'Blueprint for UK Pulses in a post-Brexit world'

Processors and Growers Research Organisation

Executive summary

The challenge

Future UK funding for agriculture needs to focus on sustainability, the environment and public good. In this context, pulses are under-exploited. The changes and challenges of Brexit present an opportunity for growers, researchers and traders to realise the full potential of pulses (protein crops/legumes such as dry peas and beans/vegetable legumes).

The benefits

- The evidence for pulses and the environment shows clear benefits from their inclusion in farming rotations by significantly improving biodiversity, crop productivity and soil fertility while reducing greenhouse gas emissions and pollution.
- Enormous quantities of soya and other oilseeds are consumed in the UK animal feed industry annually and this is the main cause of the annual protein deficit. Hence, increased UK pulse production can significantly offset this trading and environmental imbalance.
- By educating and giving a lead to dietary change to include a greater proportion of vegetable protein in the form of pulses and pulse-derived ingredients, there is a huge opportunity to bring major societal and economic benefits and reduction in health care costs.

Barriers to realisation

- Supply and demand in the UK market is inconsistent and not accurately reported, hampering market development.
- The niche crop status of pulses has traditionally minimised commercial investment and limited productivity improvements.
- Decades of policy focus on oilseeds and cereals, with the lack of any UK protein policy, has by comparison severely limited public funding for research to enhance genetic variability, pulse crop diversification and value in the legume supply chain.

Proposed strategic actions

- Encourage cropping for environmental good. Specifically targeting pulses and vegetable legumes to aid the sustainability of UK food production systems in agriculture.
- Take an approach to crop protection and nutrition to assist the production of pulse crops, ensuring more economic productivity and reliability.
- Incentivise the feeding of UK-produced plant proteins to drive local demand and fuel production.
- Stimulate investment of private equity in industrial processing and ingredient manufacture to kick-start demand and to drive increased, more efficient production and to add value.
- Increase education of growers and the supply chain about the environmental and economic benefits of pulse production.
- Set out a clear strategy of education in schools via the national curriculum to stress the health benefits of pulses, food origins and to encourage healthy eating choices.
- Require public procurement and service providers to take a lead in the provision of healthy pulse-based diets and education initiatives.
- Require Government departments to collate and distribute timely, accurate public supply statistics.
- Set up a market and research development platform with trade and research organisations to identify research priorities for funding initiatives with a unified approach.
- Use public funds for public good research directed at agronomic risk reduction, developing UK traits for genetic improvements, pulse crop diversification and added-value processing

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Introduction

Michael Gove, the Secretary of State for Environment, Food and Rural Affairs, recently said [(1)] that subsidies for farming would be reviewed as the UK left the EU and that future payments to the industry would not only be reduced, but would be heavily dependent upon delivering environment and social benefits. Future agriculture would not be run on the balance sheet alone – there would also be the need to ensure that agriculture was competitive - and that the wider rural economy also received adequate investment to enable it to thrive.

Part of the necessary change to achieve these political goals will be to examine and exploit different cropping patterns in UK agriculture. In order to embrace the concept of the environment, the protection of biodiversity and the natural capital of soil fertility, crops and cropping practices will need to be compatible with these objectives - and this is likely to impact upon use of fertilisers and crop protection products. The adoption of inputs and revised management techniques, and striving for truly sustainable development, will be essential to feed the population and protect both the economy and the environment.

In the headlong pursuit of profit and yield, and through policy encouragement to do so, the agricultural production and supply chain in both the EU and the UK has focussed on production of cereals and oilseeds. The commercial investment in these areas has been huge and has driven huge increases in productivity. Other crops have, by comparison, received very little attention and, as a result, have become relatively minor despite their potential to enhance diet and environment. Legumes - particularly those grown as field pulse crops or vegetables – are one such group of crops.

This summary document is drawn from the longer and more widely referenced position paper produced by PGRO experts: '*The potential for UK grown pulse crops in a changing environment: a critical appraisal*' which is reproduced in full at the end of this report.

1. Environment

The evidence concerning pulse and vegetable legume crops and the environment shows clear benefits from their inclusion in farming rotations.

The benefits of these crops are widely recognised by scientific researchers, environmental groups and agronomists worldwide. Diversity in the natural environment is enhanced by diversity in the cropping environment and the use of a wider crop rotation. Pulse crops vary in their requirements for nutrients and have differing water use efficiencies. In addition, growing a wider range of crops encourages diverse habitats and feeding opportunities for wildlife, both above and below ground.

Leguminous crops require no artificial nitrogen fertiliser thereby decreasing both the environmental damage from its use and the enormous energy consumption and greenhouse gas generation in its production.

Being highly symbiotic with soil microflora, pulse crops increase biodiversity, resulting in an enhanced and more fertile soil condition and ensuring that subsequent crops perform better after pulses have been grown.

Numerous studies have confirmed the positive benefits of beans and peas to pollinators, insects and birds, again increasing biodiversity and making their production highly compatible and beneficial with wilding measures for crop perimeters.

Water and land use efficiency is significantly greater when producing vegetable rather than animal protein. Clearly pulse crops offer this opportunity on a wider scale.

It is hard to find another group of crops that offer more positive potential for environmental good and long-term sustainability via increased production than legumes. Policies to encourage the use of grain or vegetable legume production would be a significant benefit to the environment and society as a whole.

2. Crop performance and legume crop diversity in the UK

For decades investment in pulse crops has been at a low level. As a result, progress has lagged behind the much larger monoculture crops of cereals and oilseeds.

