

Legumes in Sustainable Agriculture

Nicolas Rispaïl, Sara Fondevilla, Eleonora Barilli, Maria-Angeles Castillejo, Angel Villegas-Fernández, Thais Aznar-Fernández, Elena Prats and Diego Rubiales

Institute for Sustainable Agriculture – CSIC, Alameda del Obispo, Cordoba, Spain.

Agriculture is facing the most important challenge in its history. The exponential population growth drives the necessity to improve both crop yield and quality to feed the growing world-wide population. While the mid-XX century Green Revolution based on world-wide cultivation of a few elite cultivars and abuse of chemical to sustain growth and control diseases allowed to improved yield, it also led to a dramatic situation of losses of crop diversity and resilience and heavy pollution of soil and water resources. Thus modern agriculture should also contribute to preserve the environment. One way to achieve both goals is the re-introduction of legume in our growing systems that are an important source of protein and present several benefits for the environments.

Legume crops are a critical source of plant-based proteins for people and animals. These protein-rich crops are among the most important crops worldwide for both animal and human consumptions constituting an integral part of the Mediterranean and Chinese diet. Grain and forage legumes are annual and multifunctional crops with extraordinary historical importance for the agriculture and the environment. Their capacity to fix atmospheric nitrogen through the symbiotic interaction with specific soil-borne bacteria allows them to grow in poor soil without application of nitrogenous fertilizer reducing both fossil energy requirement and greenhouse gas emission. In rotation, they constitute an efficient disease break for several diseases and improve soil fertility which together impact positively on subsequent crop production. Thus they are important players of sustainable and environmentally friendly agriculture. However they are susceptible to biotic and abiotic stresses that largely compromise their yield and reduce their attraction to farmers. This situation is also reinforced by the recent socio-economic and political context that until recently discouraged further the farmers to grow these crops. By contrast, the legume consumption in Europe and China has largely increased which is covered by the massive importation of protein crops in both regions to sustain animal production. Therefore, for food security and economic reasons, it makes strategic sense for the EU and Chinese countries to set about improving their own capacity to grow legume crops. There is thus an urgent need to re-habilitate legumes in the cropping systems in order to improve productivity and sustainable exploitation of agricultural lands as well as people's quality of life. Unfortunately, both Europe and China are facing similar challenges, as both lack sufficient sources of protein and are increasingly dependent on protein imports for food and animal feed. In

recent years China is importing increasing volumes of soybeans at the level of 60 million tons what by itself corresponds to 60% of world market trade. This unique situation for a commodity will have important consequences on the equilibrium of the global market and might affect prices in the near future if imports increase further, as indicated by most recent long-term projections.

The EU and China therefore have a common interest in cooperating on long-term strategies to develop sustainable alternatives to protein imports with a view to reduce their dependency and helping to stabilize the world market. To this aim, several international efforts have been initiated to improve yield, quality and resilience of these crops. Many of these efforts, coordinated from the Institute of Sustainable Agriculture – CSIC, are contributing to define the most desirable trait for legume, improved our understanding of these traits at genetic and molecular level ultimately leading to the release of improved well-adapted legumes with higher level of resistance to its stresses. They also started to introduce modern post-genomic tools in legume breeding programs to speed up future breeding processes. Despite of these efforts, investment in advanced technologies for legumes in EU and China still lags behind that of the cereals and other major crops such as potato and tomato. This highlights the need to continue these efforts to improve further these crops and their profitability by promoting further international actions such as the currently developing CSIC-coordinated EU-China proposal on Legume breeding (ECLIP proposal) within the call “SFS-44-2016: A joint plant breeding programme to decrease the EU's and China's dependency on protein imports” of the H2020 work program (<https://ec.europa.eu/programmes/horizon2020/en/draft-work-programmes-2016-17>). It also highlights the need to gather the effort of the scientific community and further disseminate the results of these efforts to awaken the society on this topic. This key aspect is the driving force for the creation of the International Legume Society (<http://ils.nsseme.com/>) and the International Legume conferences (<http://www.itqb.unl.pt/meetings-and-courses/legumes-for-a-sustainable-world>) organized by our group to disseminate and promote legume breeding and uses.

Here we will present the strategies followed for most legume crops including soybean, pea, chickpea and faba-bean to breed them for yield and quality improvement and higher resilience both in terms of optimizing the beneficial interaction with soil-borne bacteria and introducing resistance to their main diseases, pest and environmental constraints. We will also present the different actions coordinated from CSIC to disseminate and promote legume at international level.