultivadas em consociação para testar os potenciais benefícios da ervilha na composição nutricional da cevada. O ensaio de campo foi repetido por dois anos consecutivos e comparado com um sistema de monocultura e com a aplicação de fertilizantes. Observou-se que, no primeiro ano, a provisão de diversos minerais na cevada foi impactada positivamente no sistema de consociação. Nomeadamente, a concentração de níquel (Ni), manganês (Mn), cálcio (Ca), ferro (Fe), zinco (Zn), magnésio (Mg), fósforo (P) e potássio (K) aumentou em cerca de 90%, 50%, 49%, 39%, 24%, 16%, 13% e 9%, respetivamente. No segundo ano, apenas a concentração de Ni foi significativamente aumentada. Portanto, pode-se concluir que a qualidade da nutrição mineral em cevada não foi comprometida e foi até superior em sistema de consociação. A consociação de cevada (com ervilha) é, deste modo, uma estratégia mais eficiente

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em termos de uso de recursos (uma vez que não foram aplicados fertilizantes) para a provisão de nutrientes, dado que os resultados foram iguais ou superiores aos obtidos em monocultura.

Characters: 1278

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Benefits and constraints for the introduction of lentils in rotations in temperate regions

Currently, lentil is cultivated on a relatively small acreage in European countries like France and Italy, while in Germany it is only a niche product. The main reason for this is the challenge of cultivation in temperate regions.

One of the biggest difficulties in lentil cultivation is the high risk of lodging. To overcome this problem, lentil is grown with a companion crop in temperate climates. This requires compromises in crop management, which can result in yield losses for one of the two crops. The indeterminate growth poses an additional problem. In Central European regions, the grain moisture content of lentils at harvest is often still above 20 %, so immediate drying is required to prevent quality loss. Furthermore, the two crops must be separated from each other using special equipment, e.g. vibrating screens, and drum separators, which are often too costly for an individual farmer.

However, the integration of lentil into the crop rotation is profitable in many respects. Mixed cultivation ensures high biodiversity on the field. The cultivation risk is spread over several crops, so the system is considered more stable, in terms of yield, than monocropping. The possible companion crops as well as the preceding or succeeding crops in the crop rotation are very diverse and make it easy to integrate lentils into existing structures. In addition, lentil is a legume that fixes nitrogen and therefore reduces the need for additional nitrogen fertilisers. Lentil, as a traditional food crop, also has a very high retail value in certain regions and is considered a specialty food. Finally, consumers appreciate the regional cultivation of this nutrient-rich crop, which further increases demand.

Characters: 1448

Native Language: German

Vorteile und Schwierigkeiten bei der Integration von Linsen in die Fruchtfolge

Bisher werden Linsen auf verhältnismäßig kleinen Flächen in verschiedenen europäischen Regionen vor allem in Frankreich und Italien angebaut. In Deutschland ist der regionale Anbau noch eine Nische. Der Grund dafür sind zum Teil die Herausforderungen im Anbau.
Eine der größten Probleme im Linsenanbau ist das hohe Lagerrisiko. Um diesem zu begegnen, wird die Linse in unserem Klima mit einer Stützfrucht angebaut. Dabei müssen Kompromisse beim Management eingegangen werden, die zu Ertragseinbußen bei einer der beiden Kulturen führen können.
Zu dem reifen Linsen im Gegensatz zu Getreide oder Sojabohnen nicht gleichmäßig ab. Daher liegt die Kornfeucht der Linsen bei der Ernte oftmals über 20 %, sodass zur Vermeidung von Qualitätseinbußen eine schnelle Trocknung erforderlich ist. Außerdem müssen durch den Gemengeanbau die beiden Kulturen voneinander getrennt werden, wofür eine spezielle und kostspielige Reinigungstechnik (Trieur, Tischausleser o.ä.) notwendig ist.

Neben den genannten Herausforderungen ist der Anbau der Linse in vielerlei Hinsicht gewinnbringend. Der Anbau im Gemenge sorgt für hohe Biodiversität auf dem Feld. Das Anbaurisiko verteilt sich auf mehrere Kulturen, sodass das System als ertragsstabiler gilt als die Reinsaat. Die möglichen Anbaupartner der Linse sowie die Vor- oder Folgefrüchte in der Fruchtfolge umfassen ein breites Artenspektrum, was die Integration der Linsen in vorhandene Anbaustrukturen einfach macht. Da es sich bei Linsen um eine Leguminose handelt, wird der Einsatz von N-Düngung reduziert. Heimische Linsen erzielen außerdem in einigen Regionen Deutschlands sehr hohe Preise. Verbraucher*innen schätzen den regionalen Anbau dieser nährstoffreichen Pflanze, wodurch die Nachfrage wächst.

Characters: 1499

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Figure 3. Lentil trial station with companions. *Photo credits ©: Sabine Zikeli*

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How to use legumes to benefit pollinators

Legumes can play an important role in supporting ecosystem services and biodiversity in agriculture. There is also emerging evidence that the benefits of legume crops to pollinators spill over into the wider landscape. The principal pollinators of legumes are bees, on which legumes are partially dependent for seed set. The extent of that dependency varies between species. Alfalfa, for example, is reliant on bee visitation to release its pollen, whereas peas are largely self-pollinated. Legumes provide bees with carbohydrates in the form of nectar and protein in the form of pollen. Not all bees find it easy to access floral resources; the nectar is located deep within the flower, so that legumes tend to be visited by bees with longer tongues. Most legumes will be used by a variety of bees, even if they are not dependent on them for pollination, and both grain and forage legumes support a range of pollinators and beneficial insects.

Legumes vary in the size and colour of their flowers, in the scent the flowers release, and in the time of year they flower. These characteristics influence which bees will visit. Including a range of legume species on a farm will maximize the number of pollinator species that can benefit and will lengthen the period over which they can do so.

Legumes can be incorporated into cropping as: grain legumes, both as single stands and as intercrops; as green manures and living mulches (as a break crop or undersown in crop fields); as forage legumes, and as components in field margin flower mixes. In margins, non-crop legumes such as birds-foot trefoil and vetches are useful species for pollinators. Including a variety of legumes in different parts of the cropping system will provide diverse opportunities for pollinators across the farm.

