Legume Futures

Legume-supported cropping systems for Europe

Looking Forward

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Introduction

Legume Futures has shown that legume production can be increased in Europe delivering positive economic, environmental and agronomic effects. Based on the experience gained in the Legume Futures project, this paper looks forward to how this potential can be effectively realized.

Europe is self-sufficient in most agricultural commodities that it can produce. It is even a net exporter of cereals and some livestock products. This remarkable productivity can be attributed to specialization in high-yielding cereals and oilseeds grown using synthetic

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nitrogen fertilizer, well-developed supporting technology such as pesticides, and large imports of soy from North and South America. However this productivity comes at a cost for the environment linked to imbalances in European cropping systems, particularly the combination of low use of legumes in cropping systems and the associated high reliance on imported soy. By 2010, when the Legume Futures project was initiated, awareness of these imbalances in our agricultural and food systems was already the subject of discussion in the mainstream agricultural policy community.

The production of legume crops – trends, challenges and making an impact

The low use of legumes in Europe is the result of a long-term trend. From EUROSTAT, we estimate that the area of the major grain legume crops in the EU was about 1.6 million ha in 2014 (1.5%), dominated by soy, pea and faba bean in that order. In addition there was about 1.3 million ha of alfalfa. The production of grain legumes increased by nearly 70% in 2015 to 2.7 million ha. Alfalfa also increased in 2015. The use of grain legumes in organic cropping systems (at 12% of annual arable cropped organic area) accounts (coincidentally) for about 12% of the total grain legume area (estimated from EC data[1]). From these estimates and from our discussions with grower groups across Europe, it seems that the decline in production has stopped. The increase in 2015 was highest in countries with higher coupled payments (e.g. Poland), but it was also recorded in other countries (e.g. Germany, UK). It is clear from the European Commission's review of Greening[2] that the use of nitrogen-fixing crops (i.e., legumes) to fulfil the ecological focus area has accounted for a significant proportion of the expansion.

The Legume Futures consortium has brought together people involved in research relevant to legume crops. Most have received support from the European Union for research and innovation activities that aim to support legume production. Almost all have received some form of public support. The total support for the wider legume research community in Europe certainly runs to several tens of millions of Euros. In addition to Legume Futures, the EU has invested in LEGATO, LEGRESIST, EUROLEGUME and ABSTRESS, amongst others. National governments have invested in projects such as CLIMATE CAFÉ, MEDILEG, REFORMA, COBRA and NORFAB. There are many other projects and more regional initiatives to support the production of legume crops in Europe.

[1] EC 2013.Facts and figures on organic agriculture in the European Union.
[2] European Commission (2016). Commission Staff Working Document. Review of greening after one year. SWD 218.

This is all applied research. Its primary purpose is to improve the performance of farming and food systems and thereby provide benefits for people and the environment. This purpose is served when research results are used to deliver new practices, technologies, products, support organizational and institutional change, and to support evidence-based policymaking. If successful, this research will be making an impact on our farms and in our food systems in the next decade and beyond. Will we in 10 years be able to celebrate real impact from that research? Will we be able to proudly point to positive change commensurate with the investment our research represents and say we had a part in that?

A promising crop of faba beans growing near Uppsala in Sweden (Photo: Christine Watson (SRUC and SLU).

This change is not about promoting legumes. It is about informing the effective rebalancing of farming and food in Europe using legumes. It is also about global change. In South America, cropping systems with more than 50% soy are common, so their cropping sequences are too simple, dominated by legumes. Europe is the second largest importer of soy from that region, including from cropping systems that few of us would regard as sustainable. At the same time, enabled by imports of soy, farmers in

Europe have reduced legume production to the point that most European cropping systems do not use any legumes at all. These agricultural systems are imbalanced at field, farm, regional and global scales. But is change really needed?

Europe is more self-sufficient in protein than is commonly implied. While Europe imports about 70% of the protein-rich material used for feed supplementation, it is actually about 70% self-sufficient in tradable plant protein when all grain and arable forage protein sources are considered. Self-sufficiency estimates are even higher when we take the protein from grassland into consideration. Particularly given the wider protein sources, many economists would argue that instead of regarding specialization and imports as a problem, we should regard them as a consequence of rational and effective exploitation of comparative advantage. European farmers are as good as or better than farmers in legume-exporting countries at growing legumes, but they are especially good at growing cereals. Agricultural land is scarce in Europe and the cost of land is high. High land rents in particular force farmers to allocate land to crops which are particularly profitable in the year grown, in most cases cereal crops. A text-book example of Ricardo's law of comparative advantage is clearly at work.

