Legume Generation

Boosting innovation in breeding
for the next generation of legume crops for Europe

An introduction to Legume Generation

Legume Generation (Boosting innovation in breeding for the next generation of legume crops for Europe) has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No.101081329. It also receives support from the governments of the United Kingdom, Switzerland and New Zealand.

Contents

Foreword

Following the successful establishment of Legume Generation, we want to provide an insight into the background to the Legume Generation project, how it works, and into its approach to boosting the breeding of legumes.

The goal of Legume Generation is two-fold: to boost the breeding of agriculturally important legume crops for Europe, and to build innovation frameworks for sustained public and private investment in these species. To achieve this we have combined genetic, agronomic, economic and research strategy perspectives within six species-specific innovation communities focused on the improvement of soybean, lupin, pea, lentil, phaseolus bean, and clover. Our innovation communities support 43 pre-breeding and 32 breeding programmes.

Plant breeding is a technical step at the start of the agri-food value chain, before farming. It brings great benefits for farmers and wider society. The seed a farmer sows today incorporates all the progress that generations of breeders have made since the species was first domesticated thousands of years ago. But plant breeding is the essential but often neglected link between a great amount of biological science we have seen in the last half century and innovation on farms. The practical use for society of genetic resources, gene editing, GWAS, genomic selection, transcriptomics, resistance genes, metabolomics, phenotyping etc., depend on plant breeders using these to deliver improved cultivars to the market for purchase by farmers. Our goal is to boost breeding so that Europe's farmers can benefit from what plant breeding has to offer to the production of legumes.

We describe this challenge in more detail in the following pages. We share the drivers and concepts behind Legume Generation and outline our plans for each species. Especially for true-breeding crops such as legumes, plant breeding is an 'open-source' technology that brings benefits to all of us. Reflecting this, the Legume Generation consortium is open to all interactions that can contribute to the improvement of our cropping systems using legumes.

Donal Murphy-Bokern (Science Coordinator)
and Lars-Gernot Otto (Coordinator)

It all starts with a seed: what is plant breeding?

Plant breeding is the deliberate improvement of cultivated plants by creating and selecting new gene combinations using parent plants with desirable traits. It is a specialised step that precedes farming that underpins much of the yield gains achieved over the past century. Its impact is especially powerful because genetic resources and technology are embodied in seeds which farmers readily adopt, allowing improvements to accumulate through the generations. Today, classical breeding is complemented by tools such as mutation breeding, marker-assisted and genomic selection, and gene editing. Improved cultivars benefit agriculture, the economy, society, and the environment.

Legume breeding is economically precarious

Legumes are underutilised in European agriculture even though they provide clear and well-known benefits for farms, the environment, and our diets. By delivering new cultivars that farmers are willing to grow, breeders make a key contribution to efforts to increase legume use. Despite the vital role of plant breeding, our work shows that legume breeding in Europe is currently in a precarious state.

Most agricultural legumes are true-breeding crops due to the high percentage of self-pollination. Each generation is practically genetically identical to the previous one. New varieties can generally be freely used as parents in other breeding programmes, making genetic improvement effectively a public good. Unlike with hybrid crops, breeders rely on revenues from breeder-seed sales and royalties on certified seed. These revenues are modest compared with the long-term societal value created by breeding and are further reduced when farmers save seed themselves. This creates a market failure in which rewards for breeders do not reflect societal benefits of their work, pointing to an important role for public investment.

Some alternative financing models exist in niche markets, such as direct sales of seed to organic growers, food product certification schemes that require farmers to use certified seed, or closed-loop systems where breeding, production and processing are vertically integrated. Examples include the breeding of vegetable pea for processing by freezing (vining pea). Earlier examples include the operation of barley breeding programmes by brewers to secure supplies with particular qualities. While these approaches can work in specific cases, they remain limited and do not replace the need for broader support for legume breeding.

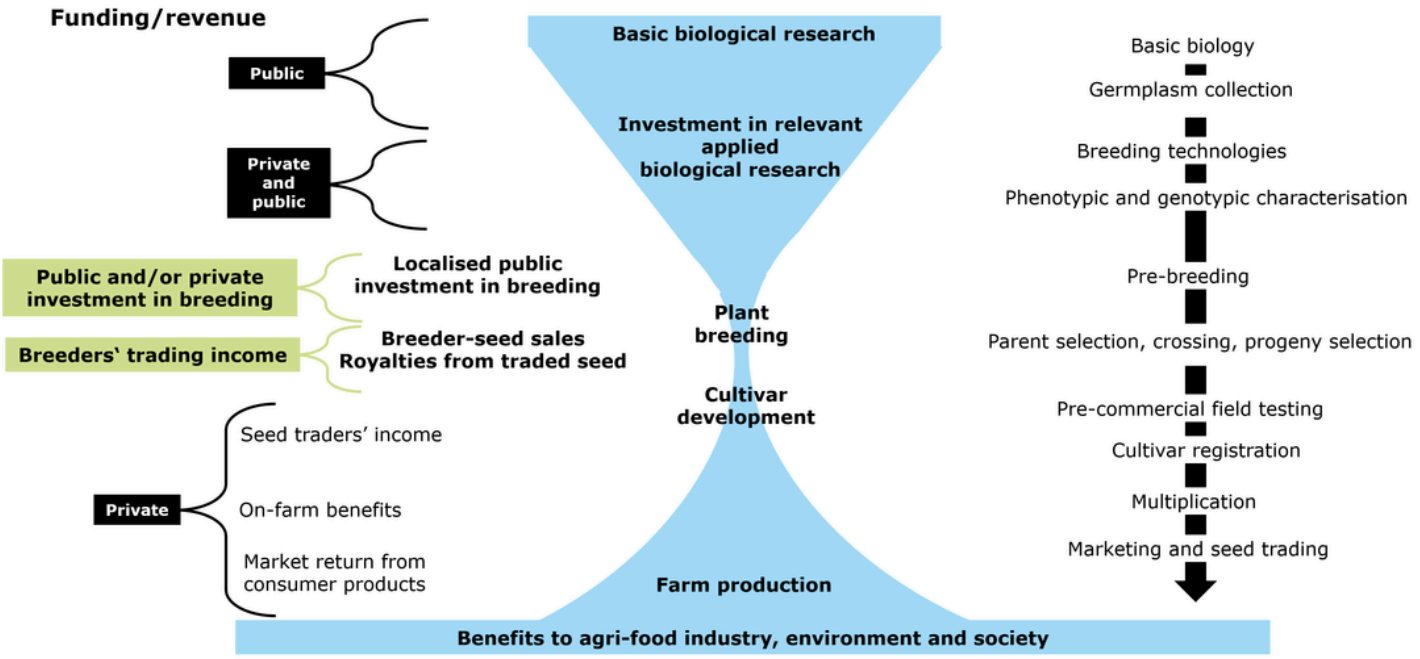


Figure 1. A schematic relating levels of funding or revenue generation through the innovation chain. The shape represents the revenue or funding potential at each stage from relatively basic research at the top to farm deployment and agri-food impacts at the bottom. The constriction between public funding for basic research and the large economic returns in farming and the food industry represents the constrained funding for plant breeding. This leads to low and insecure resourcing of the essential plant breeding compared with the investments made in basic research and the benefits of plant breeding for farmers and wider society further down the value chain. This applies particularly for true-breeding minor crop species such as the legumes. © Donal Murphy-Bokern

Breeders use two main types of parents: accessions from gene banks with valuable traits, and elite cultivars that perform well on farms. Crossing exotic material into elite lines is known as pre-breeding. The Legume Generation consortium connects research with 43 pre-breeding and 32 breeding programmes across six innovation communities.

In both the pre-breeding and breeding of legumes, selected inbred parents are crossed and the resulting progeny are self-pollinated over several generations. The crossing itself requires specialised skills and facilities. The plants of the first generation are uniform. These plants self-pollinate and genetic variation appears in the second generation (F2). Through repeated self-pollination ('selfing') of selected plants, often using single-seed descent and accelerated by

speed breeding, breeders develop genetically stable lines. The most promising lines are progressively multiplied and tested from single rows to small plots and then at field scale. Breeders sell small batches of seed to traders. They multiply this under close supervision of authorities to produce certified seed for farmers, who may also multiply their own seed under national regulations.

