



LEGumes for the
Agriculture of TTomorrow



Newsletter

**A biannual bulletin of the EU KBBE project LEGATO,
aimed at increasing grain legume cultivation in Europe**

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<http://www.legato-fp7.eu>

Project report and 2nd annual meeting in Cordoba

By Richard Thompson

The meeting was held in December 2015 in the vice-chancellorship of the University of Cordoba, a splendid building erected at the end of the 19th century in a neo-Byzantine style reminiscent of the Mezquita and Cordoba's rich architectural heritage. The programme included, besides LEGATO workshops, a stakeholder event, with a wide range of invited speakers, including Andalusian representatives.

- 2nd Stakeholder meeting in Cordoba

The central theme was "Economic models and promotional measures", and the speakers included representatives from interprofessional associations (PGRO, Terres-Inovia), the Andalusian cooperative COVAP, a Portuguese pasture legume company, FERTIPRADO, and an officer from the DG-AGRI division of the European Commission. The accent was on the uses of legumes for feed in particular, the obstacles to their wider use and the possible solutions provided by current EU policy tools. The general conclusion was that, despite their environmental assets, and although a very good source of protein for feedstock, in order to significantly increase the area sown to grain legumes, the yield instability problems must be tackled to render these crops profitable for farmers. Without this progress, they will only occupy niche markets and continue to be heavily dependent on subsidies, a situation which is insecure in the long-term.



LEGATO consortium, vice-chancellorship of the University of Cordoba

EU review of LEGATO

The LEGATO project was reviewed by the European Commission in October 2015. The reviewers nominated by the EC were Prof. M. Ines MINGUEZ (Universidad Politecnica de Madrid) and Prof. Ivana MAKSIMOVIC (University of Novi Sad). The overall assessment of the reviewers was very encouraging, whilst pointing out several areas that will need vigilance to ensure the best possible outcome for the project. The reviewers drew our attention to the importance of adhering to the timetable of the work plan to be in a position to deliver all of the promised results by the end of the project (December 2017). They made some further useful suggestions, for associating new stakeholders in the area of farm machinery for example, and some recommendations for our website that have been implemented. We clarified a number of queries and improved one deliverable with the result that the review was accepted by the Commission in December 2015. The coordinator would like to thank all those who contributed to this evaluation for their reactivity.

International year of pulses - 2016

In 2013 the United Nations declared that 2016 will be the International Year of Pulses (<http://www.fao.org/pulses-2016/en/>). Since that announcement, the IYOP steering committee has piloted and stimulated many pulse-related events worldwide, which can be found on the GPC website (<http://iyp2016.org/>).

To encourage everyone to consume pulses regularly, the Pulse Pledge has been created (<https://pulsepledge.com/>). Signatories agree to eat pulses at least once a week. For the more enthusiastic, subsequent promotion to being a Pulse Pro is the natural progression, this implying the consumption of pulses at least three times per week. A wide range of recipes is proposed to facilitate integration of pulses in the diet



Evolution of support for protein crops

Presented at 2nd Stakeholder meeting in Cordoba

Bence Major from the DG-AGRI at the European Commission presented Protein crops: EU Market situation and related Common Agricultural Policy tools. From year 2003, a single payment scheme for eligible hectares was implemented. This scheme covered only three legume species: pea, white lupine and field beans as additional stimulation apart from cereals. After reform of the CAP (2008) support was decoupled from protein crops and only three member states stimulated growing protein cover crops. In 2013., significant CAP reform divided support in two pillars and implemented three new principles: competitiveness, sustainability, territorial balance. Another new mechanism was Voluntary Coupled Support (VCS) and greening. Special provision for protein crops was made to maintain the protein-based autonomy of the breeding sector and support the production of protein crops, which can increase VCS percentages by up to 2%. Also, the definition of protein crop has changed and may include peas, beans, sweet lupins but also soya beans and alfalfa. Direct payments are coupled with greening: crop diversification (at last two/three crops) and choice of farmer to have 5% of arable land designated Ecological Focus Area, such as fallow land, landscape features, buffer strips. Apart from CAP reform, the protein crop still lacking competitiveness: market orientation leading to decline in production. Also, limitations of arable area in the EU limit protein crops. The environmental benefits of protein crops are recognized but improved performance is also needed.