Can we expect change if the current situation reflects rational economic decision-making by farmers and wider economic advantage that the use of comparative advantage brings? We can speculate on a number of fundamental changes that determine the likelihood of a rebalancing of agriculture supported by legumes grown in Europe. These are to do with:

1. better assessment of the economic performance of legumes;
2. yield and yield stability; the economic value of supporting services;
3. the value of the crop produce;
4. gaining a market advantage from environmental effects;
5. broad-based transition in value chains; and
6. public policy support.

Better assessment of the farm-level economic performance of legume crops

The research led by ZALF in Legume Futures showed that the real (farm-level) economic performance of legumes is higher than conventional gross margin analysis indicates.[3] This means that the potential for economically competitive legume production is not fully exploited. However, even accepting that the farm-level economic performance of legume crops is often underestimated, there is consensus that there is

[3] Preißel, S., Reckling, M., Schläfke, N., Zander, P. (2015) Magnitude and farm-economic value of grain legume pre-crop benefits in Europe: a review. Field Crops Research 175, 64-79.

still a lack of compelling economic grounds for growing legumes for many farmers, especially where cereals and oilseeds grow particularly well.

Testing lupins in north-east Germany where they are well adapted to the light sandy drought-prone acid soils (Photo: Moritz Reckling (ZALF)).

Yields and yield stability

The technical performance of legume crops needs to improve compared with competing crops. In practical terms, this means that the net economic output of legume crops needs to grow faster than the net output of competing crops. There is some good evidence that this is possible. Cereal crop yields are stagnating even though breeding continues to increase yield potential.[4] Climate change may be at least partly responsible, but the lack of diversity in modern cropping systems are also likely to play a role. This conclusion is supported by practical observation with increasing problems with weeds and diseases in autumn-sown cereal crops in particular. This means that modern cereal-based systems are approaching and exceeding resource and environmental

[4] Brisson, N., Gate, P., Gouache, D., Charmet, G., Oury, F-X. and Hurd, F. (2010). Why are wheat yields stagnating in Europe? A comprehensive data analysis for France. Field Crops Research 119: 201-212.

limits. If the performance of cereals stagnates or even declines, and performance of legumes continues to increase, we will over time see the attractiveness of legumes for farmers increase. This scenario is supported by investment in plant breeding and improving cropping systems in particular.

White clover is economically attractive for milk production when fertilizer nitrogen prices are high in relation to milk prices. (Photo: Christine Watson (SRUC)).

The economic value of nitrogen fixation and the break-crop effects

The economic value of the biologically fixed nitrogen that is transferred to other crops depends ultimately on the price of synthetic nitrogen fertilizer. Similarly, the value of other aspects of the break crop effect depends on the availability and cost of pesticide-based control of weed and other problems in cereals and oilseeds. In an excellent

example of combining biological and economic research, Humphreys et al.[5] identified a tipping point in the ratio of fertilizer nitrogen price and the farm-gate price of milk in Ireland. When the ratio of the cost of 1 kg of nitrogen to the price of 1 kg of milk exceeds about 3, grass/white clover-based milk production becomes economically attractive in Ireland. The price of synthetic N is particularly relevant to perennial systems where the recovery of biologically-fixed nitrogen in the system over years is high. Perennial forage crops require large amounts of nitrogen which can be effectively provided by introducing legumes. The scope for this effect in arable systems is somewhat lower although clearly the attractiveness of more diverse cropping sequences that use legumes increases as the cost of maintaining intensive cereal production using synthetic fertilizer nitrogen and plant protection products increases.

The value of the crop produce

Schätzl and Halama[6] in Bavaria have estimated that if the farm price of soy is more than about twice that of wheat, soy production is competitive with wheat for farmers in that region. This ratio depends ultimately on the base price of protein compared to starch, set mostly by the world prices for wheat, maize and soy. Long runs of commodity price data (available from Index Mundi) show that the ratio of soy to wheat prices was consistently below 1.5 between 1990 and 2009. The last three years (up to mid-2016) are characterized by relatively high soy prices. From Schätzl and Halama, we can expect that these soy prices are high enough to make growing soy competitive with growing wheat in many parts of Europe. Reports from farms confirm this. The currently rapid growth in the demand for soy from China is an underlying driver for soy prices remaining high. Using analysis of scenarios, Pilorge and Muel[7] indicated that the current high prices for plant protein are here to stay, but their scenarios do not highlight the effects of further globalization and increased free trade. It is reasonable to conclude that protein remains valuable compared with carbohydrate and oil, and that this increases the potential for legumes in Europe with protein yield per hectare being a key determinant of success. High protein prices impact on produce with the highest protein concentration (soy and lupin). The high starch content of pea and faba beans means that the effect upward pressure on the value of their protein is buffered by the downward

[5] Humphreys, J., Mihailescu E. and Casey I. A. (2012) An economic comparison of systems of dairy production based on N fertilised grass and grass-white clover grassland in a moist maritime environment. *Grass and Forage Science* 67: 519-525.