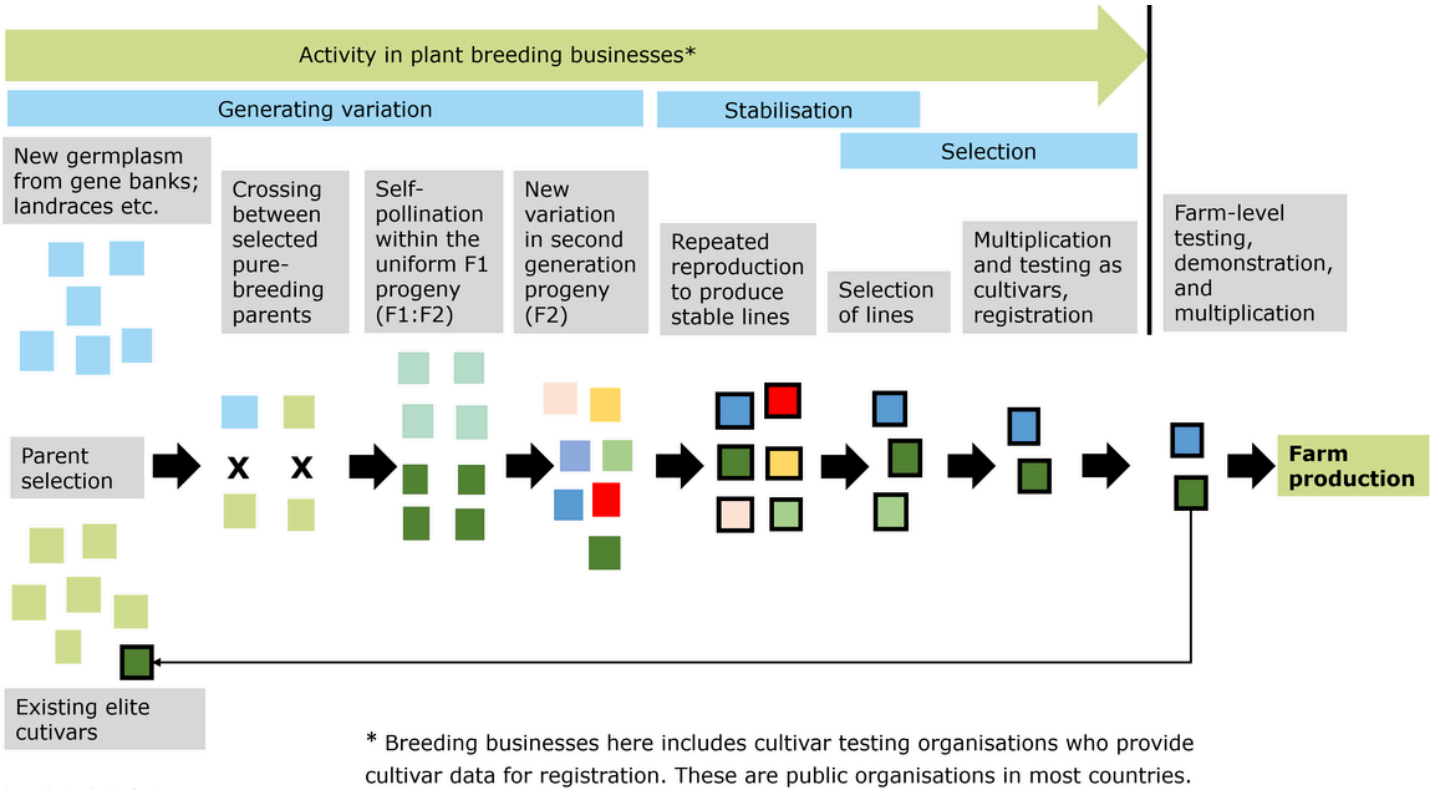


Figure 2. The basic steps in the breeding of inbred (true-breeding) crops. The process begins with the selection of parents carrying desired genes and ends with the multiplication and testing of new cultivars. New genetic techniques, such as gene editing, expand the range of traits available for plant breeding. New elite varieties can be used as parents by competing breeders. © Donal Murphy-Bokern

The link between academic research and breeding is not strong

Until around 1990, research and practical plant breeding were closely linked, particularly in government-run programmes. For example, the UK government owned Plant Breeding Institute (PBI) in Cambridge integrated strategic public research and plant breeding. It greatly increased wheat yields and quality in the UK and beyond. Similar successes occurred in eastern Europe, notably in East Germany. The privatisation of public programmes in recent decades has weakened ties and public research has become increasingly specialised into scientific disciplines based on short-term projects. About 25 years ago, the UK Department of Environment, Food and Rural Affairs addressed this growing disconnect by creating species-specific Genetic Improvement Networks (Defra GINs).

Species-specific innovation communities for new ways of working

Legume Generation boosts breeding by funding breeder-led, species-specific innovation communities. The consortium has established six innovation communities: soybean, lupins, pea, lentil, phaseolus beans, and clovers-supported by cross-cutting activities in data management, genetics and genomics, phenotyping, training, governance and finance, and communication. Each community reflects the biology and research landscape of its crop, focusing on targeted genetic improvement. These investments foster new ways of working between breeders and researchers, with potentially lasting impact. The species-specific approach enables pre-competitive collaboration tailored to each crop, supported by governance frameworks that allow genetic resources, data, and expertise to move efficiently and securely while protecting commercial interests and aligning with farmers' needs.

Partners exchange seed and breeding lines under material transfer agreements to accelerate trials while maintaining traceability. Innovation communities also align on data governance, using harmonised trait descriptors and coordinated multi-site, multi-year trials. An Open Science approach promotes early internal sharing of data and insights, followed by academic publication that safeguards intellectual property, balancing collaboration with competitiveness.

By organising research around breeding structures rather than disciplines, the consortium ensures breeders more directly guide and benefit from research while strengthening pre-competitive collaboration. This is particularly important as grain legume yields in Europe have lagged behind major crops, underscoring the need for active breeding. Unlike the more widely-grown crops, key traits such as crop architecture have seen limited progress in recent decades, with few notable advances beyond the semi-leafless pea trait developed in the 1970s.

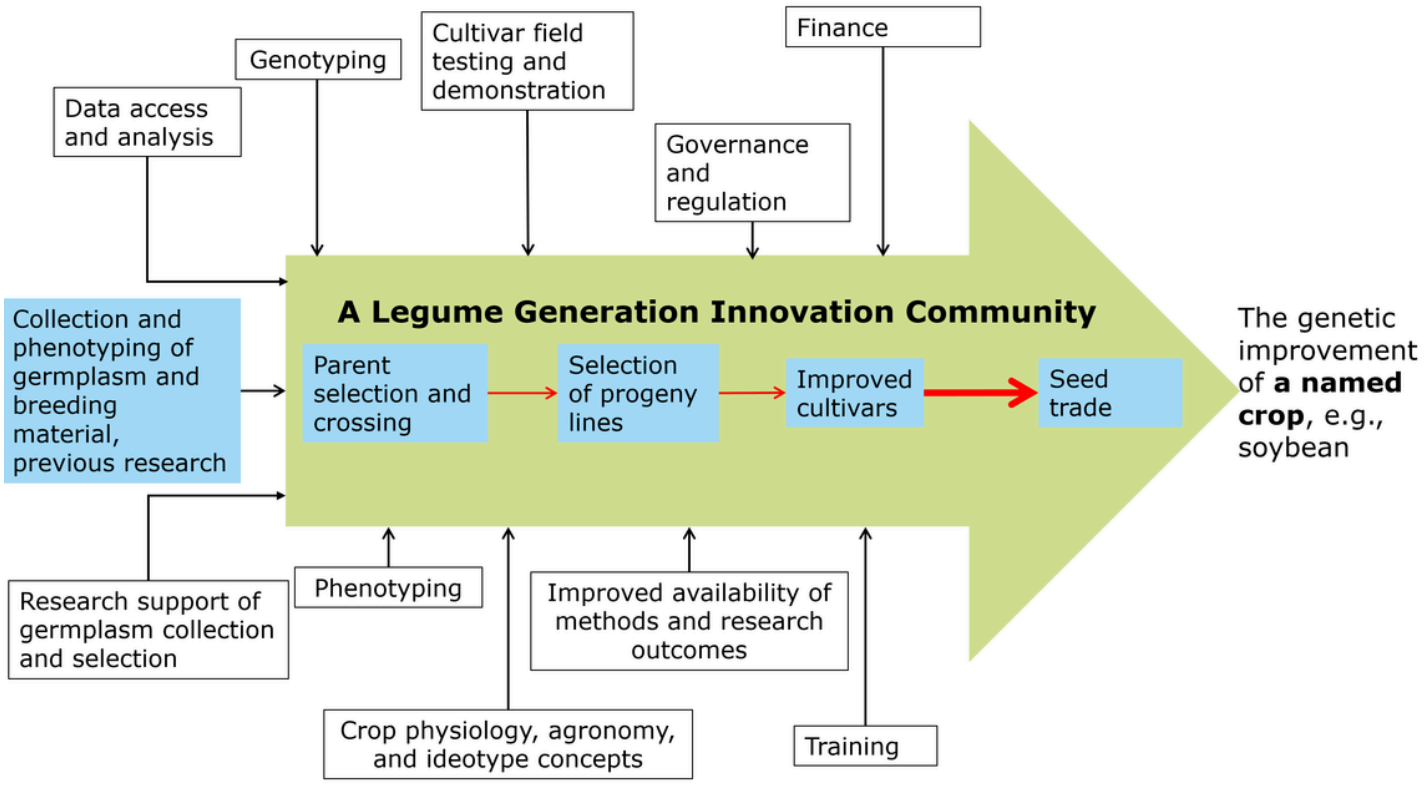


Figure 3. Plant breeding is a species-specific activity. Each Legume Generation innovation community bundles genetic resources and tools and focuses them on the genetic improvement of a named species of set of related species. This forces the organisation and prioritisation of research and innovation activities onto the structure and needs of plant breeders. © Donal Murphy-Bokern

"Plant breeding is a cornerstone of efforts to increase the role of legumes in European cropping systems. The Legume Generation innovation communities have changed the way we as plant breeders work with public researchers. They have evolved into very effective collaborations that bring together real needs in breeding and academic research. They have changed thinking and have made our interactions with our public research partners focused and efficient. It is essential that Horizon Europe projects have simple structures that facilitate effective collaboration and focus activities on boosting breeding. For me as a breeder, the Legume Generation innovation communities do this very effectively."