Positive direction of increased public research funding to minimising the risk in pulse breeding and production would encourage further commercial investment.

Breeding by conventional means requires long-term commitment and a belief that a profitable market will exist. In the same way, developments in crop protection require significant investment in research and registration backed by the assurance of potential profits from crops.

UK grain and vegetable legume production is largely restricted to peas (*Pisum sativum*) and beans (*Vicia faba*), yet there are many other types produced around the world that could be adapted for UK production (examples include lentils, chickpeas, lupins and phaseolus beans).

An enhanced political impetus for UK vegetable protein production for human consumption would encourage breeding and selection effort to commercialise types

suited to the UK's climate. This in turn would enhance their production in the UK, providing new products alongside environmental and dietary benefit.

A clear political direction, with accompanying incentives for greater and more diverse grain legume production in the UK, would encourage longer-term investment from commercial companies throughout the supply chain.

3. Crop performance, research and knowledge exchange

The UK has many excellent academic researchers with world-leading expertise in legumes. If they were sufficiently supported by policies directed at the improvement of sustainable productivity, environmentally sympathetic production and legume performance, they would make a significant contribution to increased production efficiency and reliability.

Associated investment in applied research with partnering organisations, networked for effective knowledge exchange to growers, would achieve rapid results.

The Canadian model of public funds for public good directed at improving increased and reliable pulse production research has been hugely successful in building a large and vibrant sector in their economy. Genetic improvements, processing and utilisation support, agronomy and sustainable production systems, would be key target areas for support.

4. Public health and education

The western diet must change to tackle the obesity crisis and lower the burden on the health services caused by unhealthy consumption.

A dietary change to include a greater proportion of vegetable protein in the form of pulses and pulse-derived ingredients has enormous potential benefits to society. For example, healthy pulse-based snacks could replace existing high-calorie snacks.

Policies in health and education to raise public awareness of the benefits of eating pulses are essential. Minor changes to diet to include pulses could deliver a significant benefit - but these changes need to be adopted by the UK population.

Investment in pulse processing and ingredient development in the UK food industry would accelerate the realisation of these dietary benefits. This would serve to ensure the development of a market that at present is extremely small and largely reliant upon imports of processed ingredients.

The procurement policy of public bodies such as the NHS, prisons, the armed services and schools could begin the education process by leading the way with the provision of tasty, healthy diets that include legumes.

Using the national curriculum to inform children about the origins and health benefits of different food groups would help to educate the population with the knowledge of what they consume and encourage healthy eating choices.

5. Animal feed industry and environmental impact

Enormous quantities of soya and other oilseeds are consumed in the UK animal feed industry annually and this is the main cause of the annual protein deficit.

The heavy reliance upon imported soya for animal feed has significant economic risk as it is exposed to internationally-traded futures in an ever protein-hungry world. Also, much of the UK's imported soya is produced in South America where the removal of natural vegetation for its production has a massive, negative environmental impact.

UK-produced pulses and legumes can be used to a much greater extent in animal production systems to reduce the reliance on imports. The main barrier to date is the continuity and reliability of supply.

Policy encouragement for greater pulse and legume production would drive a consistent supply which feed producers could rely on. This would reduce their need to make forward commitments to soya and other imported raw materials.

6. Market knowledge and productivity

The level of supply and demand in the UK market is not well defined or reported. The only official data produced is the national crop area of peas and beans for animal consumption in the annual *DEFRA June Survey* published in retrospect.

This is a sample survey carried out at a high level. It is not widely recognised as accurate within the industry, yet is the only firm data that can be used to estimate the crops of peas and beans.

This lack of certainty in the crop areas grown is compounded by the lack of official figures for crop yields - and no requirement to report them. This means that there is insufficient clarity about actual supply in any single year. Clearly, this reduces commercial confidence and investment in UK pulse production.

For a market to work more effectively and be more transparent, there needs to be more clarity with regard to production and supply.

Publication of crop areas before harvest would be of significantly greater value in informing the market. The Basic Payment Scheme requires declaration of the crops grown field-by-field, so precise knowledge of the area grown each year is available. Furthermore, reporting of post-harvest yields, coupled with accurate estimates of crop areas sown, would give a clear picture of the performance of pulses. Availability of these statistics would have a dramatic impact in improved planning and reduced production and marketing risks, enhancing the uptake of pulses.

7. Policies and the marketplace

The marketplace continues to be influenced by past policies whereby schemes and agreements have favoured and encouraged oilseed and cereal production. This has distorted the market supply chain by focussing heavily on those crops.

This policy has been to the exclusion of development effort in other crop areas such as legumes. The situation is further compounded by the lack of futures markets in minor crops, which means hugely increased uncertainty for buyers, sellers and producers.

It can be easily seen how policy and incentives can influence cropping. For example, the massive rise in maize production in recent times has been driven by the subsidisation of the renewable/bioenergy market.

In the UK, the lack of clear and positive action on protein crop policy has actively deterred their production, wrongly confining them to the margins of UK agriculture. This is despite their enormous advantages for the rotation as a whole, the environment and their potential positive contributions to the national diet.

As the UK exits the EU, there is a need for implementation of policies encouraging cropping for environmental good. Targeting pulses and vegetable legumes within such policies would have a positive impact on the sustainability of UK food production.

About the PGRO

The PGRO is the UK's centre of excellence for peas and beans with a long-established and respected reputation for promoting and carrying out research and development in peas and beans.