Characters 1494

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Figure 4. Bombus pascuorum on French bean, *Photo credits ©: Judith Conroy*

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Legumes used as green manure

Sustainable crop rotations for soybean production in Southern Germany

Even though soybean poses low disease risk to subsequent soybean crops, unlike many other legumes, it should still be grown as part of a crop rotation with a cropping interval of at least three years. The rotation of crops can be very diverse in both organic and conventional farming.

Soybeans have a high value as a preceding crop, as they fix inert atmospheric nitrogen in biologically useful form. They also contribute to good soil structure due to their distinctive root system. In Southern Germany, cereals such as winter and spring wheat, winter barley, spelt and triticale have a very high share in the crop rotation with soybean. As a preceding and following crop, winter wheat is the most used. Due to its slow early development, soybean is poorly competitive against weeds. Therefore, a weed-suppressive and nitrogen-consuming crop (e.g. winter cereal or maize) is suitable as a preceding crop. The subsequent low nitrogen content in the soil stimulates soybean nodulation by rhizobia and supports improved nitrogen fixation. Soy diseases, like *Sclerotinia* stem rot and *Diaporthe,* or pests, like bean seed fly, currently have a minor impact in Germany. Nevertheless, cultivation breaks between *Sclerotinia* host plants (e.g. rapeseed or sunflower) should be at least four years.

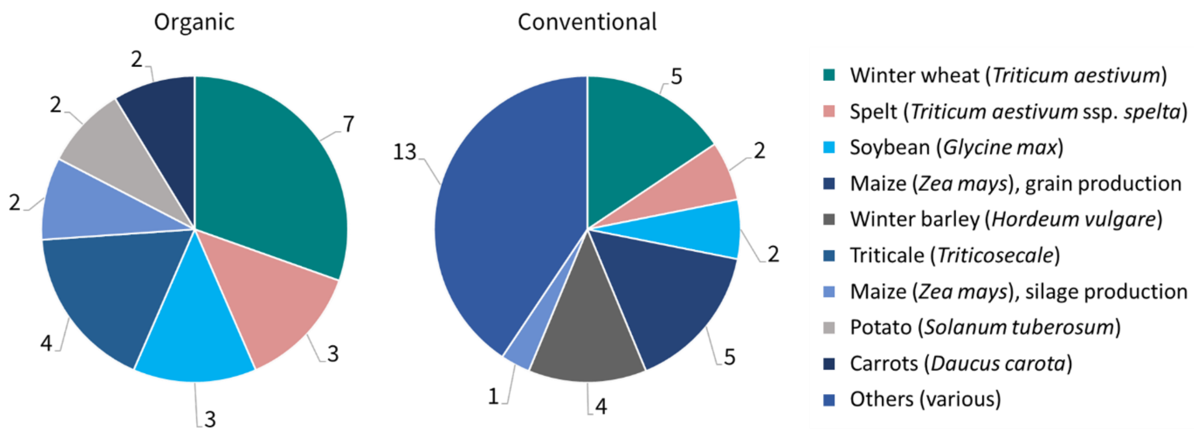

Figure 5. Frequency of the preceding crop to soybean on organic (left) and conventional (right) farms in a survey of 17 farms (8 organic, 9 conventional) in South-West Germany in the years 2015 – 2017

Characters: 1084

Native Language: German

Wie sieht die ideale Fruchtfolge für Soja in Süddeutschland aus?

Auch wenn Soja im Gegensatz zu vielen andere Leguminosen als selbstverträglich gilt, sollte sie langfristig innerhalb einer Fruchtfolge mit einer Anbaupause von mindestens drei Jahren angebaut werden. Die Abfolge der Kulturen kann sowohl im Ökolandbau als auch in konventioneller Bewirtschaftung sehr vielseitig gestaltet werden.

Die Sojabohne hat einen hohen Vorfruchtwert, da sie als Leguminose atmosphärischen Stickstoff fixiert und durch ihr ausgeprägtes Wurzelsystem eine gute Bodenstruktur hinterlässt. In Süddeutschland haben Getreidearten wie Winter- und Sommerweizen, Wintergerste, Dinkel und Triticale einen sehr hohen Anteil in Soja-Fruchtfolgen. Als Vor- und Folgefurcht wird am häufigsten Winterweizen genutzt. Durch ihre langsame Jugendentwicklung ist Soja nur wenig konkurrenzstark gegenüber Beikräutern. Als Vorfrucht bietet sich daher eine unterdrückende und gelichzeitig stickstoffzehrende Kultur an (z.B. Mais oder Wintergetreide,). Der geringe Stickstoffgehalt im Boden nach Getreide oder Mais regt die Knöllchenbildung durch die Rhizobien an und unterstütz dadurch die Stickstofffixierung. Krankheiten wie *Sclerotinia* und *Diaporthe* oder Schädlinge wie die Bohnensaatfliege spielen im Sojaanbau in Deutschland spielen derzeit noch eine untergeordnete Rolle. Trotzdem sollte zu anderen Wirtspflanzen von *Sclerotinia* (Raps oder Sonnenblumen) eine Anbaupause von mindestes vier Jahren eingehalten werden.

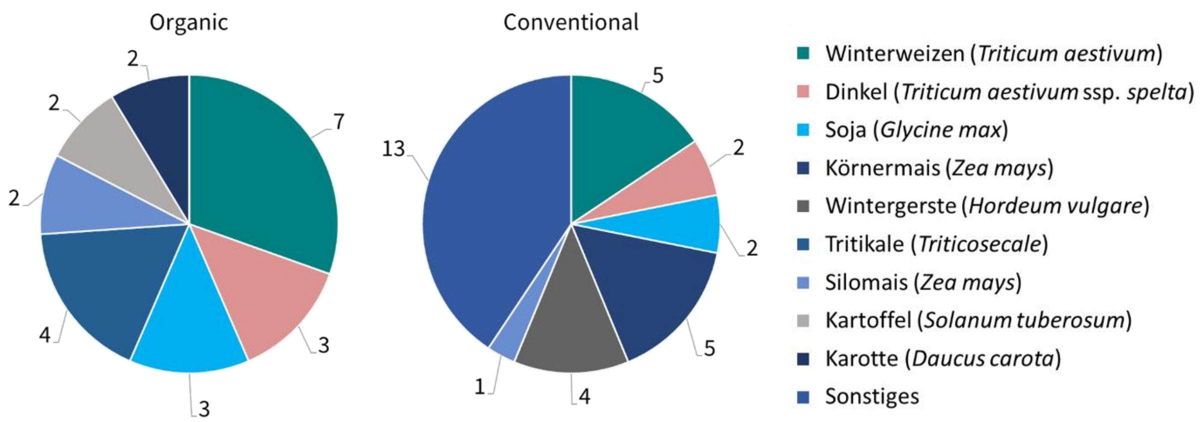

Figure 6. Häufigkeit der Folgekulturen zu Soja in ökologischer (links) und konventioneller Landwirtschaft bei Untersuchungen von 17 Betrieben (8 ökologisch, 9 konventionell) in Süd-West-Deutschland in den Jahren 2015 – 2017.