Klaus Oldach, KWS LOCHOW GMBH (Germany)

It must be stressed that our six innovation communities do not work in isolation. They have the benefits of a supporting framework of six cross-cutting areas of work. These are dedicated to supporting each IC with a knowledge centre to manage data, the coordination and provision of support in genomics and in phenotyping, the delivery of a programme of training, support in governance and financial matters, and the coordination of dissemination and communication.

Led by Jose De Vega and James Brett, the Earlham Institute in the United Kingdom provides each IC with an integrated knowledge and data management service in the Legume Generation Knowledge Centre. Mária Skrabisova at the University of Palacký Olomouc in the Czech Republic coordinates work on genomic tools across the project. Ivo Rieu at the Radboud University in the Netherlands supports the ICs with technology for phenotyping, including sophisticated controlled environment experiments. The work on training is coordinated by Amelie Detterbeck of Euroseeds (Belgium) and Juan Jose Ferreira of SERIDA (Spain). This facilitates the training of graduate students and coordinates webinars etc. Led by Donal Murphy-Bokern and Amelie Detterbeck, work on governance and finance supports the ICs in understanding and changing the governance and finance matters that affect the long-term viability of breeders' businesses. Led by Jasmin Karer (Donau Soja, Austria), all ICs are supported by a framework and tools for dissemination and communication, including the use of the Legume Hub. A project secretariat led by Donal Murphy-Bokern (Germany), Donau Soja, and the IPK represented by Lars-Gernot Otto supports all partners on administrative matters and communications with the European Commission.

"As a young person working in the private plant breeding sector, Legume Generation helps me connect with a large group of people who share the same objective as me: improving crops for current and future European needs. The formal side of the project provides opportunities to improve our crop species, acquire new knowledge and ideas about different plant species, and create collaboration networks between institutions. On the informal side, it is simply fun to meet people who share similar interests and goals, which leads to unexpected synergies. By connecting scientists with commercial breeders, I believe the project has the potential to kick-start a new wave of development of neglected legume species and make them more competitive with well-established crops."

Maximilian Lanz, Saatzucht Gleisdorf GmbH (Germany)

Soybean (Glycine max [L.] Merr.) is the world's leading legume crop and is the most widely grown and productive grain legume in Europe (about 6.4 million ha in Europe; 1 million ha in the EU; average between 2020 and 2025). It has outstanding agronomic, food and feed quality characteristics and is supported by a strong research and innovation base represented in this consortium. Compared with other grain legumes, yields are high and relatively stable with high protein concentration (40%) and oil (20%). Consequently, the intrinsic economic value per tonne of grain is high. Soybean is already competitive with the major crops over a large part of south-eastern and central Europe. Besides feed and traditional soya foods, numerous food applications have been developed for soybean protein extracts, soybean oil, or lecithin as valuable high potential ingredients in the food industry. The Soybean Innovation Community (IC) brings together all major soybean breeding actors in the EU, building on strong existing programmes involving international partners. Of the 15 partners, eight are directly involved in breeding.

The soybean breeding agenda

We aim to increase efficiency through joint testing and shared access to genetic, phenotyping, and genotyping resources in a pre-competitive framework. The IC also provides a pathway to application for seven EU and national projects, including BELIS, which is the second project funded under the same EU Horizon call.

Key priorities include increasing yield potential, stabilising performance under climate stress, and improving drought and heat tolerance in southern and continental regions, alongside chilling tolerance at flowering for central and northern Europe. Extending adaptation to higher latitudes with long daylengths (maturity groups OOOO to OOO) is a core objective, complemented by work to increase the competitiveness of cultivars for the MG 00 and MG 0–I market segments.

For food uses, selection emphasises high protein content, large seed size, and processing traits (e.g., tofu suitability, lipoxygenase-free profiles), while reducing anti-nutritional factors such as Kunitz trypsin inhibitor and addressing food safety and sensory attributes, including cadmium and allergen contents, sucrose, isoflavones, saponins, and “jasmine” flavour.

These goals are supported by modern breeding tools, including genomic selection and an updated ~5,000-SNP-marker genotyping set incorporating causative variants (notably E-gene flowering and maturity alleles such as e1-nl, e3, and e4), proxy SNPs for complex Indels (e.g., white flower, stay-green), and trait-specific or QTL markers for protein content and stem architecture. Digital phenotyping, such as hyperspectral reflectance (325–1075 nm), complements field scoring to reveal physiological drivers of resilience. Together, these approaches align varietal development with farmer competitiveness, European protein strategies, and emerging food-grade markets.

Pre-breeding and breeding programmes

We have four pre-breeding and seven full breeding streams covering the European maturity range from MG 0000 to MG I. Pre-breeding broadens the genetic base and introduces trait donors and markers into breeding pipelines. Large breeding programmes prioritise yield and broad adaptation for regions where soybean is common, while specialised breeding streams address constraints in other regions and food-grade niches. These include long-running work on chilling tolerance and tofu/LOX-free quality, very early maturity for high-latitude cool environments, Kunitz-null lines for feed without heat treatment, and research-driven lines optimised for food-grade composition and advanced phenotyping.

Our network of field experiments testing a wide range of genotypes across Europe with the support of specialists in genomics and phenotyping is a real practical contribution to my company's efforts to boost soybean breeding for our farmer customers."

Patrice Jeanson, Lidea Seeds (France)

Three coordinated, multi-country yield trials run over two seasons with two replications each: MG 000/0000 (northern, long-day environments), MG 00 (central Europe), and MG 0–I (southern Europe). These are complemented by a dedicated food-grade trial (single-row plots) evaluating 70 genotypes across all maturity groups. Trial sites span major production zones in Austria, Bulgaria, France, Germany, Poland, Romania and Switzerland, including an early-sown hot and dry stress site to assess drought and heat escape.

All genotypes are jointly genotyped with the updated marker panel, with E-gene analysis and enviro-typing guiding trial placement and adaptation. NIRS ring tests and shared reference samples enable rapid, scalable screening of seed composition. Seed exchange is managed under a standard MTA framework to protect pre-commercial material while enabling broad evaluation. Shared data and tools feed back into partner breeding pipelines, accelerating selection, refining crossing strategies, and shortening the pathway to on-farm demonstration (TRL ~7) and market uptake.

"Legume Generation has enabled us to bring almost all of the Europe's leading soybean breeders and researchers together to boost soybean breeding. Adapting soybean to different climate conditions and geographic latitudes is a top priority. Soybean must compete against other crop options on each farm with a combination of high yield and high prices. It helps us that Europe has a vibrant market for higher value food-grade soybeans. For the highest prices, we need high protein content and optimized processing and good taste properties for plant protein-based food production"

Johann Vollmann, BOKU (Austria) and the Soybean IC leader

Lupins, blue or narrow-leafed (Lupinus angustifolius), white (L. albus) and Andean (L. mutabilis), are protein-rich grain legumes increasingly used for food and feed. They are well-adapted to light, acidic soils, particularly in north-eastern Europe (e.g. ~25,000 ha in NE Germany, >100,000 ha in Poland, and ~12,000 ha of white lupin across France, Italy and Spain). However, breeding progress has been slow due to extremely narrow genetic base in sweet (low-alkaloid) types.

Lupins have significant agronomic potential: deep taproots with efficient phosphorus mobilisation, effective nitrogen fixation when inoculated with Bradyrhizobium, and diverse rhizodeposits that improve nutrient availability for succeeding crops. ESKUSA has identified valuable traits in bitter (alkaloid-rich) lupins that can be introgressed into sweet backgrounds. The genetic potential exists: the challenge is translating it into stable grain yield for farmers.

"Legume Generation has given my breeding programmes a decisive boost. It has enabled me to build on previous collaboration with the JKI. We can look beyond routine on-going breeding activities to explore new crop types that are designed to perform better. The Lupin IC is well on the way to making a big difference by putting together many single traits to make improved varieties, and thus improve farmers' crops. Without Legume Generation I would never have looked again in white and yellow lupins. The partners and locations throughout Europe give me opportunities to test genotype x environment interactions to make more from ESKUSA's germplasm"

Fred Eickmeyer, ESKUSA (Germany) and Lupin IC Leader

Only a few breeders currently run substantial lupin breeding programmes. Their spring-sown varieties are increasingly vulnerable to drought. Our strategy therefore includes developing winter (autumn-sown) lupins to extend the growing season, to avoid early summer drought, and to improve resource capture. We deliberately work with bitter lupins to access their rich agronomic diversity. In the medium term, sweet varieties will be developed either through crossing and backcrossing or by editing alkaloid transport mechanisms, enabling "sweet-seeded, bitter-plant" types and unlocking the full bitter gene pool for breeding. Seed merchants are engaged early to build industry interest and investment in this new breeding approach. Species-specific targets include:

Narrow-leafed lupin: "40/40" target (≈40 dt/ha grain, 40% protein).
White lupin: higher yield, anthracnose tolerance, low alkaloids.
Andean lupin: earliness, improved seed quality, and winter survival potential.

Cross-cutting enabling traits include alkaline soil tolerance and a non-GMO sulfonylurea herbicide resistance mutation for weed control.

Pre-breeding and breeding programmes

ESKUSA GmbH leads the breeding effort with partners including Julius Kühn Institute (Germany), IPK Gatersleben (Germany), Polish Academy of Sciences (Poland), Università Politecnica delle Marche (Italy), Radboud University (the Netherlands), BOKU University (Austria), Aberystwyth University (United Kingdom) and others. Genetic resources described by the INCREASE project and the Vavilov Institute are combined with trait-based selection in multi-site field trials and controlled stress and disease assays.