PGRO concentrates on applied research, disseminating knowledge gained to growers, agronomists and the wider supply chain. Its growing guides and Recommended Lists of varieties are the national references for all involved with the crop. It publishes 'The Pulse Magazine' quarterly, the 'Pulse Agronomy Guide' annually, and issues technical bulletins during the growing season. In addition, the PGRO provides education and training courses, and runs grower/agronomist meetings around the UK, and is currently co-sponsoring a number of PhDs.

PGRO is financed by voluntary non-statutory levy contributions from growers, associate members, and commercial contracts plus competitively sourced outside funding for research work. This is carried out both alone and in partnership with UK, European and worldwide research and commercial organisations.

The PGRO remains a unique organisation in the UK, with pulse and legume crop development and research as its core purpose. Its informed and independent perspective makes its view of the future of pulses pertinent to UK policy makers forging direction for agriculture, the environment and societal health in the years ahead.

Appendix

The potential for UK grown pulse crops in a changing environment: a critical appraisal

This paper outlines the role for pulses and UK produced vegetable protein crops in the delivery of the governments' goals of sustainable development. It is presented by the Processors and Growers Research Organisation (PGRO).

Introduction

The definition of Sustainability is evolving but the three commonly accepted conceptual pillars are those of Society, Economy and the Environment.

Whilst individuals, companies, politicians or interest groups have their own ideas about sustainability and what it means for them the governments' aim is for sustainable development defined in a policy paper updated in May 2015. **2010 to 2015 government policy: sustainable development.** [(2)]

"The government is committed to sustainable development. This means making the necessary decisions now to realise our vision of stimulating economic growth and tackling the deficit, maximising wellbeing and protecting our environment, without affecting the ability of future generations to do the same."

"All departments are responsible for making sure that their own policies and activities contribute to sustainable development. The Department for Environment, Food and Rural Affairs (Defra) has a role in overseeing sustainable development across central government."

In March 2017 the UK Government signed up to 'Agenda 2030. The UK Government's approach to delivering the Global Goals for Sustainable Development - at home and around the world'. [(3)]

17 Global Goals for Sustainable Development which will shape the world's approach to growth and sustainable development until 2030. The Goals were agreed by 193 member states of the United Nations (UN) in September 2015 and apply to every country. The UK Government is firmly committed to delivering the Goals both at home and around the world

This paper outlines the role for pulses and UK produced vegetable protein crops in the delivery of the governments' goals of sustainable development.

Where the pulse industry stands at this moment. UK and within the wider world

Whilst there are a huge number of pulse crops globally, for climatic reasons and hitherto lack of incentive for variety improvement, UK production of pulses is largely confined to various types of pea (*Pisum sativum*) and field beans (V*icia faba*).

Peas and beans, (both dry and frozen) utilised approximately 250,000 ha in 2017, just 4% of the 6.1 million ha crop able area, over half of which is cereals. For decades as crops of smaller commercial interest in the UK they have attracted significantly less attention from the inward supply chain and relatively minor effort from the plant breeders as a result. This picture is not unique to the UK. The 'Global Pulse Productivity & Sustainability Survey'[(4)] suggests annual investment in pulses hovers at $175m, whereas billions are invested into other crops such as corn.

The small crop area automatically means a lack of Political focus and public research funding by comparison. Accordingly pulse crop performance development has lagged other crop progress. Grain legumes are out with the remit of the AHDB and as a result they are not the focus of their attention either.

Whilst there are no official figures for yield, DEFRA crop area figures [(5)], matched with British Edible Pulse Association [(6)] and British Growers Association [(7)] estimates, suggest the UK produced up to 730,000 tonnes of pulses (580,000 tonnes Faba beans, 150,000 tonnes Dried Peas) and 130,000 tonnes of vining peas in 2017.

In contrast in 2017 Canada the world's largest exporter of pulses- responsible for over 50% of the world trade in peas and lentils - produced around 6 million tonnes. (3.1 million tonnes of peas, 2.6 million tonnes of Lentils, 322,000 tonnes of various dried beans, 92,000 tonnes of chickpeas: Ref: Canada: Outlook for Principal Field Crops - December 18, 2017)[(8)]

There is currently almost no domestic human consumption of dry faba beans in the UK and production is targeted at export for human consumption in Africa and the Middle East where they form a significant part of the staple diet. Egypt alone imports approximately 800,000 tonnes annually, traditionally taking approximately ¼ from the UK. Exporters are highly reliant upon grower ability to control insect pests and produce bright appealing grains. In 2017 only 20% of the production met the required standard for premium prices and exports fell as a result. The remainder is destined for the salmon and animal feed industries as a result.

Pea production is intended for exports and human consumption in the mushy pea, canned and snack categories. Again poor quality grain affected by the weather or pest control problems will make its way to the pet food and animal feed markets. In 2017 just 10% of the marrow fat peas made the grade.

These quality issues and consistency of crop performance mean there is an accented risk associated with pulse production which impacts the growers, processors and export buyers as supplies can fluctuate significantly year on year. These problems can in part be resolved throughout the supply chain by breeding, agronomic research and knowledge transfer, if investment in resources and focus can be encouraged to deliver it.

The relatively small scale of pulse cropping in the UK in part reflects the abundance and availability for decades, of relatively cheap artificial fertiliser for the production of larger commodity crops such as wheat, barley and oilseed rape and a political focus that has concentrated on vegetable oil and carbohydrate production in the absence of a national protein strategy within the UK and the wider EU. This has led to a huge protein deficit with reliance to fill that gap on the importation of soya bean and soya bean meal mainly from the Americas. The focus on domestic commodity starch production has led to the reduction in crop and crop rotation diversity, with the increased exclusion of lower yielding crops such as pulses despite their significant agronomic and environmental benefits. Latterly new competition for land area has arisen with the dramatic rise in the mono cropping of maize and other species for renewable energy production all of which have received incentives for investment.