*Sown Biodiverse Legume Rich
Permanent Pasture and Forage
Crops*

Presented at 2nd Stakeholder meeting in Cordoba

David G. Crespo from Fertiprado, Portugal presented their experience in legume production, pasture and forage crops in Mediterranean region under climate changes. Traditional pasture / forage crops in Mediterranean region are natural or sown pasture and forage crops (oats, barley, rye, triticale, ryegrass; little use of legumes). The biggest problem is low productivity related to low soil organic matter, low phosphorus, low water holding capacity, and susceptibility to erosion. However, most of the EU Mediterranean Region has excellent conditions for growing pastures, which can be grazed throughout the year. Climate change will affect production, including higher frequency of long periods of drought, concentrated rainfall inducing floods and temporary soil waterlogging and increased air temperature. Sown Biodiverse Legume Rich

Permanent Pasture and Forage Crops (SBLRSP&FC), a practice developed in Portugal after the middle sixties can improve animal production and remediate degraded lands in a sustainable way. It is, based on the formulation and use of mixtures of a large range of species and cultivars (10 to 20 for permanent pastures, 6-10 for forage crops), mainly of legumes, but also grasses and eventually other plants. Biodiverse legume rich mixtures minimize the effects of climate change, assure a good vegetation cover in patchy soil conditions and minimize the effects of grazing mismanagement. SBLRPP may sequester 3-12 t of atmospheric CO₂/ha/year thus increasing soil fertility. There are more than 20 million ha of natural pastures in the EU Mediterranean countries, a significant part of which can be converted into SBLRPP, in order to increase the production of high quality meat (and milk) on grazed pastures and, simultaneously, minimize the consumption of concentrate feed and synthetic N fertilizers.



Sown Biodiverse Legume Rich Permanent Pasture and Forage Crops

FORTIFYING OUR DAILY BREAD: EXAMPLE OF BROA

By Carla Brites

Fortification of bread with legume flour has been a great challenge for INIAV researchers and Patrimvs bakers. Our goal in the beginning was to produce a gluten free maize bread and Patrimvs has already started a certified gluten-free bakery. However, tests conducted on some legume and maize flours showed traces of gluten. Hence, it was decided to incorporate legumes flours in our traditional maize bread called *broa*. *Broa* is Portuguese ethnic bread comprised of more than 50% maize flour mixed with either wheat or rye flours. This bread is very well-known by the Portuguese people and eaten separately during the meals.



The quality of maize flour, major ingredient of *broa*, assumes primary importance which determines the consumer perception. Consequently, first approach was the optimization of legume formulations considering the influence of maize flours variability. A set of baking tests were performed with regional and industrial maize flours blended with pea, chickpea, faba bean and lentil species, respectively. The consumer evaluations considering the overall acceptability and set of attributes (e.g.: hardness, elasticity, sourness, salinity) are being accounted by contracting a specialized sensory test company (Sense Test). Legume flours used in the formulations directly exceeds the cost of traditional *broa*, however, high nutritional quality motivations and health concerns affect choices of an aware consumer. This will be confirmed by an experimental auction with a consumer panel.

Finally, the sensory profile testing of selected fortified broas will be performed with a panel of trained tasters.

Broa

Diversity of grain legume cropping systems

By Georg Carlsson

The LEGATO work package 5 assesses the effect of novel cropping system diversification approaches on production, yield stability, symbiotic performance and biotic stresses in grain legume crops. The agronomic performance of diversified grain legume crops and crop rotation sequences is evaluated in field experiments across Europe, with a core selection of experimental treatments that are common at sites in France, Serbia and Sweden. Interestingly, two Serbian pea varieties have been successfully established and assessed in field experiments across contrasting pedo-climatic conditions – as winter peas in France and spring peas in Sweden. The two pea varieties have different leaf morphology: one is normal-leafed and the other is semi-leafless. The experiments will reveal whether a mixture of the two varieties can reduce weeds compared to sole crop of semi-leafless pea, and whether this benefit can be obtained in synergy with reduced lodging compared to sole crop of normal-leafed pea.