Characters: 1242

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Intercropping legumes with cereals to improve pest and weed control

Legumes provide multiple benefits in arable systems, but are prone to weed, pest and disease infestation and suffer from inconsistent yields. Intercropping legumes with cereals can overcome some of these agronomic challenges.

Large plots (120 m x 3 m) of spring pea cv. 'Daytona' and spring barley cv 'Laureate' were sown as pea-barley mixtures (at 40 and 60 % of the standard sowing densities, respectively) and crop monocultures in Scotland (near Dundee) in 2018 and 2019. Pest and disease damage was generally low in both years. Weed pressure (weed %cover or biomass) varied between years and was generally higher in monocultures compared with mixtures due to better crop cover and light interception in mixtures. Aphid abundance on pea was highest in monocultures and was reduced in mixtures; aphid abundance on barley was low. Aphid suppression in mixtures could be due to the lower density of pea plants (creating a physical barrier to aphid spread). Crop biomass and grain yields were highest in mixtures compared with monocultures.

Intercropping with cereals can reduce weed and pest infestation in legume crops and increase overall crop productivity. This is particularly relevant for low input and organic systems where crop protection products are not used. Cereal-supported intercropping of grain legumes could help to reduce production risks and input dependencies associated with growing grain legumes as monocultures.

Characters: 1212

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Figure 7 & 8. Pea-barley intercrops, *Photo credits ©: Ali Karley*

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How can legumes help in biomass production?

As monocrops, legumes offer only non-commercially competitive quantities of biomass for feed, silage, or anaerobic digestion. However, as components of intercrops they significantly increase nutritional provisions, crop abiotic- and biotic-stress resilience, and productivity, as well as fertility-building for subsequent crops.

A series of autumn-sown trials in Scotland were carried out assessing intercrops of winter-cereals (wheat, barley, oats, rye, triticale) with winter-legumes (peas, faba beans, vetch) at several locations, seasons, fertiliser rates, proportions, component numbers, and varieties. These were cut as 'whole crop', wilted, baled for fresh- and dry-weight, plus digestibility analysis.

Peas and vetch contributed positively to yield and quality if grown at low fertiliser rates and appropriate variety-proportion combinations. Faba bean water content tended to be too high. Oats and rye together or separately were the best cereal components for yield. Barley and wheat contributed to quality but performed poorly under low nitrogen. High proportion of peas, beans, and oats gave positive yield effects on subsequent cereal crops directly drilled into their stubble. Cereal density must be sufficiently high for weed control. The addition of ryegrass to mixtures allows post-harvest grass-biomass cut (precipitation permitting).

For highly productive winter biomass production, it is recommended to choose competitive legume varieties at appropriate densities and low nitrogen fertiliser rates in intercrop combination with oats, rye, and other cereals.

Characters: 1362

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Figure 9: Plot-scale complex mixtures trial nearing marturity for biomass assessment - [Balruddery Research Farm | The James Hutton Institute](). Photo credits ©: Adrian Newton

Selection of clovers for living mulches

Clover living mulches can be a tool contributing to multifunctional benefits when well-managed. For example, evidence suggests they can help reduce reliance on agrochemical inputs, such as nitrogen fertiliser. It is important to select a clover species and variety that will work with the crop they are partnered with, with consideration of machinery and management options, as well as crop structure.

White clover (*Trifolium repens*) and Alsike clover (*T. hybridum*) are low-growing perennial species with reasonably good longevity and frost tolerance, and modest nitrogen fixation. Their prostrate growth habit makes them useful when undersown to cereal crops, as machinery can be set so that the clover does not interfere. Red clover (*T. pratense*) is a perennial species with deep rooting and good nitrogen fixation. Its upright growth habit means that it is more suitable with taller crops, such as maize, to avoid interference with machinery. Crimson clover (*T. incarnatum*) is an annual species of moderate height, limited frost tolerance, and which can give rapid soil fertility boosts, but will die back after flowering. Persian clover (*T. resupinatum*) is a fast-growing annual producing much biomass, but with very limited frost tolerance. Berseem clover (*T. alexandrinum*) is the least frost tolerant clover, which can support incorporation into the soil before following crops, and reduced interference with machinery at harvest.

Each species has different benefits, and specific varieties might further supplement these. Advice should be sought from farm advisory services, agronomists, and seed companies to select the best-suited species and varieties for local conditions, and for the desired clover behaviours and outcomes.

Characters: 1477

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Figure 10. Wheat clover. *Photo credits ©: Jennifer A. Banfield-Zanin*

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Crop rotation schemes for organic common bean production under mild-winter climatic conditions

Common bean (*Phaseolus vulgaris* sp.) is the most cultivated legume crop globally for human food production due to the high nutritional and organoleptic value of its pods and seeds. However, the growth of common bean and the achievement of high yields is mainly dependent on nitrogen (N) supply through fertilisation due to its poor N-fixing capacity. As the excessive application of inorganic N fertilisers to highly productive conventional cropping systems results in groundwater contamination with nitrates, organic farming systems could exploit the benefits of common bean cropping to reduce environmental burden. Cultivating a cool season legume with high N fixing activity, such as faba bean, as green manure crop during the winter optimises the N availability in soil and therefore, the yield of the subsequent organic common bean crop. Green manure application can boost the yield of organic common bean at conventional standards, while producing pods and seeds with greater quality performance. In addition to this organic farming practice, inoculation of either faba bean or common bean with efficient rhizobia and maintaining an adequate phosphorus availability in soil enhances the N-fixing activity of the above legume crops, reducing dependency on inorganic N and P applications.