The UK is not alone with this problem, it is mirrored across the EU. 'The EU protein deficit: what solution for a long-standing problem?' (2010/2111(INI)) report A7 -0026/2011 [(9)] report called for;

1. a long-term view in reviewing its policy on proteins - reliable new measures and instruments which support farmers in improving crop rotation systems so as to substantially reduce the current protein deficit and price volatility.
2. a report on the possibilities and options for increasing domestic protein crop production in the EU by means of new policy instruments - the potential effect on farmers' revenues, the contribution it would make to climate change mitigation, the effect on biodiversity and soil fertility, and the potential for reducing the necessary external input of mineral fertilisers and pesticides.

Increased pulse production in the UK can have a positive benefit in all of these areas for innovation and would have a direct positive impact on the protein deficit issues highlighted.

Potential for UK pulses industry - meeting the challenges of healthy diets for humans and animals and also those of the environment.

Human Health

In an era when we are facing rapidly growing obesity and health care crises pulses and legumes have a significant role to play. Pulses are a healthy alternative as recognised by the NHS Live Well recommendations. [(10)]

Cheaper than meat, they are rich sources of protein, fibre and micronutrients including iron, zinc, magnesium and folate. Low glycaemic index foods, they release their energy slowly over time, preventing surges in blood glucose, important in the control of diabetes. They are gluten-free and therefore ideal for those with intolerances or coeliac disease. Low in cholesterol, fat and sodium they can significantly contribute to effective control of heart and blood health issues.

Numerous studies confirm legume-rich diets can decrease cholesterol levels and when added to the daily diet of diabetic patients, their fasting blood sugar levels significantly decrease.

In 2016 Researchers at Sheffield University reported in comments on 'why pulses are the eco-friendly option for feeding – and saving – the world' [(11)] that populations with the greatest lentil consumption also have the lowest rates of breast, prostate and colorectal cancer. Increasingly, a high-fibre diet is associated with a reduced risk of colorectal cancer. Fibre content may also explain the satiating effect of pulses: for example, incorporating lentils into energy-equivalent meals causes greater fullness and a lower daily calorie consumption.'

In the west Pulses have faced barriers including the need for overnight soaking, unappealing tastes and potential flatulence from a high-fibre diet. Whilst the time spent on food preparation has been demonstrated as a potential indicator of dietary health (Pablo Monvsivais et.al 2014) [(12)] consumers are showing a clear preference for convenience. The Institute of Grocery Distribution (IGD) forecasts Convenience to grow twice as fast as the supermarket sector let alone the convenience products sold by them.

To this end international ingredient manufacturers are developing pulses into new functional ingredients that provide all the benefits of eating whole pulses. These already include pasta, crackers, batters, flours and egg/meat-replacement products. But there has been little encouragement for this in the UK despite the relatively huge size of the potential and significant infrastructure in the processing of pulses is almost entirely lacking (e.g. pulse flour milling capacity and protein extraction facilities) which means that it is less likely to be the UK environment or economy that benefits from their development. Redressing this capability issue would present an opportunity.

In 2017 The Institute Grocery Distribution (IGD) forecast [(13)] that the UK food and grocery market will grow by 15% by 2022 giving it a value of £213 billion. The size and continued growth of the food industry represents a potentially golden opportunity for pulses to play as key role in influencing health and wellbeing of the nation but positive encouragement at all points along the value chain is required if they are to be developed, produced, processed, manufactured and marketed into the food chain in significant and effective quantities.

Meanwhile recognition of the importance of pulses on a global scale was highlighted with the United Nations selection of 2016 as International Year of Pulses, the aim being to raise public awareness of their nutritional benefits and as part of sustainable food production, to encourage food chain connections, to better utilise pulse based proteins and their global trade. [(14)]

Positive initiatives are required and might start with guidance for procurement and use in the public sector and encouragement or incentive for the private sector companies to use pulses in the development of healthy food products and food ingredients. Education and raised awareness of the health benefits of pulses and pulse-derived products with consumers is also key.

In recent decades the general population has become increasingly detached from the origins of their food. The urbanisation of the population means that a large percentage of people are no longer familiar with vegetable or meat production and have no concept of the relative values of each, their methods of production or nutritional costs or benefits. Using the national curriculum to educate children about the origins and health benefits of different food groups would help to re-engage the population with the implications of what they consume and encourage healthy eating choices and begin to re-engage them with the concept of where their nutrition comes from and how they can use it to have positive impacts on their own health.

If increased demand can be created, awareness of the benefits of pulses raised and value added in processing, local production is capable and will respond.

Animal Health / feed

The DEFRA Animal Feed Statistics for Great Britain [(15)] reports on animal feed production in the UK. Approximately 13.7 million tonnes of animal feed is produced annually. The current use of pulses in this sector is small and not specifically recorded in the published statistics.

Faba beans represent an alternative source of protein and starch that can and is used by animal feed producers. The primary restriction in this market is the reliability of supply. The second is cost.