Another diversification approach that is tested across sites is the integration of perennial forage legumes as under-sown intercrops in grain legumes. This approach aims to reduce weeds and improve the establishment of the forage legume. At SLU, a new PhD project is linked to LEGATO by adding studies of the performance of a subsequent cereal crop in diversified crop rotation sequences containing grain legume sole crops and intercrops with cereals (see image), as well as under-sown forage legumes and forage legume-grass mixtures used as cover crops during the period between the grain legume and cereal

crops. On 7 June 2016, the Swedish LEGATO field plots were honored by the visit of the Nuffield Foundation scholar Andy Howard, who has performed an impressive collection of visits to farmers and scientists around the world to learn about different approaches to cropping system diversification <https://andyhowardnuffield15.wordpress.com> On 20 June 2016, SLU organized a seminar and field day about Swedish production and use of legumes for human consumption – as a celebration of the international year of pulses. Approximately 20 participants took the opportunity to hear about new applications of grain legumes in innovative foods, to follow Georg Carlsson’s demonstration of the LEGATO field plots and discuss benefits and challenges of crop diversification.



*Legume small grain mixture and trial visit at SLU.
Photo: Erik Steen Jensen*

*Establishment of chromosome segment substitution lines (CSSL) of wild *Pisum fulvum* in cultivated pea (*P. sativum*), as a tool for incorporating new traits in pea varieties*

By Zablazka Lenka and Petr Smykal

Plant evolution under domestication has led to increased productivity, but at the same time it has narrowed the genetic basis of the crop. Domesticated about 10,000 years ago in the Middle East, the pea domestication bottleneck has resulted in high degree of relatedness of cultivated germplasm, prone to pests and diseases. Many crop plants have benefited from incorporation of traits from related wild species. The challenges now are to reintroduce diversity into bred material, traits that have been lost or unused, including disease and resistance genes. The development of prebreeding lines is a means of facilitating the transfer of genes from wild species. To avoid genetic drag of undesirable linked traits, the synthesis of introgression lines (ILs) and chromosome substitution lines (CSSLs), containing chromosome segments from wild species in a constant genetic background of the cultivated species is used.

At Univ Olomouc, Czech Republic, LEGATO partners Zablazka Lenka and Petr Smykal have crossed wild *P. fulvum* into the pea varieties Terno and Caméor, and established a plant collection with different segments of wild species chromosome in the same genetic background. This greatly facilitates the incorporation of a specific “wild” trait (eg., disease resistance) into commercial pea varieties.



Pea substitution lines

Innovations in Phenotyping - Automated and high throughput phenotyping of root systems

By Christophe Salon and Christian Jeudy

Increasing nutrient and water use for high-yields under agroecological constraints requires an in-depth look at root architecture and performance. To date, the lack of devices suitable for high-throughput phenotyping of root structures has been a major bottleneck. In INRA Dijon (France), LEGATO partners C. Salon and C. Jeudy have set up the Phenotyping Platform for Plant-Plant and Micro-organism Interactions (4PMI). 4PMI is equipped with greenhouses and climatic chambers, where environmental conditions can be varied independently, in which conveyors transport plants automatically to watering stations and imaging cabins. In 4PMI very innovative tools have been developed for growth and phenotyping of roots of different plant species:

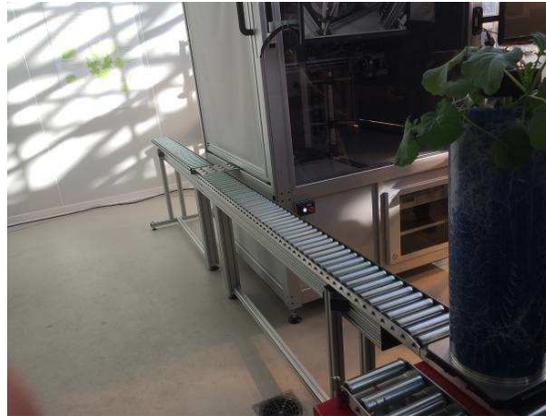
- **Rhizotrons** suitable for plant growth in controlled conditions and non-invasive image acquisition of plant shoot and root systems (**RhizoTubes**). These RhizoTubes are cylindrical rhizotrons that allow visual access to the entire root system of one to six plants.
- **RhizoCabs** High Throughput (RhizoCab HT) are phenotyping cabins designed to take images of the entire root systems of plants growing in RhizoTubes, and focus on some parts of the root systems. RhizoTubes are automatically conveyed, like pots, inside RhizoCab HT. Both shoot and root compartment can be imaged automatically and non-destructively throughout the experiment.