Characters: 1098

Native Language: Greek

Πρόγραμμα εναλλαγής καλλιεργειών για βιολογική καλλιέργεια φασολιού υπό ήπιες χειμερινές κλιματικές συνθήκες.

Το φασόλι είναι μία ευρύτατα διαδεδομένη καλλιέργεια ψυχανθούς παγκοσμίως λόγω της σημαντικότητας της υψηλής θρεπτικής αξίας των παραγόμενων λοβών και σπερμάτων στην διατροφή του ανθρώπου. Ωστόσο, η ανάπτυξη και η απόδοση της καλλιέργειας εξαρτάται κυρίως από τις εξωτερικές εισροές του αζώτου εξαιτίας της περιορισμένης ικανότητάς του φυτού να αζωτοδεσμεύσει. Καθώς η υπερβολική εφαρμογή ανόργανων λιπασμάτων αζώτου (N) στα συμβατικά συστήματα υψηλών αποδόσεων οδηγεί σε μόλυνση υπόγειων υδάτων με νιτρικά, η βιολογική καλλιέργεια φασολιού αποτελεί μία πιο φιλική προσέγγιση ως προς το περιβάλλον, αποκομίζοντας ταυτόχρονα τα διατροφικά οφέλη της καλλιέργειας. Η καλλιέργεια ενός ψυχανθούς, ως χλωρή λίπανση, με υψηλή αζωτοδεσμευτική ικανότητα κατά την χειμερινή καλλιεργητική περίοδο βελτιώνει την διαθεσιμότητα του αζώτου, επομένως και την παραγωγή, της ακόλουθης καλλιέργειας φασολιού κατά την εαρινή καλλιεργητική περίοδο. Ειδικότερα, η εφαρμογή χλωρής λίπανσης μπορεί να αυξήσει τις αποδόσεις της βιολογικής καλλιέργειας φασολιού στα επίπεδα αυτών της συμβατικής, παράγοντας ταυτόχρονα λοβούς και σπέρματα με βελτιωμένη θρεπτική και ποιοτική αξία. Εκτός από την παραπάνω βιολογική καλλιεργητική τεχνική, ο εμβολιασμός του φυτού είτε της κουκιάς είτε της φασολιάς με αποδοτικά αζωτοδμευτικά βακτήρια και η διατήρηση του φωσφόρου στο έδαφος σε υψηλά επίπεδα βελτιώνει την ικανότητα των ψυχανθών να αξιοποιήσουν το άζωτο που περιέχεται στην ατμόσφαιρα, εξαρτώντας λιγότερο από εξωτερικές εισροές αζώτου μέσω της λίπανσης.

Characters: 1319

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Processing of legumes for food

Update to brewing abstract – Pulses as an adjunct in beer production

In the production of any alcoholic beverage, one must understand the character of the starch present, how to convert them to fermentable sugars and separate the sugar-rich liquid from insoluble materials. Both steps occur during the mashing process of beer making and involves a temperature-holding step 63-64°C. This allows starch gelatinisation and enzyme action to occur. For pulses, this temperature is too low, and a cooking step is required to gelatinise and allow enzymatic degradation of its starch to occur prior to adding barley. While legume starch character varies across species, 80°C was found to allow hydration and disruption of most legume-starch granules tested. In addition, and unlike some cereals, legumes lack the necessary starch degrading enzymes. The use of pulses may also present high levels of undegraded cell wall components such as β-glucans and arabinoxylans which thicken the wort leading to filtration and extract recovery problems, as well as final product quality issues such as haze formation. The extent of these issues is pulse-species specific, e.g., faba bean. To address these issues, it is necessary to add commercially available proteolytic and starch degrading enzymes.

Recommended milled faba bean kernel processing steps are as follows.

1) Pre-treatment of flour slurry at 40°C in the presence of protease.
2) Precook at a minimum of 80 °C for 1 hour in the presence of alpha-amylase.
3) Mash the malted barley etc as normal using the cooked legume slurry as a portion of the mashing in water.
4) Proceed using normal brewery procedures (mash, boil, cool, and ferment).

Characters 1361

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Marketing of legumes for food

Organizing a PGI/PDO labelled product (dried pulses)

Consumers are becoming increasingly interested in the origin of their food, which creates demand for products that are certified with labels like the Protected Geographical Indication (PGI) or Protected Designation of Origin (PDO).

PGI/PDO labels are relevant for dried pulses, as they promote the origin of the product as a key quality parameter. The labelled products are sold at higher prices than comparable dried pulses. You can find PGI/PDO labelled pulses in supermarkets, specialty food stores, web sites or farm shops. Labelled products may also be relevant to restaurants, canteens or in public procurement settings. The appeal of PGI/PDO labelled products span across local markets to export markets.

A label for a PGI/PDO product (e.g. dried pulses in a consumer-ready packaging) requires an organizational set-up involving growers, facilities for cleaning and packing the crop, and a distribution network. A coordination unit, such as a visionary farmer, must be present to connect the supply chain and formalise the organization, which includes keeping control of the seed material for the specific crop and documenting traceability. The coordination unit is responsible for compliance with the rules of the PGI/PDO scheme. There should be a marketing strategy that emphasizes the local specialty features of the crop e.g. a special variety, special conditions for cultivation, culture and tradition, or other quality attributes.

Characters: 1227

Native Language: Danish

Organisering af produkt (tørrede bælgfrugter) med PGI/PDO mærke

Forbrugerne er interesserede i at kende oprindelsen på fødevarer og det skaber en efterspørgsel efter produkter med oprindelsesmærkning som f.eks. Beskyttet Geografisk Betegnelse (PGI) eller Beskyttet Oprindelses Betegnelse (PDO).

