An effective national protein strategy can be a sustainable food- and feed-systems strategy

Grain legumes in Scotland

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Legumes

- ***specific plant types to help realise 'ecological food systems'***

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Grain legumes

Forage legumes (cover crops)

Q - Legumes: what's not to like?

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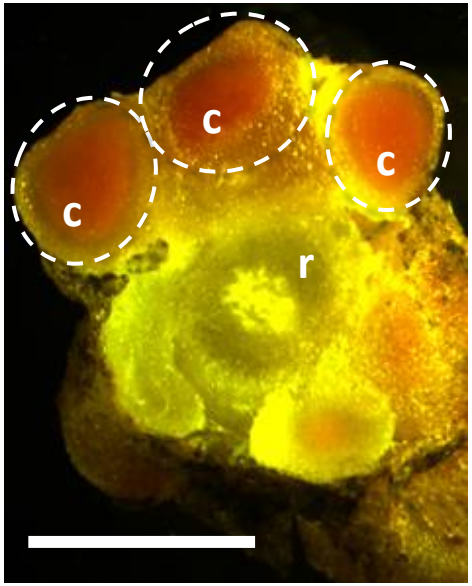
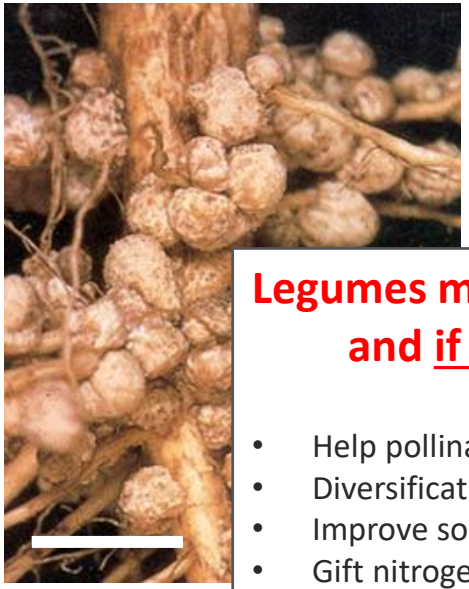
Cross-section of **white lupin seedling root (r) and surrounding nodules** (*dashed ellipsoids*), showing the pink (leghaemoglobin), rhizobial infected (i.e. nitrogen fixing) *nodule cores* (**c**).



Scale bars = 4 mm

A nodulated root system of soybean (*Glycine max* L.)



A well-nodulated root-system of field bean (*Vicia faba* L.)

Legumes make multifunctional provisions, and <u>if well managed</u> can ….

- Help pollinators & beneficial insects
- Diversification and biocontrol agents (pesticide reduction)
- Improve soil-qualities, -diversity and so -function
- Gift nitrogen to non-legumes (inorganic N-fertiliser offset)
- Help liberate soil phosphorous
- Offer highly nutritious food and animal feeds
  - Protein & energy (carbohydrate)
  - High fibre and resistant-starch (low glycaemic index)
  - Essential-amino acids and -minerals
  - "Non-nutritionals" – antioxidants *etc*

Q - Legumes: what‘s not to like?

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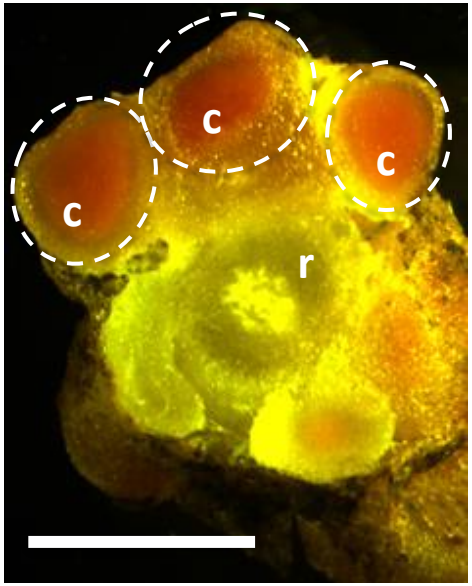

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LEGUME CROP TYPES

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Grain Legumes
annual crops

Dry Grains
Pulses
protein & starch
Mainly peas and beans in Scotland

Lentil possible

Others? Increasing grain legume diversity is important.