In a recent paper (Jeudy et al., 2016), the team demonstrated that Rhizotubes allow unbiased and reproducible measurement of plant responses to abiotic or biotic factors, contrasted species and/or genotypes of *B. napus*, *V. myuros*, *P. sativum*, *M. truncatula*, *V. vinifera* and *T. aestivum*. Plants were grown both in RhizoTubes and in pots, and exposed to similar variations in either nitrate or water availability, or inoculated with soil microorganisms, according to the experiments.

- RhizoTubes are flexible enough to allow growing plants from various species at several developmental stages. They allow similar plant growth to that observed in pots, for all the plant species studied.
- RhizoTubes are suitable for inoculating both symbiotic (rhizobia and arbuscular mycorrhizal fungi) and free-living microorganisms on plant roots. RhizoTubes can therefore be used to measure kinetically and non-invasively the interactions between plant roots and microorganisms.
- Growth processes (root elongation, increase in nodule biomass, nodulation waves etc) can be followed dynamically throughout a large span of its growth cycle. The resolution of the images allows detection of the thinnest roots and nodules.
- RhizoTubes allowed us to study shoot, root and nodule growth responses to drought or varying soil mineral availabilities in the same ranges as those observed in pots;
- RhizoTubes allow not only to compare plant genotype/species in similar environmental conditions but also to compare their ranking in their responses to environmental factors:
- During the root harvest, RhizoTubes allow the recovery of the entire root giving unbiased plant root biomass comparison during the various experiments.

This integrated system, which is being used within the LEGATO project, will include 1200 Rhizotubes, thus permitting high-throughput phenotyping of plant shoots and roots under various abiotic and biotic environmental conditions. The utility of this system for studying root system architecture will greatly facilitate the identification of genetic and environmental determinants of key root traits involved in crop responses to stresses, including interactions with soil microorganisms.

Reference: *Jeudy C, Salon C., et al (2016) RhizoTubes as a new tool for high throughput imaging of plant root development and architecture: test, comparison with pot grown plants and validation. Plant Methods (2016) 12:31.*



RhizoTubes

Pro-Bio recognition for LEGATO partner

ProBIO (<http://www.probio-project.eu/>) is a support action for KBBE projects which identifies KBBE research results to facilitate their uptake in the relevant commercial sector. ProBio has contacted LEGATO SMEs to evaluate their suitability for Pro-Bio services. As a result of these contacts, Decollogne has been selected for FTI funding to market its legume based flours in EU28. The assistance offered is in the areas of product and market development.

LEGATO activities and events

- ✓ Erik Steen Jensen participated in the First francophone conference on legumes, 31 May to 1 June in Dijon, France as chairman of the scientific and technical committee.
- ✓ J. Burstin and R. Thompson gave presentations at "Trésor des fèves et fleur des pois - the genius of legumes". Conference organized by the French Horticultural Society (<http://www.snhf.org/>), May 20th 2016.
- ✓ Paolo Annicchiarico held the speech titled "Innovative strategies for legume crop improvement in two international projects (LEGATO and REFORMA)" at "Legumes: for a more sustainable cropping system and improved diet", organized by the FP7 project EuroLegume.