PGI/PDO certificeringer er relevante for tørrede bælgfrugter, da disse mærker fremhæver produktets oprindelse som en kvalitets-egenskab. De mærkede produkter sælges til en højere pris end tilsvarende ikke-mærkede bælgfrugter. Produkter med PGI/PDO mærkning sælges gennem supermarkeder, specialforretninger, hjemmesider eller gårdbutikker. Mærkede produkter kan være relevante for restauranter, kantiner eller i den offentlige forplejning. Der kan være interesse for et PGI/PDO mærket produkt i et lokalt område eller på et eksportmarked.
Det kræver en organisering af forsyningskæden at få et PGI/PDO mærket produkt på markedet, f.eks. tørrede bælgfrugter i en forbrugerpakning. Organiseringen omfatter avlerne, faciliteter der kan rense og pakke produktet, og et distributionssystem. Måske er en visionær landmand den, der koordinerer den formelle organisation, og det omfatter også kontrol med udsæd og opfyldelse af dokumentationskrav. Den koordinerende enhed har ansvaret for at produktet lever op til kravene for PGI/PDO mærkerne. Der bør være en markedsføringsstrategi som fremhæver de lokale kvaliteter

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af produktet, f.eks. i form af en særlig sort, særlige forhold med indflydelse på dyrkning, kultur og tradition, eller andre kvalitetsparametre.

Characters: 1287

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Figure 11: PGI/PDO labels

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Nordic consumers' preferences for meat alternatives

Nordic consumers' awareness of diets and climate impact from food production creates a demand for products made with pulses in the market. Nordic consumers seek plant-based products to reduce or replace their meat consumption in an attempt to improve their personal health or reduce climate impact. They understand it is necessary to cut down on meat consumption to mitigate greenhouse gas emissions from animal production, and the health risks associated with high consumption of meat and animal fats. It is very important for Nordic consumers that these meat alternatives appeal to their taste and liking. A typical product in the Nordic food market is plant-based burgers made with pea protein or soya protein, vegetables and mushrooms, and spices. The core consumers of these products are the young generation (age group 20-30 years) and the seniors (age group 50-60 years). The former group is motivated by the reduced climate impact and "doing something good" whilst the latter is motivated by personal health and climate impact.

Plant-based meat alternatives are expensive in the Nordic food market. Producers of plant-based meat alternatives (burgers, nuggets, and similar products) actively inform consumers about their reduced environmental impact in their marketing. Information about the origin of the ingredients is also used for marketing purposes.

Characters: 1155

Native Language: Danish

Nordiske forbrugeres præferencer for kødalternativer

De nordiske forbrugeres bevidsthed om kost og klimapåvirkning fra fødevareproduktion stimulerer efterspørgslen efter produkter fremstillet af planteproteiner. Forbrugerne i Norden efterspørger disse produkter for at mindske eller erstatte indtag af kød. Forbrugerne køber plante-baserede kødalternativer ud fra motiver om sundhed eller klimapåvirkning. Forbrugerne ved, at det er nødvendigt at skære ned på kødforbruget for at reducere udledning af drivhusgasser fra husdyrproduktion og, forbrugerne er opmærksomme på sundhedsrisici forbundet med et højt indtag af animalsk protein og fedt. Det er vigtigt for forbrugerne i Norden at de produkter, der udbydes som erstatning for kød opfylder forventningerne til smag og spiseoplevelse. Et typisk produkt på det nordiske marked er burgere fremstillet af planteproteiner (f.eks. fra ærter eller sojabønner), grøntsager, svampe samt krydderier. Kernemålgrupperne for produkterne er aldersgrupperne 20-30 år og 50-60 år. Den første gruppe er især motiveret af en reduceret klimapåvirkning og det at "gøre noget godt for verden", og den sidstnævnte gruppe motiveres af personlig sundhed og påvirkning på klima og miljø.

Plantebaserede kødalternativer er dyre produkter i det nordiske marked. Producenterne af den type produkter (burgere, nuggets, og lignende) anvender oplysninger om reduceret klimapåvirkning som en væsentlig del af deres markedsføring til forbrugerne. Oplysning om oprindelse af ingredienserne kan også indgå i markedsføringen.

Characters: 1288

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Legume supply chains

Pulse consumption: potential drivers and barriers towards a sustainable diet

The population growth worldwide poses significant challenges in food production, further aggravated by the low area of arable land suitable for crop production. Therefore, it is necessary to rethink current food production and consumption patterns. This study aimed to characterise current pulses consumption in adults and to describe the potential drivers and barriers to the inclusion of this source of protein in the diet. Using a quantitative approach, a semi-structured questionnaire was distributed online, and 1174 valid responses were obtained. The most consumed pulses were beans and peas, consumed at least once a week by 48% and 44% of the participants, respectively. When participants were asked about the possibility of replacement, even partially, of animal products for pulses, 15% stated they would not substitute even in a food scarcity scenario. In the qualitative study, ten individuals involved at different stage of the pulses' supply and value chain were interviewed to study behaviours and experiences linked to knowledge and consumption of pulses. Their underrated nutritional value, the high cooking time and the effect of the anti-nutritional factors were commonly pointed out as barriers. Therefore, for the successful replacement, even if partially, of meat by plant-based protein alternatives, like pulses, it is essential to involve different stakeholders in the agri-food chain. Agricultural and nutritional policies should be developed or adjusted, aiming to optimise food availability and the population's health and to promote environmental sustainability. These strategies should include encouraging farmers to produce pulses and to invest in polycultures and more sustainable farming methods.

Characters: 1478

Native Language: Portuguese

Consumo de grãos de leguminosas: potenciais motivadores e barreiras para uma dieta sustentável

O aumento da população mundial coloca desafios relevantes para a produção alimentar, agravado pela limitada área de terreno adequada à produção agrícola. É, portanto, necessário repensar os padrões atuais de produção e consumo de alimentos. Este estudo pretendeu caracterizar o consumo de leguminosas em adultos e descrever os potenciais motivadores e barreiras para a sua inclusão na alimentação. Primeiro, foi distribuído um questionário semiestruturado online, tendo-se obtido 1174 respostas válidas. As leguminosas mais consumidas eram o feijão e a ervilha, consumidos pelo menos uma vez por semana por 48,3% e 44,4% da amostra avaliada, respetivamente. Quando os participantes foram questionados sobre a possibilidade de substituição, ainda que parcial, de produtos de origem animal por leguminosas, 15,0% afirmaram que não o fariam mesmo num cenário de escassez alimentar. Por forma a avaliar comportamentos e conhecimentos relativos ao consumo de leguminosas, foram entrevistados dez indivíduos ligados

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a diferentes etapas da cadeia de valor das leguminosas. O desconhecimento do seu valor nutricional, o elevado tempo de confeção e o efeito dos fatores antinutricionais foram frequentemente apontados como barreiras. Portanto, para o sucesso da substituição, ainda que parcial, da carne por alternativas vegetais, como as leguminosas, é fundamental o envolvimento dos *stakeholders* da cadeia agroalimentar. Políticas agrícolas e nutricionais devem ser desenvolvidas ou ajustadas visando otimizar a disponibilidade de alimentos e a saúde da população, bem como promover a sustentabilidade ambiental. Estas estratégias devem incluir o incentivo para produzir leguminosas de forma sustentável, bem como métodos agrícolas mais sustentáveis.