Numerous independent studies and on farm feed experiences have shown that very high proportions of soya feed can be replaced with faba beans in various animal production systems with appropriate additional changes to dietary balance and supplements. In numerous studies - including the DEFRA LINK Green Pig project [(16)] and *Optibean* and *Beans 4 Feeds* [(17)] sponsored by Innovate UK - this has been shown without the loss of performance and in many cases the perception of improved animal wellbeing. Indeed Waitrose (partners in the *Optibean* project) have begun to embrace and drive the possibility for partial substitution of soya with faba beans in UK monogastric diets as reported in their Member annual public report 2014. [(18)]

Faba beans are being used extensively in the UK salmon industry which consumes 30 - 40,000 t of faba beans annually. Processing is required to remove the bean skins but the high protein content and the binding nature of the flour makes the bean a valued ingredient in salmon feed. Export opportunities exist here as the Norwegian industry is approximately 10 times that of the domestic UK salmon market. These opportunities can be further and significantly increased in the fish feed industry if either breeding or processing methods can be used to economically significantly increase the protein concentration of the faba bean.

Innovative mixed farming enterprises are also realising the effective possibilities of producing and feeding bean protein on farm, feeding dried or preserved grains or even ensiled whole bean crops. A concept explored in the article ‘Hold on to more profit with home-grown beans’. [(19)]

The main problem in the delivery of a significantly larger uptake of faba bean is the ability of the supply chain to deliver year round and the lack of a forward commodity market. The purchasing of soya is easy. There is a futures market and essentially apparent security of supply – albeit with a volatile price and risk.

The UK is currently unable to effectively produce soya importing the whole 12-month rolling requirement of 1.08 million tonnes. In addition importing 364,000 tonnes of sunflower cake and meal which is also used as an alternative protein feed source. (Animal Feed Statistics for Great Britain – October 2017). [(20)]

As soya protein content is roughly 35% higher than faba beans it shows the potential to use well over 1.45 million tonnes of faba bean in the UK animal feed market. This represents 4-5 times the quantity produced for UK animal feed in 2017 and would require a cropping area at current yields of approximately 362,000 ha for that market alone. Whilst a total replacement for soya is unrealistic it none the less demonstrates that the upside for crop area increase is very significant.

The second break on use is price. When faba bean is plentiful the price falls and becomes perceived as competitive to soya and other alternative feeds per unit of protein. At these low levels and with average yields growers claim it to be uneconomical to grow and drop it from the rotation. This drives shortage (fulfilling the processors view in unreliability of supply), the price goes up and the cycle resumes. This begs the question of the need for intervention in terms of support for protein crop production (and / or support for ecosystem services and environmental crop benefits.

Additionally growers need to be further educated in best practices of production in order to increase yields and decrease the average unit cost of production. Both of these objectives are achievable as demonstrated by the achievements of leading producers.

It would be folly to believe that meat production and consumption will stop. However it is undeniable that the production of meat is inefficient in terms of resources and to base that production so heavily in the feeding of imported soya is unsustainable and an economic risk.

The picture for soya in the UK is confused by its classification as an oilseed. Whilst it is also a legume it falls under the remit of the AHDB. Due to climatic reasons there is little produced in the UK and therefore it too attracts little attention from the AHDB as there is little levy to be returned. A natural home for independent applied soya research in the UK would be the PGRO (legume specialists) and it receives many enquiries. Although it would welcome the opportunity to work on soya whilst the crop it outside its remit, it too is currently doing little in this direction.

Other barriers to wider use of beans in the animal feed industry include:

1) In the Fish production industry: An uplift of 5 -10% in bean protein content without the need for concentration in processing would increase consumption dramatically. It would also have significant advantages in ruminant and monogastric diets. This could be a plant breeding objective but would require a leap of faith for a breeder in what appears to be a very small market. Investment is required here to bring on higher protein beans and to bring on line economic protein extraction processes on a commercial scale together with finding alternative uses for the resulting co products (mainly starch) that can add value.

2) Feed Industry location - The development of the feed industry around the importation of Soya has had the additional effect of placing significant infrastructure at ports, geared towards handling bulk vessels. This plays against UK grown produce which of necessity has to be collated by lorry from farms around the country to centralised processing facilities. Investment in regional or on farm pre-processing capabilities would provide versatility and improved opportunity for wider and more extensive utilisation of this nutritionally valuable crop.

Environmental benefits

The Cost of Unsustainability:

There are only a limited number of studies estimating the external costs of agriculture. In recent work on the addition of pulses in crop rotations - their study 'Diversifying crop rotations with pulses enhances system productivity'; Yantai Gan et al 2015 [(21)] show that the addition of pulses leads to an:

- increase in the moisture of the soil;

- increase in nitrogen available in the soil;
- increase in crop production by 36%;
- increases the amount of protein in cereals by 51%; and increased the efficiency of nitrogen fertilizer use by 33%.

Despite these benefits, which can improve cereal productivity whilst reducing the needs for nitrogen fertilization, which may decrease global warming and environmental pollution, most farmers don't seem interested in integrating pulses in agricultural production. This failure in itself causes possibly large external costs to the environment, by causing an unnecessary overconsumption of fertilisers and chemicals that reduce the environmental quality of soils and ecosystems.

In a French study Magrini et al. (2016) [(22)] show this situation was caused by favourable economic conditions of cereal markets and to an increase in low-priced imported pulses (mainly soybeans), which in turn discouraged pulses production in continental Europe. This market-driven situation resulted in the evolution of crop systems based on stimulating production by using agrochemicals to keep costs down, rather than focusing on more sustainable alternatives.