- ✓ On May 27, 2016 LEGATO partner CREA-LFC in Lodi hosted a dissemination event for high-school students in the framework of the International Year of Pulses, in which they showed research work funded by LEGATO and other projects
- ✓ Francisco Madueño, from CSIC-IBMCP, Valencia, gave an invited talk in the 24th International Congress on Sexual Plant Reproduction, March 2016, Tucson, US. In the talk, “Evolution of floral initiation gene network to a compound inflorescence in legumes”, he discussed the genetic control of inflorescence architecture in legumes, particularly in pea, what has strong implications on yield
- ✓ At the Plant Europe EPSO-FESPB congress, held in Prague from 26 to 30 June 2016 the following LEGATO-funded scientists gave talks:
 - Combinational anatomical, chemical and genomic approaches to dissect pea seed dormancy, a key domestication trait - Petr Smýkal (Olomouc, Czech Republic)
 - Investigating belowground dynamics with MRI and PET - Ralf Metzner (Jülich, Germany)
 - Towards the genome sequence of pea: a tribute to Gregor Mendel - Judith Burstin (INRA, France)
 - Carpel code: A protein combinatorial system to direct gynoecium morphogenesis - Cristina Ferrandiz (CSIC, Spain)
- ✓ Georg Carlsson from SLU attended a Swedish seminar about grain legume production and uses for human consumption, organized by Eurolegume partner Fredrik Fogelberg, at JTI - Swedish Institute of Agricultural and Environmental Engineering, Uppsala, Sweden, 4 February 2016. Also, he attend a meeting organized by the Swedish Farmers Association about strategies to meet the goal zero net emissions of greenhouse gases by 2045, where he brought forward the multiple benefits of growing and eating more legumes. LRF – the Swedish Farmers Association, Stockholm, 12 April 2016.



Swedish stakeholders visiting the LEGATO field experiment at SLU, Alnarp (SITES field research station Lönnstorp) during a thematic day about legumes in Swedish agriculture and possibilities to grow and use more legumes for human consumption. Photo: Lisa Germundsson

- ✓ As one of the events sparked off by the IYOP in France, the “1ère Rencontres Francophones des Légumineuses” (1st French-speaking Gathering on legumes) were organized on May 31st and June 1st in Dijon. The congress attracted more than 260 participants from a wide public ranging from fundamental science to plant breeding and the food industry. Exchanges between participants were stimulated by “business to business (B2B)” encounters, and “pitches” of 5 minute presentations besides the more usual posters and lectures. LEGATO partners were

strongly represented in the programme and the audience, and among the subjects treated were the continuum between politico-economic incitation of production, the limits to yield, the limits to and potential benefits of, introduction of legumes in cropping systems, at the regional level, and in the human food product chain.

✓ The 10th-11th of March 2016, R. Thompson, D. Rubiales, and C. Salon attended a scientific workshop on the effects of biotic and abiotic stresses in legumes in Balcarce, Argentina, during which a presentation of the LEGATO project was made. The workshop, organized by FP7 ABSTRESS and the South American project BIOTECISOJASUR, was followed by a stakeholder event held in the Rosario Grain Stock Market, one of the largest in South America, and a visit to one of the impressively huge facilities for shipping grain at Rosario docks on the River Parana. Despite many differences in legume farming systems between Argentina and Europe, as the visit illuminated, the two projects exchanged on a vital common interest, the management of crops grown under water and disease stresses.



FP7 ABSTRESS and Biotechsojasur members visiting the San Lorenzo Grain shipping facility near Rosario, Argentina

✓ Claire Domoney and other researchers from JIC have engaged at many levels to promote research within LEGATO and national projects to a range of stakeholders, including breeders, growers, end-use industries, policy-makers and the general public. This has helped to raise awareness of how we function as an international legume research community, as well as raising the profile of pulse and legume crops more widely. Major talks have included presentation at the EUCARPIA International Symposium on Protein Crops (2015) and at the UK DEFRA GINs Conference: Uncorking the genetic 'GINie' for British crops (2016). Interviews with the press have led to radio broadcasts on BBC Radio 4 Farming Today and Future Radio, plus newspaper articles.



Tracey Rayner (John Innes Centre, Norwich, UK) discusses the potential of pea genetics with George Eustice, Minister of State, Department for Environment, Food and Rural Affairs (DEFRA, UK), at the UK DEFRA GIN conference, 2016

Forthcoming events

LEGATO 3rd annual meeting workshop will be held on 11 October 2016 in Troia, Portugal.

Second International Legume Society Conference – Legumes for a Sustainable World. Troia, Portugal 11-14 October 2016.



International Congress on Plant-Microbe Interactions, Portland Oregon, July 17-21 2016

European Society Of Agronomy congress (<http://esa14.org.uk/>), Edinburgh, September 5-9,2016

VIII International Conference on Legume Genomics and Genetics, Siófok, Hungary September 18-22, 2017

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LEGATO partners