Characters: 1499

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Figure 12. Different types of legumes, *Photo credits ©: Mariana Duarte*

Guidance to the small-scale, organic growing of selected grain-legume species

The production and consumption of legume grains is very low in Hungary. However, domestic crop seed- or gene-banks maintain significant collection of indigenous grain-legume types, termed 'land races'. Based on a 4-year cultivation experiment, assessing land-race varieties cultivated at small-scales organic gardens, the following key practical findings which are targeted to small-scale producers of all kinds: farmers, kitchen-garden owners, community gardeners – all who want to immerse in the rich culinary world of beans - can be made.

1. Apart from the commonly grown *Phaseolus vulgaris* (common bean), 6 further neglected, or at least little-known species can be successfully grown at small scales. These are: *Cicer arietinum* (chickpea); *P. coccineus* (runner bean); *P. lunatus* (lima or butter bean); *P. acutifolius* (tepary bean); *Vigna sinensis* (cowpea sp.), *V. unguiculata subsp. sesquipedalis* (asparagus or yardlong bean).

2. In addition to the central gene-banks, decentralized, community-based collections can be excellent sources of good quality seeds. These sources are also more likely to provide tested, well-performing species, with information on best-cultivation practices.

3. Changing climate, and the increasing frequency of atmospheric droughts, may cause significant yield-loss but drought-tolerant species and cultivars may still be found and successfully grown.

4. While the grain legume types are robust garden crops, they may still present growth challenges and suffer from pests. Yet, there are effective methods against these in organic farming.

5. These lesser-known legumes may also provide novel foodstuffs for the gastronomist: such as edible flowers, green chickpeas, green cowpea, and yardlong bean pods.

1491 characters

Native Language: Hungarian

Útmutató egyes hüvelyes fajok és tájfajták kisléptékű termesztéséhez.

A hüvelyesek termesztése és fogyasztása Magyarországon európai összehasonlításban is alacsony, ugyanakkor a hazai génbankok nemzetközi szinten is jelentős hüvelyes fajgyűjteményt őriznek. Négyéves termesztési kísérletünkre alapozva a tájfajták kis léptékű, biokertekben történő tesztelésével a következő legfontosabb gyakorlati megállapítások tehetők - kifejezetten kistermelők, konyhakert-tulajdonosok, közösségi- és balkonkertészek részére.

1. A leggyakrabban termesztett veteménybabon kívül további hat elhanyagolt, illetve kevéssé ismert fajt termesztettünk sikeresen kisüzemi, ill. kiskerti körülmények között: csicseriborsó, tűzbab, holdbab, tepary bab, tehénborsó vagy homoki bab és méteres bab.

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2. A központi génbankok mellett a decentralizált, közösségi alapú gyűjtemények is kiváló forrásai lehetnek a jó minőségű magoknak. Ez utóbbiak nagyobb valószínűséggel nyújtanak tesztelt, jól működő szaporítóanyagokat, illetve a növények növekedési módjával, termesztési gyakorlatával kapcsolatos információkat.

3. A változó éghajlat és az egyre növekvő gyakoriságú légköri aszályok jelentős termésveszteséget okozhatnak, de a szárazságtűrő fajok és fajták megtalálhatók és ilyen körülmények között is sikeresen termeszthetők.

4. A hüvelyesek nem tartoznak a legérzékenyebb kerti növények közé, mégis számos élettani problémával és – elsősorban polifág – kártevővel rendelkeznek. A biogazdálkodásban ezek ellen hatékony módszerek léteznek.

5. A kevésbé ismert hüvelyesek új alapanyagokat is szolgáltathatnak a gasztronómiához: például az ehető virágok, a zöld csicseriborsó, a tehénborsó és méteres bab zöld hüvelyei.

1425 characters

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Figure 13. Traditional hungarian dish with chickpea, Norbi_csicseri_teli, *Photo credits ©: Attila Káll*

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Decision support system Path Finder promotes sustainable legume path from farm to fork

The agri-food chain serves as a channel for the transmission of demand information from users to producers and supplies consumers with the required products. Due to the increasing demand for balancing the technological and economic development of society with the protection of the environment, the link between producers and consumers must meet strict sustainability criteria, which is a very complex challenge.

To address this, the TRUE project developed a decision support system (DSS) Path Finder. It provides a sustainability assessment of the individual links in the chain according to the environmental, economic, and social pillars, and the chain as a whole. Since the DSS provides sustainability assessment at different levels, it is designed to be used by different end-users, e.g., farms and businesses, and various government agencies and ministries. The Path Finder helps end-users to modify their management plans and production infrastructure to achieve their sustainable goals.

For example, relevant agencies and ministries can use the DSS to draft or modify sustainability strategies in the agriculture and food sector. In addition, it can be used to develop financial incentives for sustainable development. The application of the DSS at the individual farm, enterprise, and consumer levels can improve the sustainability of production, processing, and consumption. The Path Finder allows for simultaneous sustainability assessment of all elements of the agri-food chain (e.g., from farm to fork) and the integration of results across different levels. It also promotes the numerous environmental and human nutritional benefits of legumes, as well as synergies with several Sustainable Development Goals.