In it's paper on Pulse Market Trends, Newcastle University School of Agriculture [(22a)] reported on the economic value of more sustainable agricultural systems reporting that 'Unsustainable agricultural systems cause significant external costs to society including ground water contamination and reduced biodiversity. These costs are external because they are not usually integrated into the economy (e.g. they are not included in the price of agricultural goods). Importantly, these costs can occur sometimes in a relatively distant local and time frame from when the polluting started. A shift to more sustainable agricultural system can lead to a reduction in the external environmental and health costs imposed by agriculture on society.' They cited a report by Pretty (2008) [(23)] who showed that sustainable practices: increase agricultural yields by an average 79% across a wide range of agricultural systems and crop types (geometric mean: 64%); often (60% of the studies) reduce pesticide use without losing yields; and increase in carbon sequestration by an average of 0.35 t C/ (ha/ yr.).

Comprehensive studies of sustainable and unsustainable practices and cost and benefit measurement are few due to their complexity however Pretty et al. (2000) [(24)] in 'An assessment of the total external costs of UK agriculture' found that the annual total external costs of UK agriculture is in the order of £2,343 M - £3907 M. This value is sizeable: incorporating these external costs would increase the costs to farms by £208/ha of arable and permanent pasture. In the UK, the costs refer to the contamination of drinking water (over £210 M/year), greenhouse gas emissions (£1113 M/year), damage to the soil (just short of £100 M/year), losses in biodiversity and landscape (circa £130 M/year), and damages to human health (£777 M/year).

In just one amongst many recent reports the Forum for the Future study "The Protein Challenge 2040: Shaping the future of food" [(25)] identified the crisis in over fishing, habitat loss, water use and efficiency, feed price volatility, soil degradation, antibiotics and global warming greenhouse gases and put forwards 6 areas for innovation.

1. Increasing the proportion of plant based protein consumption with consumers
2. Scaling up sustainable animal feed innovation to meet demand for animal protein
3. Closing the protein nutrient loop – *extracting more from what we produce and wasting less*
4. Developing indigenous plants as protein sources for local communities
5. Scaling up sustainable aquaculture for food and animal feed
6. Restoring soil health

Studies on the positive environmental benefits of pulse crops are numerous and are the conclusions are widely recognised by both government departments, NGO's and numerous specific interest groups.
It is clear that the wider use of pulse crops and legumes in the arable rotation can have a positive impact in all of these areas and an increase in their production needs to be encouraged.

Soil Health:

Nitrogen fixation:

Peas and beans are protein crops. They are legumes (members of the leguminosae family) and are most notable for the natural symbiotic relationship they form with nitrogen fixing bacteria (Rhizobia), which through the formation of nodules on the plant root system fix nitrogen from soil air. This means that uniquely in agriculture legumes require no artificially produced nitrogen fertiliser whilst fixing up to 240kgs/ha of N themselves. Surplus nitrogen not converted to protein in the seeds is released back to the soil as the plant decays making it available for subsequent crops.

DEFRA and the Environment Agency provide guidelines on the management and restriction of Nitrogen inputs for crops in large parts of the UK designated Nitrate Vulnerable Zones (NVZ's) [(26)] with increasing concern about the leaching of nitrate pollutants into water courses nationally.

The wider and more extensive use of legumes together with cover and catch crops to prevent leaching to watercourses can help significantly reduce nitrogen use and at the same time reduce the amount of artificial nitrogen fertiliser applied in the following crop as well.

Soil biology

Additionally, legume crop root systems form extremely close symbiotic associations with mycorrhizal fungi which significantly enhance their ability to scavenge and release other nutrients in the soil. The result is that legume crops leave the soil in an enhanced condition for subsequent crops and play an important part in crop rotation. They are especially valued in organic production systems, which without recourse to artificial fertilizers rely almost entirely upon the natural enhancement of soil fertility.

In addition to reducing the inoculum potential of some cereal soil-borne pathogens as a result of growing, legumes can also influence the populations of specific rhizosphere organisms which may compete, antagonize or suppress pathogens. Some legumes appear to reduce the survival of certain species of nematodes and stimulate the activity of a plethora of soil organisms such as earthworms - all of which is quoted in the "Impacts on soil biology" review article. 'The contributions of nitrogen-fixing crop legumes to the productivity of agricultural systems': (M.B. Peoples et al.) [(27)].

Biodiversity:

The loss of biodiversity is commonly quoted as a problem with intensive farming. Whilst giant strides have been made by farmers and land owners to address this issue in recent years the relatively narrow crop sequences that have been driven by short term economics have depleted the soils and the lack of variation in the crops themselves cannot be compensated completely by the use of margins and conservation strips alone. A widening of the rotation and a wider use of different crop species has a significant benefits and in this respect pulses and legume crops can play a major role which is widely recognised.

Pollinators

Legumes are flowering plants that benefit from the services of pollinating insects - especially bees. Yields of beans are significantly enhanced when bees are in abundance. Beans are very attractive to bees and their extended flowering pattern provides valuable bee feeding habitat especially early in the year. Via the 'Sustainable pollination services for UK crops project' sponsored by DEFRA and UK Research councils M.P.D Garratt et al [(27a)] (2014) quantified the active nature and importance of bees finding that

"visitation improved pod set in beans, and bumblebees, honey bees and mason bees have the capacity to improve pod set by between 60% and 69%".

This was highlighted in The National Pollinator Strategy: for bees and other pollinators in England published by DEFRA in November 2014 [28], discussing "Opportunities for pollinators are available through new measures in the reformed CAP". Specifically Ecological Focus Areas (EFA) to be applied to 5% of arable land could include nitrogen-fixing crops and farmers were encouraged to consider, on a voluntary basis, how their selection and management of those EFA options can bring the greatest environmental benefit of their farm, particularly for bees and other pollinators.