[6] Schätzl, R. and Halama, M. (2013). Micro economics of soya production - soya bean cultivation under the aspect of crop rotation and economy. Danube Soya Congress in 2013 in Augsberg Germany.

[7] Pilorge, E. and Muel, F. (2016). What vegetable oils and proteins for 2030? Would the protein fraction be the future of oil and protein crops? Oilseeds & fats crops and Lipids.

pressure on the relative value of the starch. However, the overall effect is that pea, faba bean and other pulses will also become more competitive when protein prices rise.

Gaining a market advantage from environmental effects

There is definitely growing interest within agriculture and food in higher process quality, particularly reduced negative environmental impacts, manifest in the rapid growth in corporate social responsibility (CSR) schemes in the sector.[8] However, for legume production in Europe to sustainably and substantially benefit from such market premiums, it must be clear that legume crops support improved environmental performance that consumers recognize and reward. There is consensus that diversifying our cropping systems using legumes will bring environmental benefits, but these benefits are modest and probably not sufficient to drive large premiums. However by recognising a wide range of social and environmental benefits, CSR can still play a major role in transition.

Broad-based transition in value chains

In addition to changes in the individual fundamental factors outlined above, there is also the possibility of combinations of small changes leading to breakthroughs at the system level. Voisin et al.[9] argued that the development of legume production has been hindered by lock-in within incumbent structures and processes. For example, past trade agreements supported specialization of EU agriculture in cereal production and this has stimulated infrastructure investment in processing large amounts of imported soybean meal. Complementing this, Europe's natural ability to produce high-yielding cereal crops was reinforced by public and private investment in cereal breeding and supporting technologies. The resulting lock-in or dominance of the incumbent system is manifest for example in the market under-valuation of pea and faba bean in relation to their nutritional contribution in compound feeds.[10] Compared with the dominant European cereal/imported soy system, the lack of a critical mass of production of legumes in Europe reduces investment in technical support e.g., plant breeding) and leads to higher transaction costs. With such lock-in, a self-reinforcing dynamic supporting the dominant

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[8] Murphy-Bokern, D and Kleeman, L. (2015). The role of corporate social responsibility in reducing greenhouse gas emissions from agriculture and food. A study for the International Food Policy Research Institute. www.murphy-bokern.com.

[9] Voisin, A.-S. (Auteur de correspondance), Guéguen, J., Huyghe, C., Jeuffroy, M.-H., Magrini, M.-B., Meynard, J. M., Mougel, C., Pellerin, S., Pelzer, E. (2014). Legumes for feed, food, biomaterials and bioenergy in Europe: a review. *Agronomy for Sustainable Development, 34*, 361-380. DOI : 10.1007/s13593-013-0189-y http://prodinra.inra.fr/record/254912 Voisin et al. (2014).

[10] Preissel, S., Reckling, M., Bachinger, J. and Zander, P. (2016). Introducing legumes into European cropping systems: farm-level economic effects. In: Murphy-Bokern, D., Stoddard, F. and Watson, C. (ed.) *Legumes for European Cropping Systems*. CABI.

system works parallel to self-reinforcing dynamic that discourages alternatives, for example in different levels of research investment. Voisin et al. (2010) argued that starting with combining niche high-value chains that give priority to a secure and high quality supply within regionalized systems, new broader structures and processes can be established. The theory of transition[11] indicates that such new systems can emerge when the effects of several niche innovators coalesce. The innovators in these niche systems are free of the constraints in the dominant system and a wide range of technical and organizational innovations can play a role in each case. Eventually the success of these niche innovations influences the dominant system and changes it. New value chains may synergise with each other and with the dominant system. In animal feeding, legume species not only complement cereals, they complement each other offering a more diverse and resilient supply chain. In agricultural development contexts, the development of a high-value tradable crop such as soy can be used to spearhead improvement of farming more generally. This is particularly relevant in eastern Europe where synergies based on improved cropping sequences that use legumes can increase the output of both legumes and non-legume crops. Growth of legume production in the east offers the opportunity of new east to west trade within Europe as an alternative to trans-Atlantic soy imports.

Public policy support

Helming et al.[12] make clear that the development of policy instruments to encourage legume production is not as easy as is often assumed in public debate. A range of policy instruments supporting legume production have been introduced in the last two years in the European Union and there are early indications that the trend in the decline in the production of legumes has been reversed. However, as observed in debate recently in the European Parliament, there are economic and political trade-offs. There is particular caution about forfeiting the benefits of comparative advantage and the effect that using alternative protein sources might have on feed costs (assuming that alternatives are more expensive). Policy instruments that seek to influence cropping decisions are controversial. In addition to the general 'Greening' measures (crop diversification and the ecological focus areas), direct subsidy for protein crops (grain legumes and alfalfa) is provided by the Voluntary Coupled Support in 16 of the 28 EU countries. Payments range from 36 €/ha in Finland to 417 €/ha in Slovenia.