Characters: 1470

Native Language: Slovenian

Sistem za podporo odločanju Path Finder spodbuja trajnostno pot stročnic od kmetije do vilic

Agroživilska veriga omogoča, da potrošniki ponudnikom sporočajo potrebe po pridelkih in prehranskih proizvodih, pridelovalcem pa omogoča, da s pridelki in proizvodi oskrbujejo potrošnike. Zaradi vse večjih zahtev po uravnoteženju gospodarskega razvoja z varstvom okolja, mora agroživilska veriga izpolnjevati stroga merila trajnostni. To je izredno zahteven izziv, zato smo v projektu TRUE razvili sistem za podporo odločanju (DSS) Path Finder, ki uporabnikom omogoča oceno trajnosti posameznih členov in verige kot celote. Pri tem smo se osredotočili na verige s stročnicami. Trajnost ocenimo z integracijo izpolnjevanja kriterijev okoljskega, ekonomskega in socialnega stebra trajnosti. Ker DSS zagotavlja oceno trajnosti na različnih ravneh (členi verige, stebri trajnosti in celotna veriga), ga lahko uporabljajo različne skupine končnih porabnikov. Ti so namreč poleg kmetov in podjetnikov lahko tudi različne vladne agencije in ministrstva. Poleg ocene izpolnjevanja kriterijev trajnosti, Path Finder omogoča uporabnikom poiskati spremembe načinov in pogojev pridelave in proizvodnje, ki jim bodo zagotovili uresničitev zastavljenih trajnostnih ciljev. Na primer, ustrezne agencije in ministrstva lahko DSS uporabljajo za pripravo ali spremembe strategij in finančnih vzpodbud trajnostnega razvoja v kmetijskem in živilskem sektorju. Uporaba

DSS na ravni posamezne kmetije, podjetja in potrošnikov zagotavlja izboljšanje trajnosti proizvodnje, predelave in potrošnje. Path Finder omogoča celostni trajnostni razvoj agroživilskih verig (od kmetije do vilic) in vzpostavitev sinergij številnih okoljskih in prehranskih koristi stročnic s cilji trajnostnega razvoja.

Characters: 1453

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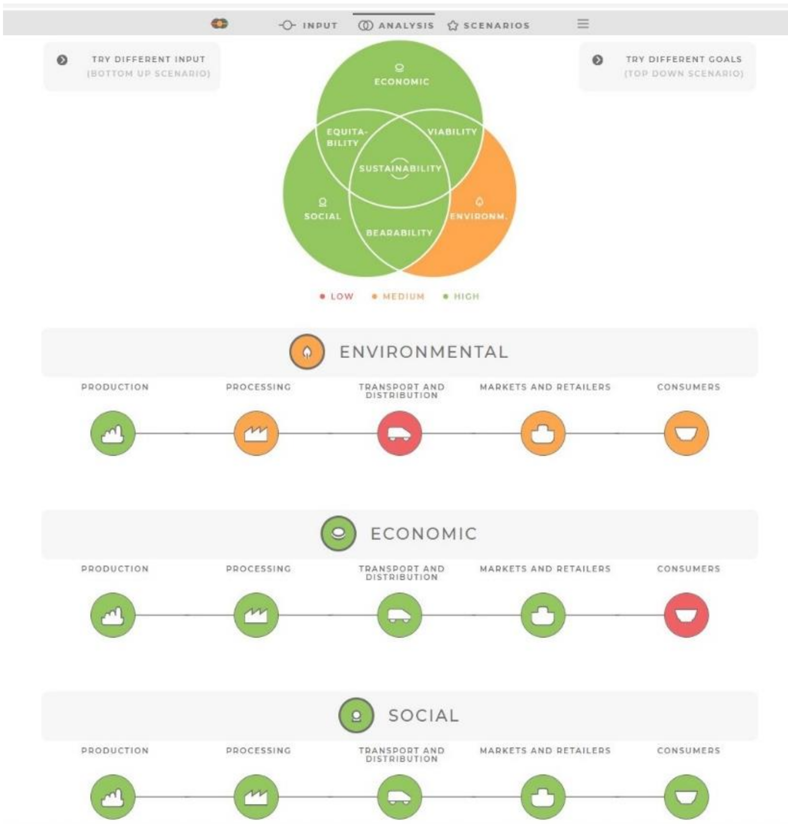

Figure 14. The results of the sustainability assessment of agri-food chain.

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Legumes and uptake – producers and consumers

While profits and economic sustainability of farms cultivating legumes are necessary, they may not always be sufficient and farmers' decision-making may be influenced by non-economic factors, e.g., perceptions of how what they create affect others (environment and human health). Similarly, consumers' choices may be influenced by environmental and health concerns as opposed to purely economic reasons.

Producers intentions towards legume uptake and consumers willingness to increase legume share in diets were analysed, which showed that socio-economic characteristics (education, profit orientation, farm-succession) have significant effects on producers' intentions to cultivate legumes. Other factors involved are: perceived usefulness of information; uptake of technologies; market influences on business; intentions to increase diversification, agri-environment, technological investment; and, previous changes to legumes cultivation.

Results of the analysis on consumers' willingness to pay for pulse-based mince in ready meals, and the role that labels for desirable food attributes can play to foster consumption show that flexitarians, vegetarians and pescatarians are potential consumers of pulse-based mince. We also found that demand for pulse-based mince by regular meat-eaters can be fostered if the product is promoted as high in protein and fibre, organic, British, and low in saturated fat.

While slow changes in consumption patterns to include legumes are apparent, they need to be translated into "home-grown" production patterns, and a higher integration of policies incentivising consumers towards healthier diets, and producers towards sustainable production is required.