Since the introduction of this environmental measure the area of faba beans in the UK has risen significantly year on year. Ironically the changes to EFA rules in 2018 preventing the use of any plant protection chemicals on area to be claimed as an EFA will result in the reduction of beans being grown to the detriment of the environment as growers will simply tot up the other existing qualifying features on the farm to make good their requirements (a more laborious task without environmental benefit).

In the Friends of the Earth report ("Farmers need bees, bees need farmers 1 January 2014 - Farmers' perspectives on why we need a strong National Pollinator Strategy") [29] a key finding was that 'Crop diversification can help with pest control and soil fertility and provide food for bees'. In discussing crop diversification they conclude that - By diversifying the crops grown – to include more open flowering plants in crop rotations farmers can help to increase food sources when wildflower margins are less likely to be flowering. In arable farming an increase in the planting of pulses (peas, beans and lupins) would also help to control diseases, pests and pernicious weeds such as blackgrass – and deliver a free source of soil nitrogen.

Birds

Attracting and providing habitats for insects has a resulting impact for birds. Work at the RSPB's Hope Farm ('*Making explicit agricultural ecosystem service trade-offs: a case study of an English lowland arable farm'*)[30] concluded that removing up to 10.5% of land from production coupled with a more diverse rotation from winter wheat and oilseed rape only to include legumes, resulted in a large increase in breeding birds (177%).

A not uncommon anecdotal response is similar from most bean growers. *(E.g. Pulse Magazine Winter 2016* "Birds and the Beans".) [31]

In its' report 'The Use of Pea Crops by Farmland Birds; Evidence for an Extended Breeding and Enhanced Feeding Opportunities in Crop Mosaics' [32], the British Trust for Ornithology (BTO) reported positive benefits of peas for farmland birds, stating "The extensive survey revealed that a greater number of species and a greater abundance of most types of species were recorded on pea fields compared to cereal fields, including insectivores and seed-eating species."

Water use efficiency and Greenhouse gas emissions

The conversion of food into animal protein for human consumption is hugely inefficient. Water footprint.org [33] quote that beef protein production consumes on average over 6 times more water for the equivalent production of protein from pulses and show that all forms of livestock and poultry protein production are significantly less water efficient than pulses.

In their heavily referenced "Solutions for the farm of the future- Grow Green Report -2017" [34] - The Vegan Society addresses a wide range of environmental topics including the issue of declining farmland biodiversity and concludes that the benefits of Protein crops, and pulses in particular, are of interest because they provide a solution to many of the problems identified. They cite the positive benefits of pulses in tackling issues such as greenhouse gas emissions (both nitrous oxide and carbon dioxide), soil

health / quality, reduction in nitrogen fertiliser use, diversity of soil microbes, opportunities for crop pest and disease reduction and general low environmental impact.

In their 2017 discussion paper "The future of British farming outside the EU" [35] the Soil Association specifically address nitrogen fertiliser and climate change "Nitrous oxide – a potent greenhouse gas (GHG) with a global warming potential 265–298 times that of CO_2 – accounts for around a third of the UK agricultural sector's total emissions. The majority of these emissions arise from the estimated 900,000 tonnes of nitrogen fertiliser that is applied annually on British farmland, the manufacture of which is alone responsible for an estimated 6 million tonnes of CO_2, equivalent to around 1% of the UK's emissions total. The Committee on Climate Change estimates that measures aimed at reducing N_2O emissions from agriculture – through increased the use of leguminous crops and the reduction of untimely or over-application of fertilisers – could deliver an annual emissions reduction of 2.7 million tonnes of CO_2 by 2030."

The earlier referenced RSPB study also concluded that the diversification of the rotation from winter wheat and oilseed rape only, to include legumes, resulted and reduction of 9.4% in greenhouse gas emissions.

Centre for Alternative Technology; ZERO CARBON BRITAIN REPORT – Rethinking the Future 2010 [36] section 3.6.1 Agriculture, food and diets - covers emissions from agricultural systems that produce food. Their conclusions involve increased grain legume production and consumption. It shows that we can reduce these emissions whilst improving the healthiness of the average UK diet with implications for land use, and agricultural systems.

They summarise as follows.

• Agricultural food production is responsible for just under 10% of total UK GHG emissions – about 63.4 $MtCO_2e$ in 2010.

• The UK's agricultural GHG emissions can be dramatically reduced through changing the mix of foods in our diet: less meat, more fruit and vegetables, pulses and starchy foods (such as pasta, bread and potatoes). These proposed dietary changes would have positive health outcomes: reducing levels of obesity and diet-related diseases.

• Reducing how much beef, lamb and dairy we eat not only reduces GHG emissions significantly, but also frees up large amounts of both grassland and cropland.

• Reducing the amount of food wasted on the farm, throughout the supply chain and at home would greatly reduce food production burdens, and hence GHG emissions.

• The UK could become more self-sufficient in food production, reducing imports and the impact of food production for our consumption elsewhere in the world.

•In our scenario, emissions from food production ('on the farm') are reduced to 17 MtCO2e per year – about 27% of what they were in 2010. Imports are reduced from 42% to 17%. Land used for food production is reduced from about 78% of total UK land to about a third, freeing up space – all grassland – for other uses.

These groups are not alone in wondering if there is there a role for policy-making in shaping, embracing and realising the objectives of truly sustainable development in agriculture food and farming.