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[11] Geels FW (2011) The multi-level perspective on sustainability transitions: response to seven criticisms. Environmental Innovation and Society Transition 1:24–40.

[12] Helming, J., Kuhlman, T., Linderhof, V., and Oudendag, D. 2014. Impacts of legume scenarios. Legume Futures Report 4.5. Available from www.legumefutures.de

The future, of course, depends on a combination of these six developments. A systematic use of value chain approaches will help combine developments for sustained change at local level within the diverse farming and food systems across Europe. New value chains will emerge. In this, establishing new connections between crop and livestock, particularly through new feeding strategies. This means giving attention to breeding strategies.

New animal feeding strategies: a major challenge for developing value chains

While there is a wide range of value chain opportunities, we must realise that the largest market and greatest challenges relate to the use of legumes as components of animal feeds. The economic production of feed for intensive pig, poultry and fish production is particularly challenging. From a technical viewpoint, reliance on soybean meal is perhaps not as essential as is sometimes assumed. For example, the Green Pig Project in the UK concluded that peas and faba beans are viable home-grown alternatives to soybean meal in nutritionally balanced grower and finisher pig diets.[13] Higher than traditionally considered upper inclusion limits can completely replace soybean meal without detrimentally affecting growth performance, digestibility and N-balance, and carcass quality whilst reducing environmental impact, arising from reduced transatlantic transport emission and global warming potential, especially if soybean meal replaced is associated with land use change[14] These outcomes from the Green Pig project and others like it support a very important point about the development of feeds that reduce reliance on imported soybean meal: 100% replacement of soybean meal per se is not required to improve sustainability, especially given that soybean meal is the most produced grain legume in Europe. The use of other legumes is also made easier by synthetic amino acids. For ruminants, legumes offer a range of possibilities including the harvesting of grain legume species as high quality forage, or mixed with cereals. Particularly considering the increasing demand for source-defined livestock products, the opportunities for flexible approaches to using legumes, cereals and other feedstuffs is increasing within new emerging value chains.

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[13] Houdijk, J. (2012). Final report LK0682. The environmental consequences of using home-grown legumes as a protein source in pig diets (Green Pig). http://www.pgro.org/images/site/2016-RD/Final-report-LINK-Project-LK0682-Green-Pig.pdf

[14] Houdijk, J.G.M., Smith, L.A., Tarsitano, D., Tolkamp, B.J., Topp, C.E.F., Masey-O'Neill, H., White, G., Wiseman, J., Kightley, S. and Kyriazakis, I. (2013). Peas and faba beans as home grown alternatives for soya bean meal in grower and finisher pig diets. In: Recent Advances in Animal Nutrition 2013, Edited by P.C. Garnsworthy and J. Wiseman. Nottingham University Press, Nottingham, pp. 145-175.

Conclusion

Developments in the last 10 years have provided a rich resource of practical knowhow and insights embedded in farming and food businesses which can now be used to improve systems supported by research-based experts. Such an open 'multi-actor' approach complements the research we have had to date, which was largely about components of systems. The successful combination of knowledge in value chains is the way forward if we are to be able to look back proudly at effective change in ten years. Overall, a four-fold increase in grain legume production over the 2014 level to about 6.5 million ha (6% of the arable area) would be beneficial from a farming systems perspective. Given the huge market for plant protein now met by imports, there is no fundamental internal market constraint on this high level of growth. If we assume that the output of non-leguminous crops was to remain stable (due to rotation benefits and the general technical progress in Eastern Europe), we estimate that the aforementioned four-fold increase would result in an increase in the supply of protein from EU-grown grain legumes from 1.37 million tonnes of plant protein to 5.5 million tonnes. This compares with a total demand for 54 million tonnes of 'tradable' arable plant protein including a net import of 15 million tonnes of soy protein. This increase would reduce the deficit in high protein commodities from about 70% to about 50%. This might be regarded as a small impact, however Legume Futures results indicate that it comes with broad complementary agronomic, economic, environmental, and social impacts. Unless this change causes a reduction in cereal exports, we can expect improvement in Europe's balance of trade. Through improved value chains, this translates into increased economic activity and employment in rural areas. From our work with value chain developers, we expect positive impact in terms of territorial cohesion and regional development. Given that the proportion of grain legume crops in organic systems is 12% on average, and frequently as high as 20%, further expansion in conventional cropping to 10% of the arable area is reasonable to strive for. This would radically reduce reliance on imported soy. The challenge for the future is the optimal expansion of production of legume crops to while maximising complementary impacts so that change can be economically, socially and politically sustained. For this, European legumes must be competitive for land at produce prices that are competitive with imports.

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