Characters: 1467

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Appendix I: 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 sustainability*' – '*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 supply 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 LCA 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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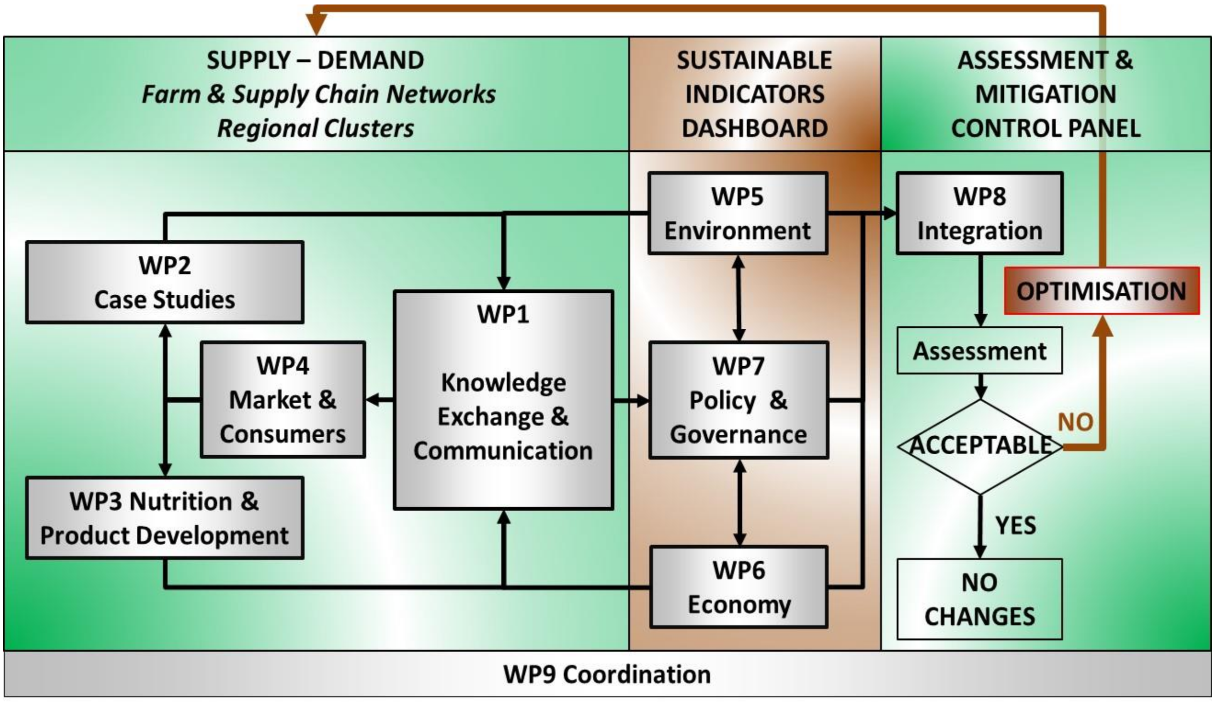
Work-package structure

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	Universitat Hohenheim (UHOH)	Germany	University
8	Agricultural University of Athens (AUA)	Greece	University
9	IFAU APS (IFAU)	Denmark	SME
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	Croatia	Development Agency

*Coordinating institution

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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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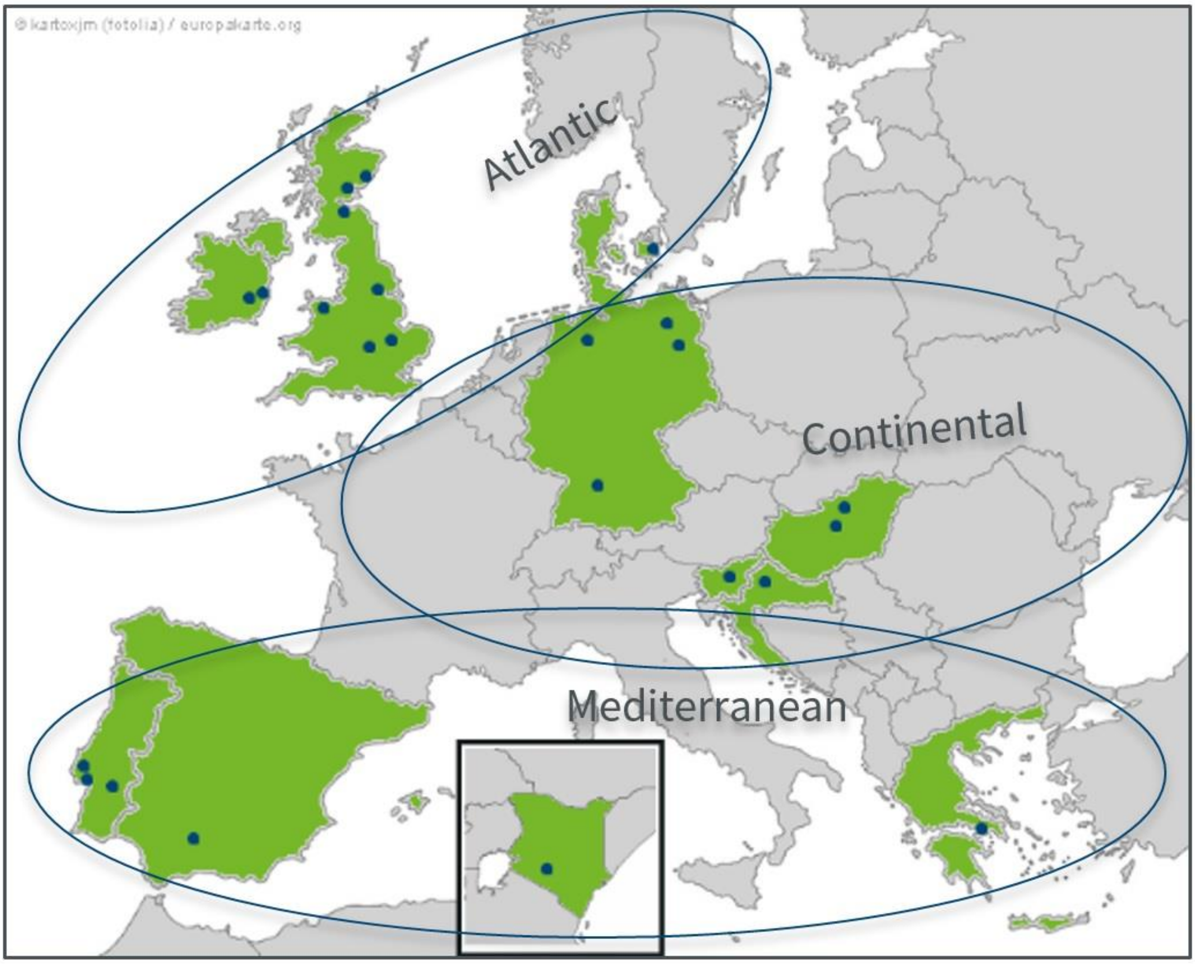
Legume Innovation Networks



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 biogeographical regions of Europe illustrated above within the ellipsoids for Continental, Mediterranean and Atlantic zones.

Acknowledgement

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