Economic opportunities:

Of course sustainability has an economic pillar and it is not just the economics of not acting sustainably that need to be considered. Whilst such an approach is very valid it is a rather negative proposition to simply consider the costs of not doing something. There is a powerful and positive message to be taken from the

Canadian economy which has focussed on the positive and outwardly more immediate economic benefits of driving pulse crop production.

Canada as an example

A multi-billion dollar pulse and special crops industry has developed around the production of eight major pulse and special crops, increasing from about 1 million tonnes in the early 1990s to 5.9 million tonnes in 2015, more than a fivefold increase in 25 years. Canada has emerged as the world's largest exporter of lentils and peas, and one of the world's top five exporters of beans in 2010, accounting for 32% of world pea production and 38.5% of world lentil production. It is dominant in world trade in peas and lentils, accounting for 55% and 50%, respectively. In 2015, Six (6) million tonnes of pulses were exported worth more than $4.2 billion, reaching over 150 markets around the globe. (37)

This has been achieved with the aid, focus and the determination of the Canadian government department Agriculture and Agri-Food Canada (AAFC). Pulse Science Research Clusters (38) were established involving AAFC, Pulse Canada, provincial pulse producer organizations and growers. Addressing pulse industry priorities, (initially through Genetic improvement programmes, agronomy and sustainable production systems and processing and utilisation support) in this way has helped the Canadian pulse industry continue growing in a globally competitive fashion.

UK Potential

The independent Anderson Centre Report (39) '*Revealing the opportunities for growing peas and beans in the UK'* in 2015 explored the UK pea and bean industry focussing chiefly on cultivation and markets.

It identified the main commercial opportunities and the wider economic potential and concluded that to realise the potential for the UK economy the sector must take action to overcome the existing barriers.

The report made recommendations and defined opportunities in support of this objective.

Opportunities:

- Global markets are growing; exports to Japan have increased from the UK by 250% in 5 years.

- Pea and bean exports could grow strongly over the coming 5 years if properly supported, adding value to the entire UK economy. UK pulse exports are currently estimated at approximately £60,000,000

- A rise in UK production would help build markets in animal feed compounding, fish food, exporting higher value foods and drive new product innovation in added-value food manufacturing for sports nutrition and health food markets.

- Existing markets could sustain a doubling in the size and value of the UK pea and bean industry in the coming five years.

- Pulses offer growers an opportunity to raise profits, and manage farm resources in a more sustainable way. Yields can increase and better quality can be preserved.

- The inclusion of a pulse crop in the rotation provides the only opportunity to fulfil the Ecological Focus Area (Greening) requirements of the revised Common Agricultural Policy whilst also gaining a profit on the area by maintaining land in production. - *A positive opportunity that has potentially been lost with recent policy changes prohibiting the use of plant protection products on EFA crop areas.*

- The excellent UK research base has the capability to improve yield and quality traits to meet production and market needs.

The 2016 UK balance of payments as indicated by the HMRC UK trade statistics is hugely negative in relation to dried pulses and vegetable legumes. The UK exported circa £80million yet imported £245million in the same period. These numbers were very similar in the previous 2 years. This situation reflects the

large volume of faba bean exported at relatively low value in comparison to the much lower volume of higher value alternative pulses that are imported. Adding value to UK produce by investment in processing and the diversification of types produced would assist in significantly reducing this deficit.

Political environment:

In the DEFRA document from the 'Natural Capital Committee Advice to Government on the 25 Year Environment Plan': September 2017. [(40)] Section 5.2 Limitations of the current support system, recognises the need to change the system of farm subsidy, suggesting that in future 'Public funding should be closely targeted to the delivery of public goods. These include, but are not limited to: environmental conservation and enhancement, animal welfare, biosecurity, and rural development programmes (such as poverty reduction and the transfer of knowledge). At present such schemes account for a small proportion of agricultural subsidies, yet these are important benefits to society which farms currently provide for relatively modest (and arguably inadequate) reward.'

In his recent address at the Oxford Farming Conference (January 2018)[(1)] The Secretary of State -DEFRA (Michael Gove) stressed the "imperative to husband, indeed wherever possible, enhance our natural capital - safeguarding our oceans, cleaning our rivers, keeping our soils fertile, protecting biodiversity - has to be at the heart of any plan for our country and our world."

The theme was the need to embrace change with a view to environmental benefit whilst recognising "We can, and should, invest in both technology and infrastructure. We can direct public money to the public goods of scientific innovation, technology transfer" and alluding to changes in the public funding of the farming sector, " having a subsidy system which incentivises farmers to place every acre they can into food production means that public money isn't always being spent on renewing natural capital assets", "As well as thinking about how our interventions to support food production currently affect the environment, we also have to consider the impact on the nation's health". To this end farmers were reassured that it is recognised "that moving to more sustainable and, ultimately, productive farming methods can involve transitional costs and pressures. So we plan to provide new support for those who choose to farm in the most sustainable fashion". "And as well as supporting progressive and productive farming methods we also want to support what economists call the provision of ecosystem services".

As demonstrated in this document these policy outlines are all compatible and closely align with a greater role for grain and vegetable legume production in the UK. A policy for agriculture and the environment which stimulates the wider encouragement of legume production can only assist in the delivery of the politically defined sustainable developments, social, economic and environmental objectives.

Encouragement for the development of a more vibrant secure and reliable pulse supply chain would help towards securing many of these objectives. In the UK pulse cropping is showing signs of market failure. Intervention by policy measures would greatly assist in moving markets forwards to aid the realisation of the societal and environmental benefits that they accrue.

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