



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/

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Editorial

The EU-FP7-supported project LEGATO (legumes for the agriculture of tomorrow) reached the end of its four-year span in December 2017. This Newsletter reports on the major events that took place during the last year of the project, and includes research highlights that have emerged recently. Whilst it is too early to give a quantitative assessment of the project, it is clear that the LEGATO consortium has contributed key research in several areas that can help to promote legume cultivation and use. Furthermore, the European legume research community has been consolidated, and its vigour is reflected in the bouquet of recently launched H2020 projects in this area. The UN-initiated International Year of Pulses in 2016 has given a further timely boost, and hopefully, the impetus leading to an agroecological and dietary revolution, for which legumes are key, can be maintained.

Finally, this Newsletter gives me the opportunity to thank all LEGATO participants for their diverse contributions over the past four years, and to wish all readers every success in future.



Richard Thompson LEGATO Coordinator



LEGumes for the Agriculture of TOmorrow

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White lupin trait mapping and synteny with narrow-leafed lupin

The research groups of IPG Poznan, Poland (M. Książkiewicz, B. Naganowska, B. Wolko, S. Rychel, M. Tomaszewska) and CREA Lodi, Italy (P. Annicchiarico, N. Nazzicari, B. Ferrari) have produced a high-density consensus linkage map of white lupin and exploited it to map a few key agronomic traits

Quantitative trait loci (QTL) mapping in white lupin (Lupinus albus) has so far been limited by low marker density in the available consensus maps produced in 2007 and 2013, which contained about 400 markers. Genotyping-by-sequencing has been used to produce 3597 new sequence-defined SNP markers with correct segregation ratio. In total, 25 linkage groups were constructed (ALB01 - ALB25), consistently with the 25 chromosome pairs reported for this species. The new consensus map included 4050 markers, obtained by pooling the 3597 markers developed within Legato and 453 markers from two previous maps. The new map is a milestone achievement that enables high-resolution QTL mapping.

Our mapping work focused on three important agronomic traits within a recombinant inbred line



population, namely: (i) vernalization responsiveness, which influences genotype adaptation to European climatic regions; (ii) anthracnose resistance (the main lupin disease in Europe); and (iii) alkaloid content (low content being indispensable for food or feed use). Vernalization responsiveness proved to be controlled by four QTLs with explained phenotypic variance ranging from 6.5% to 41.9%. Anthracnose resistance was controlled by two major QTLs that explained jointly more than 40% of phenotypic variance. Alkaloid content was controlled by a single gene that mapped with the high-confidence LOD value of 37. For all QTLs we defined tightly linked, sequence-defined markers.

Efforts have been undertaken to implement these markers for genotyping of germplasm materials in breeding programs.

All QTLs were located in regions showing shared collinearity to the narrow-leafed lupin (L. angustifolius) genome. However, a key finding from our work was the different control of flowering and anthracnose resistance between the two lupin species, on the grounds of different number of genes involved (several QTLs vs single genes), different inheritance patterns (recessive vs dominant), and putatively different genes or homologs involved. This suggests a limit for our ability to exploit the genetic information made available by a close, genome-sequenced species such as narrow-leafed lupin, and reinforces the need for genome sequencing of white lupin. Also, our findings highlight the importance of GBS-based discovery of putative QTLs.

Reference : Książkiewicz, M., N. Nazzicari, H. Yang, M.N. Nelson, D. Renshaw, S. Rychel, B. Ferrari, M. Carelli, M. Tomaszewska, S. Stawiński, B. Naganowska, B. Wolko, P. Annicchiarico (2017). A high-density consensus linkage map of white lupin highlights synteny with narrow-leafed lupin and provides markers tagging key agronomic traits. Scientific Reports 7, 15335 https://www.nature.com/articles/s41598-017-15625-w





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Inoculation of pea and faba bean – a good insurance policy for efficient Nitrogen fixation?

The teams of Marc Lepetit (LSTM Montpellier) and Peter Young (University of York) have been investigating the requirement for inoculation in pea and faba bean cultivation in Europe.

European agricultural soils generally have substantial established populations of rhizobia that are able to nodulate pea and fababean effectively. These populations are genetically diverse, and strains differ in the level of benefit they provide to the host plants. Furthermore, their relative performance on pea and on faba are not necessarily the same. Inoculation with an elite strain should, in principle, be beneficial, although it will not always lead to a significant yield increase compared to nodulation by the established soil population. Selection of efficient bacteria, requires specific selection processes based on efficiency and competitiveness for nodulation of the associations. The traits have been measured for rhizobial isolates obtained from agricultural soil samples collected at several European sites. The molecular QQAD technique they have developed (ms in prep.) makes it possible to determine whether an effective soil population exists, and to estimate its genetic diversity. If uncertainty about the need for inoculation remains, it will generally be more cost effective just to inoculate, which may have substantial yield benefit and seldom has any negative effect.