Introgression from bitter donors increases yield, protein contents and stress resilience in sweet backgrounds. White lupin enters crossing after initial screening, while work on Andean lupin focuses on multiplication, regional testing and winter survival. Deployment pathways include standard variety registration, closed-loop contracts with processors, and contract breeding with seed companies. These pathways providing near-term impact while longer-term winter and gene-editing strategies mature.

Pea is Europe's most widely-grown cool-season legume. It is important in emerging novel food markets and for high value feed uses (e.g., aquaculture). Despite being a model for plant genetics, the rate of pea genetic improvement has lagged behind that of cereals. Improving the agronomic competitiveness of pea compared with cereals is of critical importance. Our breeders (e.g., KWS, RAGT, DANKO) are well-positioned to draw on the extensive resources we have in JIC to combine several different types of traits including developmental, morphological, stress-related and metabolic traits.

Focusing primarily on dry (grain) pea, we bring together six key partners across Europe to improve traits such as yield, disease resistance, and climate resilience. Using diverse germplasm, high-throughput phenotyping, and genomic tools, the community targets challenges like soil fatigue, drought, and pathogen pressure. Our work involves multi-location field trials, controlled environment testing, and development of genomic markers to support breeding decisions. These efforts are supported by a diverse pea germplasm collection maintained at the John Innes Centre. The emphasis is placed on pre-competitive collaboration, training, and data sharing, while navigating differing EU and UK regulatory frameworks for new breeding technologies. Dissemination and exploitation efforts include workshops, publications, and breeder engagement to ensure the commercial uptake of improved varieties. The PIC also explores sustainable business models to boost the financial viability of pea breeding in Europe.

Pea breeding goals

Pea breeding targets include high yield and resilience across temperate Europe by combining drought/heat tolerance at flowering and pod fill with durable resistance to root rots (damping-off, fusarium wilt, ascochyta complex), powdery and downy mildew, and viruses. Agronomic priorities include lodging resistance, uniform maturity, and standability to ease harvest. Two strategic directions drive adaptation:

1. selecting winter-hardy, autumn-sown types to extend resource capture and avoid spring droughts; and
2. addressing soil fatigue so peas can return more frequently in rotation.

Grain quality remains important for food and feed markets. A deep-sequenced germplasm panel underpins genome-wide association studies and marker-assisted selection, enabling faster introgression of priority traits into elite pools. Multi-location field data are complemented by controlled inoculations to verify and stack resistances that hold across environments.

Pre-breeding and breeding programmes

Breeding is led by KWS Lochow GmbH (Germany), RAGT Seeds (France), Danko Hodowla Roślin (Poland), and the Regional Service for Agrofood Research and Development—SERIDA (Spain), supported by pre-breeding and research at the John Innes Centre (United Kingdom), Aberystwyth University (United Kingdom), the Leibniz Institute of Plant Genetics and Crop Plant Research (IPK, Germany), Radboud University (Netherlands), and others. A curated ~250-line germplasm panel, which includes wild accessions, landraces, and modern cultivars, is maintained by the John Innes Centre's Germplasm Resource Unit and shared via Standard Material Transfer Agreements. Two-season field trials run across the United Kingdom, Spain, Germany, Poland, and France, scoring emergence, height, flowering time, pods and seed traits in small plots or wires, while controlled environment assays disentangle overlapping diseases. High-throughput phenotyping at Aberystwyth University complements field work; winter trials screen frost tolerance; and a high-depth (~20×) genomic dataset feeds marker development that breeders deploy in crossing blocks. Deliverables include ranked core lines, validated markers, and prioritized parents for rapid gain in dry-pea types while supporting vegetable peas where relevant.

"We are very proud of our long-standing pea research work at the John Innes Centre. We are committed to build on this strong foundation. Plant breeding is the essential link between our work on pea and bringing benefits for farmers and wider society. Legume Generation has enabled us to build strong partnerships with breeders across Europe to effectively support Europe's farmers and strengthen innovation across the sector. We are working on biotic and abiotic challenges that pea is facing to make it resilient and suitable for different environments and benefit European agriculture in the future. By integrating advanced genetics, genomics, and phenotyping approaches, we are accelerating the development of improved varieties that meet the needs of modern agriculture. A key outcome of this project will be new ready-to-use breeder's toolkit available for plant breeders to develop new varieties."

Sanu Arora, JIC (UK) and Pea IC leader

Lentil (Lens culinaris Medik.) is an important pulse crop with high nutritional value and a growing demand in Europe. However, production is constrained by a lack of cultivars adapted to European conditions and limited investment in breeding. The Lentil Innovation Community addresses this by bringing together partners from Greece, Italy, France, Germany, and the Netherlands. We link practical breeding with cutting-edge research in a transdisciplinary platform, combining expertise in genetics, phenotyping, agronomy, and breeding under both conventional and organic systems.

Through collaboration, training, and dissemination, the Lentil IC aims to deliver new cultivars, strengthen Europe's lentil production, and reduce dependence on imports, while fostering a sustainable community through strong public–private partnerships and knowledge sharing. Our plan to boost lentil breeding includes five major steps:

1. Initial germplasm screening.
2. Development of lines using single seed descent (SSD) approach.
3. Genomic prediction.
4. Production of composite crosses.
5. Multi-site field testing and demonstration.

These activities will generate diverse and well-characterised pre-breeding and breeding materials, including elite SSD lines, composite cross populations, and tools for marker-assisted selection.

Lentil breeding goals

Regional priorities guide lentil improvement. In northern and central Europe, the emphasis is on cold tolerance, disease resistance, lodging tolerance, and uniform ripening to secure yields in cool, wet summers, with exploration of winter-hardy cultivars for autumn sowing. In southern Europe, breeding prioritises earliness, drought/heat tolerance, pod shatter resistance, and seed health under stress conditions affecting plants in Mediterranean climates. For both conventional and organic systems, targets include competitiveness against weeds, improved phosphorus uptake, and food-grade seed quality. We combine individual-plant selection with single-seed descent (SSD) line development to develop new cultivars. Lines are phenotyped under field conditions, grouped according to their differing characteristics and potential uses. Looking forward, we use genomic prediction to optimise the combination of the crosses and composite cross populations (evolving "modern landraces") that are especially relevant to organic farming systems.

Pre-breeding and breeding programmes

Pre-breeding and breeding are led by the International Hellenic University (Greece), Keyserlingk Institut (Germany), the University of Basilicata (Italy), Università Politecnica delle Marche (Italy), Lidea Seeds (France), the Leibniz Institute of Plant Genetics and Crop Plant Research (IPK, Germany), ESKUSA GmbH (Germany), and Radboud University (Netherlands), with data stewardship provided by the Earlham Institute (United Kingdom). The pipeline progresses from germplasm screening to SSD lines and composite cross populations, then to multi-site field trials in Greece, Italy, France, and Germany. Standard descriptors harmonise data. NDVI and spectral reflectance support biomass and stress assessment; controlled drought/heat assays at Radboud University and disease screens (e.g., ascochyta) refine selections. Our outputs include elite SSD lines (including candidates well-suited to organic systems) and validated genomic tools for targeted crossing. The programme also evaluates intercropping and rotational effects (e.g., wheat–lentil–wheat vs. monoculture) to derisk adoption and support region-specific recommendations.

Legume Generation has enabled us to deliver a step-change in the development of lentil for European farmers. Our IC links practical breeding with cutting-edge research combining expertise in genetics, phenotyping, agronomy, and breeding under both conventional and organic farming conditions. Due to the lack of modern cultivars, we have to start with the gene bank material as a valuable initial germplasm source and explore the adaptability across Europe in the current environmental conditions. Our task is to search for favourable genetic variability, which will help us to provide lentil lines with high protein content, high yield performance and suitable for different environments."

Elizabeth Ninou, IHU (Greece) and the Lentil IC leader

Phaseolus beans (‘beans’) are the most important pulse legume species in the world (33 million ha) and the most important legume for human consumption. Beans are a traditional food crop grown widely over Europe for grain. Eighteen European traditional high quality dry bean production chains are protected by PGI (Protected Geographical Indication) and PDO (Protected Designation of Origin). However, despite our substantial research base in Europe, the growing market for beans for sustainable healthy diets will be met by imports unless the European crop is revived. This revival is our goal.

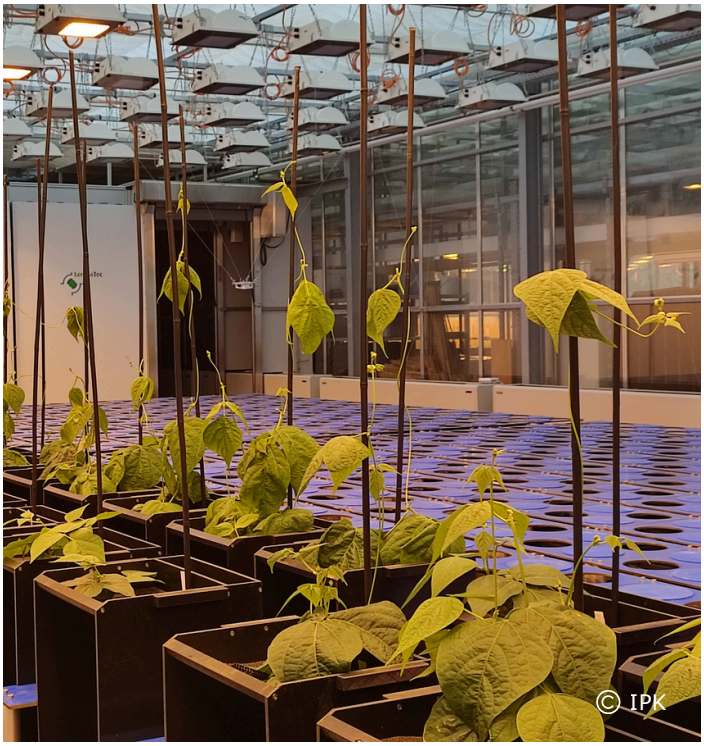
We are focused on several crops belonging to two species: Phaseolus vulgaris (common bean) and Phaseolus coccineus (scarlet runner bean). Reflected also by the 11 breeding and 13 pre-breeding programmes within our innovation community of breeders and public research partners, the different crops for the two phaseolus beans are snap and dry bean, both growing as bush and pole bean for common bean. Common bean cultivated in intercropping for feed is another usage form important for our innovation community.