Pea inoculation trial in Sweden (photo by Erik Jensen)

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Management of biotic stresses through intercropping

The intensification of modern agriculture has entailed a loss of biodiversity increasing the incidence and severity of pests and diseases. Crop diversification can mitigate this risk, as shown by LEGATO results.

Intercropping reduced incidence of powdery mildew and aphid in pea and of chocolate spot in faba bean: Field experiments performed at Cordoba, Spain during 2014-2017 showed (Spain) a reduced incidence of powdery mildew in pea when intercropped with faba bean, wheat or barley. Also, chocolate spot was reduced in faba bean intercropped with barley. Similar trials performed at Šumperk, Czech Republic during 2014-2016 showed a reduction of aphid infestation in pea intercropped with barley or wheat.

Variety mixtures reduced incidence of powdery mildew and weevil in pea: field studies performed at Córdoba showed a reduction of powdery mildew in mixtures of pea cultivars. Similar studies performed at Šumperk showed an effect on the distribution of weevils, which clearly preferred the early-flowering variety. Intercropping, on the contrary, did not affect weevil incidence.

It can be concluded from these works that both intercropping and varietal mixtures are promising tools for the control of biotic stresses, although it ought to be confirmed for more diseases and pests. These positive results should contribute to the extension of legumes in European agro-ecosystems.



Application of Multi-attribute Assessment of the Sustainability of Cropping systems (MASC) to Cropping System design

By E. Pelzer, C. Bourlet, G. Carlsson, E.S. Jensen, R.J. Lopez-Bellido, M.-H. Jeuffroy

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Our aim in T5.1 was to design locally adapted innovative cropping systems (CSs) including grain legumes for three European local pedoclimatic contexts (Scania in Sweden, Parisian Basin in France and Andalucía in Spain), to assess their sustainability with MASC[®], and to discuss their feasibility with stakeholders. MASC[®] is a hierarchical tree structuring and breaking down the assessment problem into sub-problems. Typically, the overall sustainability is decomposed in three pillars of sustainability, *i.e.*, economic, environmental and social sustainability. In MASC decision tree, all criteria are qualitative. Each pillar is split up into a set of basic criteria (e.g., profitability or NO₃ losses), inputs of the tool, also qualitative, describing the assessed CSs. MASC aggregates information towards overall sustainability through Utility Functions: "if then rules" translated in weight sets that can be changed by the users of the tools according to their preferences. Regional stakeholders meetings were organized in the three regions to discuss the feasibility of the designed CSs, and to collect their points of view on sustainability. For this objective, MASC[®] weight sets were proposed by each stakeholder, and a Principal Component Analysis on weight sets allowed us to identify four groups of stakeholders sharing the same point of view on sustainability. These four groups led to four different MASC[®] trees. Cropping systems were assessed for their sustainability using the four new MASC[®] trees, and the initial MASC[®] tree, where weights are proposed by default. Assessments differed according to the five trees. But some systems offered a compromise as they were assessed "good" or "bad" for a given criteria whatever the tree. The Innovative cropping systems were in general better than the reference system. Stakeholders from different countries, with different activities and different priorities proposed four weight sets corresponding to four different points of view

on sustainability. However, it was possible to find cropping systems including grain legumes that could be implemented in each region as they were considered feasible by stakeholders during discussions and assessed sustainable by MASC[®] whatever the stakeholder weight sets.



Example of overall, environmental, social and economic sustainability assessment of the French reference cropping system and one of the designed innovative cropping systems (see description in Pelzer et al. 2017) with the five MASC[®] tree (SH tree: Stakeholder tree)

Reference

Pelzer E, Bourlet C, Carlsson G, Lopez-Bellido RJ, Jensen ES, Jeuffroy MH, 2017. Design, assessment and feasibility of legume-based cropping systems in three European regions. Crop and pastures, 68,902-914.





Advance in grain legume cultivation and use – International Conference

The final joint conference of the two FP7 projects devoted to grain legumes was held in Novi Sad, Serbia, from 27-28. September 2017. The conference was divided into 6 thematic sessions: 1. Genetics and breeding, 2. Biotic stress resistances, 3. Enhancing legume quality - novel food & feed, 4. Defining ideotypes, root phenotyping and microbial interactions, 5. Agronomy, 6. Climate changes, stress adaptation & mitigation measures. The sessions were launched by five invited plenary lecturers: Professor Timothy Close (UC Riverside, USA), Professor Moira Dean (QU Belfast, UK), Dr. Stephanie Mittermaier (Fraunhofer IVV, München, D), Professor Mark Peoples (CSIRO, Canberra, AU), and Dr. Thomas Nemecek (Agroscope, Zürich, CH). The conference was opened by Dr. Sandra Bogdanovic, representative of Ministry of education, science and technological development, Republic of Serbia.