Our goal is twofold: to select promising lines for breeding programmes, and to develop advanced breeding tools such as molecular markers and an integrated data management platform. We are conducting field trials for two bean breeding sets with 200 single entries at 3 locations over two years each to select superior material and to identify novel marker-trait associations. In parallel, indoor trials under controlled conditions are being conducted to evaluate drought and heat stress tolerance, aiding the selection of climate-resilient genotypes. Furthermore, we are developing key genetic resources to support the breeding of improved varieties:

1. Novel plants from an interspecific cross between *P. vulgaris* and *P. coccineus* as a new source for improved traits like disease resistances.
2. A common bean genotype that combines resistance genes against four major diseases.
3. A multiparent advanced generation inter-cross (MAGIC) population for use in both breeding and genetic analysis.

"By taking active role in the evaluation of diverse snap bean genotypes (both genebank and elite varieties) under open field conditions, I got the chance to observe the wide genetic variation existing within the species. The insights I have gained into new breeding methodologies and tools now influence my practical decisions in phaseolus bean breeding. This experience also highlights the significant selection gain achieved over the years, reinforcing the importance of continued breeding efforts in the EU."

David Gaikpa, van Waveren Saaten GmbH (Germany)



Bean breeding goals

Our general goal is to raise yield and stability by pyramiding resistance to anthracnose, bean common mosaic virus/bean common mosaic necrotic virus, powdery mildew, and white mould, combined with drought/heat tolerance, improved plant architecture, and traits that support mechanised harvest. For snap beans specifically, further objectives are pod quality traits (colour, shape, stringless, indehiscence), and processing adaptation. The genetic strategy includes interspecific introgression (*Phaseolus vulgaris* × *Phaseolus coccineus*) to access novel resistances, stacking resistance genes (for example Co-2, I, Pm1, bc-3), and developing a multiparent advanced generation inter-cross(MAGIC) population to broaden diversity and enable precise QTL deployment across market classes (bush/pole; snap/dry).

Pre-breeding and breeding programmes

We support 13 pre-breeding and 11 breeding programmes across public and private partners including the Regional Service for Agrofood Research and Development (SERIDA, Spain), the University of Basilicata (Italy), the Leibniz Institute of Plant Genetics and Crop Plant Research (IPK, Germany), Università Politecnica delle Marche (Italy), Radboud University (Netherlands), Saatzucht Gleisdorf GmbH (Austria), KWS Lochow GmbH (Germany), Lidea Seeds (France), and Van Waveren Seeds GmbH (Germany). Two curated panels anchor testing: BBS1 (~200 lines) (elite lines, Protected Geographical Indication/Protected Designation of Origin landraces, selected snap/dry types) and BBS2 (bush snap-focused, including preselected drought-tolerant candidates). Two-year field trials at three locations each (for example SERIDA, University of Basilicata, Saatzucht Gleisdorf GmbH; and Van Waveren Seeds GmbH, University of Basilicata, Leibniz Institute of Plant Genetics and Crop Plant Research) use harmonised descriptors for yield components and seed/pod metrics. Controlled screens quantify responses to major diseases, root architecture, and abiotic stress (drought/heat, partly on automated platforms), alongside seed/pod composition analyses. Outputs feed an integrated database and provide segregating intra- and interspecific populations, the MAGIC resource, and breeder-friendly markers to accelerate selection. Moreover, pilot track demonstrates resistance pyramiding tailored to market-relevant common bean classes.

“We want to reverse the decline in the role of phaseolus beans in European farming and food. We hope that our new varieties will contribute to a protein transition and the increase of agrobiodiversity on the European agricultural landscape. This requires a reversal in recent trends in breeding with declining investment. We address disease and abiotic stress resistance in particular. The project structure has enabled us to build a strong collaboration that brings a wide range of genetic resources and technologies together focused on boosting breeding.”

Lars-Gernot Otto, IPK (Germany) and Phaseolus Bean IC Leader

Red clover (Trifolium pratense) and white clover (T. repens) are among the most important forage species in Europe. They make up a significant and growing element of ruminant diets. There is growing awareness of the benefits they bring to grassland agriculture, both in productivity and in mitigation of environmental impact. The Clover Innovation Community supports 10 pre-breeding and 8 breeding programmes spread across three continents.

Clover breeding goals

In white clover (Trifolium repens), breeding focuses on legacy selection under high-nitrogen, intensive systems toward varieties optimised for low-input grasslands: strong biological nitrogen fixation, persistence and grazing tolerance, and resilience to cold, drought, and diseases, while maintaining forage yield and quality (for example crude protein and water-soluble carbohydrates). In red clover (Trifolium pratense), the commercial bottleneck is unreliable seed yield. The programme increases S-allele diversity at the self-incompatibility locus to boost compatible pollinations and explores semi-hybrid breeding to exploit heterosis, alongside improvements in forage yield/persistency and biotic/abiotic stress tolerance.

Pre-breeding and breeding programmes

Activities span 10 pre-breeding and 8 breeding programmes involving Germinal Horizon (United Kingdom), Aberystwyth University (United Kingdom), AgroBioInstitute (Bulgaria), the Bavarian State Research Center for Agriculture (Germany), the United States Department of Agriculture (USA), the Earlham Institute (United Kingdom), Aarhus University (Denmark), AgResearch (New Zealand), the Leibniz Institute of Plant Genetics and Crop Plant Research (IPK, Germany) and Radboud University (Netherlands).

For white clover, a 200-accession diversity panel (wild, semi-wild, commercial) is phenotyped for two harvest years at four contrasting sites: two in the United Kingdom (one conventional; one no-fertiliser/low-phosphorus) and two in Germany (dry Franconia; Alpine). Traits include yield, clover content, persistence under hard defoliation and disease scores. Whole-genome sequencing (population-based) supports genome-wide association studies, QTL discovery, and a predictive SNP set for genomic selection, with data shared via project databases.

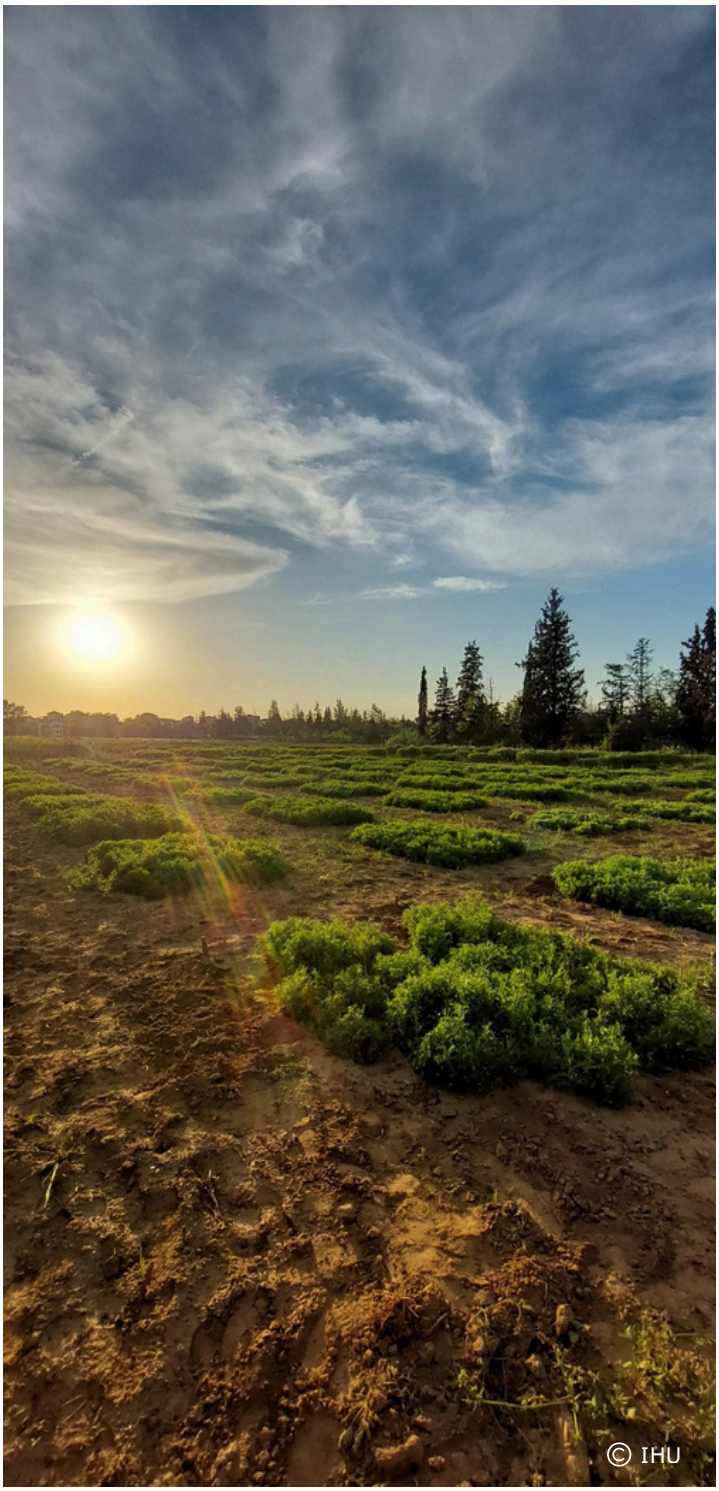
In red clover, partners map S-alleles using multiplex simple-sequence-repeat markers, profile a 100-accession panel, and pilot a semi-hybrid scheme (two parent pools with limited S-allele sets) targeting approximately 75% hybridity. The aim of this is firstly to examine its effect on seed yield, which is increasingly challenging for seed producers, and secondly to explore the potential of developing a novel semi-hybrid breeding methodology that could better exploit hybrid vigour than traditional methods. We are also testing boron sprays are tested for nectar/pollination effects and seed set.

Legume Generation has enabled us in Germinal Holdings to extend existing collaborations to deliver a coherent European effort to improve clovers. White clover and red clover are native to Europe and the cornerstone of sustainable pasture-based farming systems. Our work looks to explore yield, persistency and disease resistance across a wide range of wild white clover collections, providing data to facilitate GWAS, determining genetic markers to be used for assisted selection to improve breeding efforts."

Christina Holland, Germinal (UK) and Clover IC Leader

Fostering an enterprising environment for legume breeding

The overall purpose of Legume Generation is to boost the breeding of legumes. For biologists and breeders, this is largely a technical challenge which we have already described in some detail. However, particularly for true-breeding minor crops, sustaining breeding programmes requires consideration of financial and regulatory matters.



Building innovation frameworks for legume breeding

Our consortium shows that legume breeding is conducted by a few international companies alongside smaller, region-specific breeders, all supported by interactions with public research organisations. This fragmented structure and reliance on public support underlines our second goal: creating innovation frameworks to sustain long-term public and private investment. This involves collaboration in pre-competitive activities. A core principle of Legume Generation is the active fostering of pre-competitive collaboration research and development conducted collectively by universities, research institutions, governmental bodies, and private companies. These are activities that boost breeding for all partners but do not compromise competition and market positions. These efforts generate shared knowledge, resources, and tools that benefit the whole breeding community.

Our species-specific approach within our innovation communities helps identify opportunities for pre-competitive collaboration tailored to each species. Effective internal governance ensures genetic resources, data, and know-how move quickly and legally between partners while protecting pre-commercial assets and keeping selection aligned with European farmers' needs. Partners exchange seed and lines under standard material transfer agreements (SMTA/Easy SMTA/MTA) to accelerate trials while protecting ownership of lines and preserving traceability.

Our innovation communities also align on data governance: harmonised trait descriptors, multi-site/multi-year trial designs, and an Open Science policy that shares data and insights internally as early as possible. This is followed by academic publication that protects all partners' intellectual property and balances Open Science with protection of competitive positions.

Improving regulatory and financial conditions

Breeders' marketing costs and revenues are strongly shaped by public regulation. We contribute to public debate and policy development through discussion and position papers on EU-wide governance and market rules that reflect modern legume breeding. Proportionate and harmonised EU regulation is needed to strengthen returns on investment, support long-term breeding efforts, and ensure pipelines deliver competitive legume varieties to European farms. Fair returns on investment are essential to boost legume breeding.

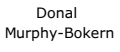
Our work addresses key issues including assessment of revenue models (e.g. closed-loop systems and contract breeding); tackling illegal farm-saved seed that undermines fair remuneration (notably soybean, which is not covered by Article 14 of Regulation (EC) No. 2100/94); ensuring a predictable, proportionate EU framework for new genomic techniques and avoiding EU–UK misalignment; promoting demand-side measures such as recognition of certified seed; and providing targeted SME support through Horizon Europe and national programmes to stabilise revenues and accelerate deployment of competitive legume varieties.


© ABI


© SERIDA

Project partners

Leibniz Institute of Plant Genetics and Crop Plant Research (IPK, Germany)
The Leibniz Institute of Plant Genetics and Crop Plant Research is a non-profit research institution dedicated to understanding the genetic and molecular basis of crop performance to improve sustainable development and resilience in agriculture. Represented by Lars-Gernot Otto, the IPK coordinates the project. The IPK also contributes to breeding research on lupin, lentil, and phaseolus bean, as well as studies on legume genetics, yield, flowering time, drought tolerance, and disease resistance. Lars-Gernot Otto leads the Bean Innovation Community.



Donal Murphy-Bokern (DMB, Germany)
Donal Murphy-Bokern is an agricultural scientist and economist specialising in agronomy and food systems, with extensive experience in EU Framework Programmes and public research. He is the science coordinator in Legume Generation. He guides research and innovation activities, interactions with the European Commission, and leads work on governance and sustainable financing of legume breeding.

University of Natural Resources and Life Sciences (BOKU, Austria)
The University of Natural Resources and Life Sciences, Vienna, is Austria's leading life sciences university. With a long tradition in soybean research dating back to the 1870s, BOKU is engaged in breeding and seed quality studies to enhance adaptation and climate resilience. In Legume Generation, BOKU leads the Soybean Innovation Community, contributes to field trials, food-grade soybean development, molecular analyses in lupin, and activities in training and dissemination.

Julius Kuhn-Institute, Federal Research Centre for Cultivated Plants (JKI, Germany)
The JKI Institute for Breeding Research on Agricultural Crops advances the development of plant genetic resources by applying modern breeding research methods to enhance crop resilience, quality, and sustainability. In Legume Generation, JKI develops biparental populations to study trait inheritance and identify molecular markers, supporting breeding progress and innovation.

Universita Politecnica Delle Marche (UNIVPM, Italy)
Università Politecnica delle Marche is a leading Italian university known for its strong research and innovation, particularly within its Department of Agricultural, Food and Environmental Sciences. In Legume Generation, UNIVPM focuses on lentil, lupin, and common bean. It is characterizing key agronomic and nutritional traits, developing new breeding populations, and testing genomic prediction models to enhance adaptation and variety development.

Donau Soja (DS, Austria)
Donau Soja is a European non-profit organisation based in Vienna that promotes European sustainable, non-GM soya production and supports the European Protein Transition. In Legume Generation, Donau Soja leads dissemination, exploitation, and communication, manages the Legume Hub knowledge platform, and provides the project's secretariat. It also contributes to the Soybean Innovation Community, training activities, and work on governance and sustainable business development.

Radboud University (SRU, Netherlands)
Through its Institute for Biological and Environmental Sciences, the Radboud conducts world-class research on ecosystem health and adaptation. In Legume Generation, Radboud coordinates phenotyping support, assesses reproductive heat tolerance in legumes, and develops hyperspectral imaging tools for field evaluation.

KWS Lochow GmbH (KWS, Germany)
KWS Lochow GmbH is one of Europe's leading plant breeding companies, specializing in cereals and legumes, with extensive trial networks and advanced genomic tools. In Legume Generation, KWS focuses on pea breeding to improve yield and quality. There is a focus on identifying germplasm for better disease resistance, crop architecture, and nutritional value.

International Hellenic University (IHU, Greece)
The International Hellenic University is a major public university in northern Greece with strong expertise in agricultural sciences and applied research. In Legume Generation, IHU's Department of Agriculture leads activities to boost lentil breeding across Europe, providing facilities for field and laboratory experiments on lentil and lupin. The team contributes expertise in agronomic evaluation, plant breeding, seed quality, and agricultural economics, and supports dissemination and collaboration with seed companies and the Greek Gene Bank.

Saatzucht Gleisdorf GmbH (SZG, Austria)
As a traditional local breeding company based in Gleisdorf, Styria, SZG develops high-yielding and efficient crop varieties while preserving agricultural diversity. Alongside hybrid breeding for corn and Styrian oil pumpkin, we focus on legumes such as soybean and faba bean. In Legume Generation, we contribute to the Soybean and Phaseolus Bean Innovation Communities through field trials and phenotypic evaluations, providing soybean genotypes for early maturity and food-grade testing.

University of Hohenheim (UHOH, Germany)
The University of Hohenheim, founded in 1818, is renowned for its strong specialization and innovative, interdisciplinary research addressing global agricultural challenges. Within Legume Generation, its State Plant Breeding Institute (LSA) focuses on improving soybean varieties using advanced breeding methods such as speed breeding and high-throughput phenotyping.

Bavarian State Research Center for Agriculture (LfL, Germany)
The Bavarian State Research Center for Agriculture serves as Bavaria's central hub for agricultural research, development, and advisory services. Within Legume Generation, LfL participates in the Clover Innovation Community and the governance and finance models working group, providing test sites for white and red clover and contributing to breeding research to advance clover improvement.

Danko Hodowla Roslin. (DANKO, Poland)
DANKO Hodowla Roślin Sp. z o.o., part of the National Food Industry Group, is a leading Polish breeding company with a long tradition in developing high-performing crop varieties to enhance agricultural efficiency. In Legume Generation, DANKO focuses on breeding activities in soybean and pea, contributing its expertise and genetic resources to support crop improvement.