The conference attracted 132 registered participants from 45 different countries. In total, 40 oral presentations were held and 15 flash presentations.

The abstract book is available at:

http://www.legato-fp7.eu/FinalConference/pdfs/Book_of_abstracts_LEGATO_EUROLEGUME.pdf

During the conference, two stakeholder-driven round tables dedicated to the cultivation and to the use of legumes were held, which gave participants an initial feedback on the likely impact of the project, and possible avenues to follow in the future. The host institute IFVCNS kindly organized a press conference with leading Serbian journalists with the result that the event was widely reflected in the national media.



TRAINING COURSE: "Advances in breeding and agronomy for improving sustainability and quality of grain legume crops",

This 5 days advanced course was jointly organized by the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM), through the Mediterranean Agronomic Institute of Zaragoza (IAMZ), and the EU FP7 KBBE research projects LEGATO (LEGumes for the Agriculture of TOmorrow) and EUROLEGUME (Enhancing of legumes growing in Europe through sustainable cropping for protein supply for food and feed).

The course took place at IAMZ and was given by 15 well-qualified lecturers participating in these projects, coming from research centres and universities throughout Europe. The scientific coordination was at the charge of Dr Richard Thompson (INRA, France, LEGATO Coordinator) and Dr Eduardo Rosa (UTAD, Portugal, EUROLEGUME Coordinator). Other partners from the two projects contributed in the design of the course and also as lecturers.

The training course was intended for scientists interested in grain legumes with backgrounds in at least one of the following disciplines: agronomy, genetics, breeding, physiology. It was also open to technical advisors and professionals from companies with these same qualifications. The 36 hours programme dealt whit a wide spectrum of scientific topics reflecting the mustidisciplinary research of the two projects:

- Quality of grain legumes and technological innovation in legume products and byproducts
- Advances in plant-microbial communities' interactions
- Advances in agronomy

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- Advances in breeding and genomics
- New phenotyping methodologies, with emphasis on roots

A total number of 24 participants attended the full course, coming from 11 countries: Algeria (3), Austria (2), Chile (1), Egypt (1), Morocco (2), Palestine (1), Portugal (3), Spain (4), Tunisia (5) and Turkey (2). Almost all the participants were already involved in the subject matter of the course, with previous experience in basic or applied research, working in universities, research centres or private companies. To promote the young researchers the scientists from non-European countries to benefit from this training, several of the participants were awarded scholarships from the LEGATO project. Some of them came from North African countries, where legume cultivation and consumption is traditional, and research programmes on legumes are active. English was the language of the course although IAMZ provided simultaneous interpretation of the lectures in English, French and Spanish.



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The 8th International Conference on Legume Genetics and Genomics

The 8th International Conference on Legume Genetics and Genomics (ICLGG), was hosted by Hungary between 18-22 September 2017, in Hotel Azúr, on the southern shore of lake Balaton, in the city of Siófok. ICLGG was organized by the Biological Research Center of the Hungarian Academy of Sciences (BRC-HAS) and AMBIS Biotechnological Research and Development Ltd. from Szeged (Hungary).

This meeting brought together legume scientists working on different aspects of genetics and genomics, with the breeders and stakeholders. About 120 participants from more than different 25 countries attended the event, with the largest number of representatives from Australia, France and the United States. The conference was focused on dissemination and discussion of the most recent research results and achievements of the legume sciences, aimed to create opportunities to establish new partnerships among the academic, applied and commercial agriculture communities that will have positive effects on the future of the legume industry

LEGATO partners also featured prominently in the programme, including the Chair of the Organizing Committee, Dr. György Kiss, and eight of the speakers. Amongst the highlights was the announcement of the completion of the pea genome sequence by a consortium headed by Judith Burstin (INRA), also a LEGATO participant. Genome sequences of lentil (Kirsten Bett, CRC Canada) and cowpea (Timothy Close, UC Riverside) were also presented, and an impressive « alfalfa breeders toolbox » (Maria Monteros, Noble Foundation) which included sequencing and re-sequencing of the genomes of alfalfa genetic resources. A consortium headed by Doug Cook (UC Davis) is exploiting the potential of resequencing genetic resources for evaluating genetic diversity and the history of domestication in chickpea.





Life after death : LEGATO will continue to exist online after the project ends officially

The LEGATO project ends officially on the 31st of December 2017. The LEGATO website (www.legato-fp7.eu/), however, will continue to be active for several years. Data resources created during the project will be accessible via the site. The annual reports and deliverables will be accessible, as will the newsletters. The site will also include links to ongoing projects with the same or similar themes, including the H2020 projects in this area (EUCLEG, REMIX, LEGVALUE), and updates on publications arising out of LEGATO research.

Some current EU H2020 projects involving grain legumes :



http://www.eucleg.eu/



https://www6.inra.fr/remix-intercrops/The-Project



http://www.legvalue.eu/



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LEGATO partners



UNIVERSITY of York



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