Aarhus University (AU, Denmark)
Aarhus University, Denmark's second-largest university, is a leading research-intensive institution. Within Legume Generation, the Department of Molecular Biology and Genetics focuses on uncovering the genes controlling white clover self-incompatibility and applying this knowledge to develop improved breeding strategies.

RAGT Seeds (RAGT, France)
RAGT, a farmer-founded French company established in 1919, is a European leader in seed innovation, breeding over 30 crop species and registering more than 250 new varieties annually. With over 50 years of experience in legume breeding, RAGT develops leading pea, faba bean, soybean, and forage varieties. In Legume Generation, RAGT contributes germplasm and conducts multilocation field trials for pea and soybean, analysing genetic diversity to enhance breeding efficiency and genetic gain.

Lidea Seeds, (Lidea, France)
Lidea is a leading European seed company with over 80 years of expertise in plant breeding and R&D, offering innovative, sustainable solutions to help farmers adapt to environmental and market challenges. In Legume Generation, Lidea provides genetic resources for soybean, lentil, and bean, conducts field phenotyping and biochemical analyses, and contributes to data analysis, genotyping, and genomic selection, particularly for soybean improvement.

Keyserlingk Institut (Keyserlingk, Germany)
The Keyserlingk Institut develops site-adapted varieties of winter wheat, durum wheat, and lentil suited to central European conditions, with a focus on agronomic performance, food quality, and niche market suitability. In Legume Generation, KEY contributes to the Lentil Innovation Community by phenotyping lentil genetic resources, conducting field trials, and advancing breeding through single-plant selection. It also tests promising lentil genotypes in intercropping systems to evaluate productivity and sustainability benefits.

Palacký University Olomouc (UP, Czech Republic)
Palacký University Olomouc, founded in 1573, is a leading research institution in central Europe. In Legume Generation, UP leads genotyping efforts across the ICs, applying genomics to study legume traits. It designs genotyping and resequencing strategies for soybean to explore European genetic diversity, predict ideal genotypes, and facilitate knowledge transfer within the consortium.

Regional Service for Agrofood Research and Development (SERIDA, Spain)
The Regional Agrifood Research and Development Service is a public research institution in northern Spain dedicated to advancing sustainable agriculture and agri-food innovation. In Legume Generation, SERIDA strengthens pea and phaseolus bean breeding by providing genetic resources, conducting field and controlled-condition trials, and identifying resistance genes and molecular markers. It also contributes to training, dissemination, and communication activities to support European breeding efforts.

University of Basilicata (UNIBAS, Italy)
The University of Basilicata is a public research university in southern Italy with strong expertise in plant genetics, breeding, and agronomy. In Legume Generation, UNIBAS contributes to the Bean Innovation Community, advancing phaseolus breeding through the use of genetic resources and collaborative improvement strategies. It also contributes to the Lentil Innovation Community with multi-location field trials, phenotyping, and the development of tools to support sustainable legume breeding in Europe.

ESKUSA GmbH (ESKUSA, Germany)
ESKUSA coordinates the subgroup of lupin specialists in Legume Generation, focusing on breeding-driven collaboration. The company conducts crosses, selection, field trials, and seed production in lupin species, following a trait-oriented approach to improve germplasm and develop new cultivars, which are then multiplied and marketed through seed company partners.

Institute of Plant Genetics, Polish Academy of Sciences (IPG, Poland)
The Institute of Plant Genetics of the Polish Academy of Sciences is a leading research centre in agricultural sciences, with over 70 years of experience in advancing plant genetics, breeding, and biotechnology. Its research supports sustainable agriculture and addresses challenges related to plant adaptation and climate change. In Legume Generation, IPG contributes to boosting lupin breeding by developing tools for improving nutritional value, grain quality, alkaloid content, and yield-related traits.

Euroseeds (EURS, Belgium)
Euroseeds represents the European seed sector, bringing together national associations and companies involved in plant breeding, research, production, and marketing across Europe. In Legume Generation, Euroseeds leads training and capacity-building activities, contributes to business and financial assessments of legume breeding, and supports communication, dissemination, and exploitation efforts to strengthen innovation partnerships and stakeholder engagement.

Agrobioinstitute (ABI, Bulgaria)
Agrobioinstitute, part of the Agricultural Academy in Bulgaria, is a leading research centre focused on plant biotechnology, molecular biology, genomics, and metabolomics. It conducts both fundamental and applied research to enhance crop improvement and sustainable agriculture, and serves as a national training and research hub in plant genetics and biotechnology. In Legume Generation, ABI participates in the Soybean and Clover Innovation Communities, conducting multi-year field trials, biochemical and transcriptomic analyses of soybean genotypes, and genetic studies on red clover to improve yield, flowering, and pollination traits.

John Innes Centre (JIC, United Kingdom)
The John Innes Centre is a world-leading research institute in plant and microbial science. In Legume Generation, JIC leads the Pea Innovation Community, coordinating multi-site pea trials across Europe, managing seed distribution, harmonising phenotyping, and ensuring effective collaboration and communication among project partners.

Germinal Holdings Ltd (GER, United Kingdom)
Germinal is a leading grass and forage seed specialist with nearly 200 years of expertise in developing sustainable grassland varieties and premium agricultural seeds for the UK, Ireland, and New Zealand. Dedicated to innovation and sustainability, Germinal works closely with partners to advance productive and environmentally responsible farming. In Legume Generation, Germinal leads the Clover Innovation Community, coordinating innovative breeding efforts in red and white clover and uniting researchers and breeders from three continents.

Aberystwyth University (ABER, United Kingdom)
The Institute of Biological, Environmental and Rural Sciences (IBERS) at Aberystwyth University is a global leader in applying 'omic' technologies to crop breeding, with a legacy dating back to 1919. Its research and breeding programmes span oats, pulses, forages, and legumes, supported by extensive genebank and phenomics facilities, including the National Plant Phenomics Centre. In Legume Generation, Aberystwyth University conducts phenotyping of genetic diversity populations of peas, clover, and lupins in both field and controlled environments, analysing data to develop advanced breeding tools for legume improvement.

Earlham Institute (EI, United Kingdom)
The Earlham Institute (EI) is a leading UK centre for genomics research, innovation, and training, based at the Norwich Research Park and funded by the UK Research Council. Its work spans technology development, bioinformatics, and data-driven life science research across plants, animals, and microbes. In Legume Generation, EI leads the data-focused work by managing the project's central 'knowledge centre' platform for genotyping and phenotyping data. EI ensures best practices in data management, standardisation, and accessibility while providing bioinformatics analysis, training, and support to advance legume breeding innovation.

United States Department of Agriculture (USDA, United States of America)
The Agricultural Research Service (ARS) is the principal scientific research agency of the U.S. Department of Agriculture, dedicated to developing solutions to agricultural challenges from field to table. In Legume Generation, ARS collaborates with the Clover Innovation Community to study gametophytic self-incompatibility in red clover and explore its application in breeding and seed production to improve crop performance.

WBF Agroscope (AGS, Switzerland)
Agroscope is Switzerland's centre of excellence for agricultural research, working under the Federal Office for Agriculture (FOAG) to advance sustainable farming, high-quality food production, and environmental protection. In Legume Generation, Agroscope focuses on breeding soybean varieties adapted to Swiss and European climates, particularly for early maturity, cold tolerance, and enhanced nutritional quality. Agroscope contributes germplasm for multi-location testing, conducting phenotyping, genomic selection, and association studies to improve key agronomic and quality traits.

AgResearch (AGR, New Zealand)
AgResearch is one of New Zealand's Crown Research Institutes, dedicated to advancing the productivity, sustainability, and value of the country's pastoral and agri-food sectors. With a team of over 600 experts, AgResearch combines world-class science with indigenous knowledge (mātauranga Māori) to create resilient and future-focused agricultural solutions.
In Legume Generation, AgResearch builds on its long-standing expertise in forage and legume breeding to identify genes controlling gametophytic self-incompatibility in white clover, supporting the development of innovative clover breeding strategies.

University of Oxford
The Department of Biology at the University of Oxford is a leading centre for research and teaching across animal, microbial, and plant sciences. In Legume Generation, the department collaborates closely with the John Innes Centre to enhance pea performance and contribute to the project's breeding and research objectives.

Van Waveren
Van Waveren Saaten GmbH is a German vegetable breeding company founded in 1898 and headquartered in Rosdorf, Göttingen. It develops robust, high-yielding and multi-resistant vegetable varieties and, since 2025, part of the RAGT Groupe. As a member of the Bean Innovation Community, the company shares practical breeding perspectives and supports the alignment of research with market needs

The Legume Hub

The **Legume Hub** is an open access publishing platform with the aim to provide access to validated knowledge. It is a platform dedicated to sharing knowledge and successful practices across value chains, from plant breeding, on-farm activities, through to processing and consumption.

The Legume Hub is governed by the members of the European Legume Hub Community, Donau Soja provides the Secretariat. All users involved in the development of legume production and use are invited to join the Legume Hub Community by registering as a member. Members are welcome to contribute to the Hub by creating a personal profile related to their legume work, publishing articles and providing information about their projects.

The Legume Hub is also an open access project platform, guarantying that project outputs are permanently available, beyond the project.

Legume Generation is using the Legume Hub as main communication and dissemination platform, providing permanent availability of all project outputs: Legume Generation - legumehub.eu.

Interested in joining the Legume Hub? Scan the QR code on the right.

Further reading

Legume Generation reports

Vollmann, J., Hahn, V., Murphy-Bokern, D. and Škrabišová, M., 2024. The plan for boosting the breeding of soybean. Legume Generation Report 1. Available from www.legumegeneration.eu and www.legumehub.eu. DOI: https://doi.org/10.5281/zenodo.17243541

Eickmeyer, F., Flüß, H., Susek, K. and Murphy-Bokern D., 2024. The plan for boosting the breeding of lupin. Legume Generation report 2. Available from www.legumegeneration.eu and www.legumehub.eu. DOI: https://doi.org/10.5281/zenodo.17249160

Arora, S., Oldach, K., Gervais, L., Ferreira, JJ., Niewinska, M., Ostergaard, L. and Murphy-Bokern, D., 2024. The plan for boosting the breeding of pea. Legume Generation Report 3. Available from www.legumegeneration.eu and www.legumehub.eu. DOI: https://doi.org/10.5281/zenodo.17249772

Ninou, E., Mylonas, I., Murphy-Bokern, D., Hennenkaemper, U., Lohwasser, U., Jeanson, P., Gioia, T. and Papa, R., 2024. The plan for boosting the breeding of lentil. Legume Generation Report 4. Available from www.legumegeneration.eu and www.legumehub.eu. DOI: https://doi.org/10.5281/zenodo.17287728

Ferreira, J.J., Gioia, T., Otto, L.-G. and Murphy-Bokern, D. 2024. The plan for boosting the breeding of phaseolus bean. Legume Generation Report 5. Available from www.legumegeneration.eu and www.legumehub.eu. DOI: https://doi.org/10.5281/zenodo.17250917

Jones, C., Andersen, S. U., de Vega, J., Griffiths, A., Hartmann, S., Howarth, C., Iantcheva, A., Lloyd, D. and Riday, H., 2024. The plan for boosting the breeding of clovers. Legume Generation Report 6. Available from www.legumegeneration.eu and www.legumehub.eu. DOI: https://doi.org/10.5281/zenodo.17257789

Murphy-Bokern, D., Vollmann, J., Eickmeyer, F., Arora, S., Ninou, E., Gioia, T., Ferreira, J.J., Otto, L.-G., and Lloyd, D., 2025. The Legume Generation innovation communities. Legume Generation Report 7. Available from www.legumegeneration.eu and www.legumehub.eu. DOI: https://doi.org/10.5281/zenodo.17415034

Murphy-Bokern, D., Papathanasiou, F., Hast, M. and Stoddard, F., 2025. Characterisation and genetic improvement of protein crops. Legume Generation report 8. Available from www.legumegeneration.eu and www.legumehub.eu. DOI: https://doi.org/10.5281/zenodo.17988915

Vollmann, J., Hahn, V., Murphy-Bokern, D. and Škrabišová, M., 2026. Progressing the breeding of soybean. Legume Generation Report 9. Available from www.legumegeneration.eu and www.legumehub.eu. DOI: https://doi.org/10.5281/zenodo.18919804

Eickmeyer, F., Flüß, H., Susek, K. and Murphy-Bokern, D., 2026. Progressing the breeding of lupin. Legume Generation Report 10. Available from www.legumegeneration.eu and www.legumehub.eu

Arora, S., Gaurav, K., Oldach, K., Howarth, C., Ferreira, J. J., Negrillo, A.M.C., Gervais, L., Niewinska, M., Katańska-Kaczmarek, Agnieszka., Murphy-Bokern, D. and Ostergaard, L 2025. Progressing the breeding of pea. Legume Generation Report 11. Available from www.legumegeneration.eu and www.legumehub.eu

Ninou, E., Mylonas, I., Murphy-Bokern, D., Hennenkaemper, U., Jeanson, P., di Vittorio, V., Papa, R., Gioia, T. and Lohwasser, U., 2025. Progressing the breeding of lentil. Legume Generation Report 12. Available from www.legumegeneration.eu and www.legumehub.eu

Otto, L.-G., Adam, E., Gioia, T., Murphy-Bokern, D. and Ferreira, J. J., 2026. Progressing the breeding of phaseolus bean. Legume Generation Report 13. Available from www.legumegeneration.eu and www.legumehub.eu. DOI: https://doi.org/10.5281/zenodo.18920707

Holland, C., Hartmann, S., de Vega, J., Liu, J.-S., Andersen, S.U., Griffiths, A., Howarth, C., Iantcheva, A., Riday, H. and Lloyd, D., 2026. Progressing the breeding of clover. Legume Generation Report 14. Available from www.legumegeneration.eu and www.legumehub.eu.

Legume Generation, 2026. An agenda for public investment in legume plant breeding. Legume Generation Position Paper 1. Available from www.legumegeneration.eu and www.legumehub.eu. DOI: https://doi.org/10.5281/zenodo.19563945

Other publications

Donald, C.M. The breeding of crop ideotypes. Euphytica 17, 385–403 (1968). https://doi.org/10.1007/BF00056241

Lanique, N., Reif, J.C., Otto, L.G., Mirdita, V., Oppermann, M., Lohwasser, U., Kotter, M., Weise, S., El Hanafi, S. 2025. Harnessing historical genebank data to accelerate pea breeding. Theoretical and Applied Genetics (2025) 138:243. Available from www.legumehub.eu and https://doi.org/10.1007/s00122-025-05032-5

McClatchie, M., Matterne, V., Rovira Buendia, N., Andonova, M., Lohwasser, U., Waalen, W., Bantis, F., Knez, M., Milešević, J., Orahovac, A., Prosperi, P., Banerjee, A., Radić, I., Mueller-Bieniek, A., Beglaryan, M., Murphy-Bokern, D., Gil, D., Balázs, B., & Negrão, S. 2025. Underutilised crops in Europe: An interdisciplinary approach towards sustainable practices. Archaeometry, 1–16. Available from www.legumehub.eu and www.legumegeneration.eu

Murphy-Bokern, D., 2022. Developing legume-supported cropping systems in Europe: Have we overlooked something? Annals of Applied Biology,1–4. https://doi.org/10.1111/aab.12764

Murphy-Bokern, D., 2026. Legume Generation: Putting breeders back at the centre of Europe's protein transition. Seed World Europe, May 2026. https://www.seedworld.com/cdn/flipbooks/EU/volume-13/issue-2/index.html?page=1

Piller, B. J., 2025. Phenotyping of European soybean varieties with different time to maturity for drought tolerance. Master thesis, University of Natural Resources and Life Sciences (BOKU), 2025.

Revalska, M.; Radkova, M.; Lyubenova, A.; Naydenova, G.; Iantcheva, A. Preliminary Investigation of Foliar Application of Boron on Pollen Viability and Development in the Cultivation of Red Clover in the Field. Agriculture 16, 681 (2026). https://doi.org/10.3390/agriculture16060681

Rodríguez Madrera, R., Campa Negrillo, A., Ferreira Fernández, J. 2026. Quantitative Assessment of Soluble Carbohydrates in Two Panels of Pulses (Phaseolus vulgaris and Pisum sativum) Using Ultrasound-Assisted Extraction (UAE) and HPLC. Foods 2026, 15, 391. Available from www.legumegeneration.eu and https://doi.org/10.3390/foods15020391

Tosoroni, A., Di Vittori, V., Nanni, L., Musari, E., Papalini, S., Bitocchi, E., Bellucci, E., Pieri, A., Ghitarrini, S., Susek, K. and Papa, R., 2025. Recent advances in molecular tools and pre-breeding activities in white lupin (Lupinus albus). Plants 2025, 14, 914. Available from https://doi.org/10.3390/plants14060914

Please cite this publication as follows:
Legume Generation, 2026. An introduction to Legume Generation. Available from www.legumegeneration.eu and www.legumehub.eu

Legume Generation project partners:

IPK LEIBNIZ INSTITUTE

Donal Murphy-Bokern

DONAU SOJA

BOKU UNIVERSITY

John Innes Centre

Euroseeds Embracing Nature

Agroscope

Germinal

PRIFYSGOL ABERYSTWYTH UNIVERSITY

Lidea

SZG

KWS

SERIDA

1880 DANKO

agresearch āta mātai, mātai whetū

Earlham Institute

UNIVERSITY OF HOHENHEIM

Ideen um Pflanzen ESKUSA Ideen pflanzen

LfL Bayerische Landesanstalt für Landwirtschaft

IGR PAN

RAGT 2n

UNIVERSITÀ DEGLI STUDI DELLA BASILICATA 1982

JKI Julius Kühn-Institut

VAN WAVEREN Saaten GmbH

Radboud Universiteit

UNIVERSITÀ POLITECNICA DELLE MARCHE

UNIVERZITA PALACKÉHO V OLOMOUCI

UNIVERSITY OF OXFORD

USDA

ABI

ΔΙΕΘΝΕΣ ΠΑΝΕΠΙΣΤΗΜΙΟ ΤΗΣ ΕΛΛΑΔΟΣ

AARHUS UNIVERSITY

SaatGut Keyserlingk-Institut

Contact us:

Dr Donal Murphy-Bokern
Legume Generation project science coordinator
donal@murphy-bokern.com

Dr Lars-Gernot Otto
Legume Generation project coordinator
Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)
ottol@ipk-gatersleben.de

Follow us: *#LegumeGeneration*

www.legumegeneration.eu

@legume-hub-eu

@legumehub.bsky.social

@LegumeHubEU

@legumehub1840