Phaseolus spp.,
5 Grass-pea?

Vegetables
fresh
(including from greenhouses)

Oleaginous
Seed contain oil

Oil-legumes not yet cultivated at scale In Scotland

Lupin & Soybean possible

Forage Legumes
herbaceous perennials

Cover Crop
Understory
(to cash crops)
Livestock Feed
Livestock Bedding
Manures

Living
(maintained)

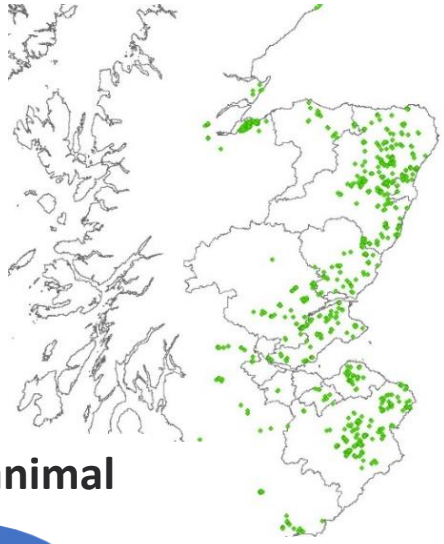
Green- or Brown-
(killed)

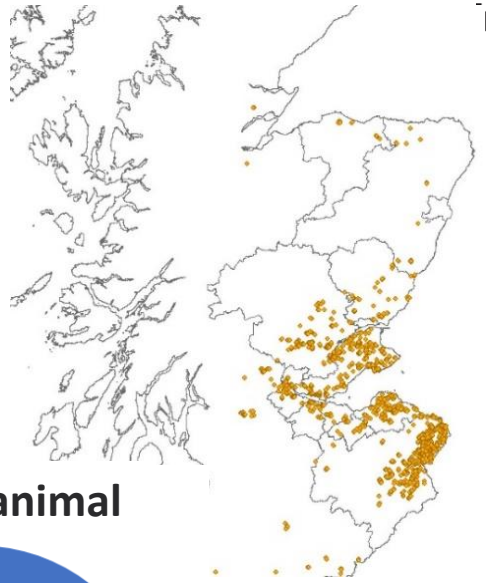
Forage legumes
Clovers (red & white)
Vetches (*Vicia* spps)
Alfalfa (*Lucerne*)

Woody legumes
Woody perennials
e.g. Gorse & Broom

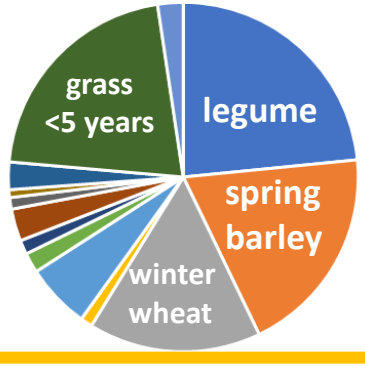
Grain legume supported crop rotations in Scotland

Grain legume cultivation <1 % of arable ground cover in Scotland

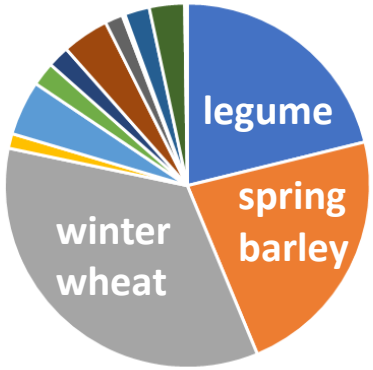




Peas - animal



Beans - animal



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ORIGINAL RESEARCH | Open Access

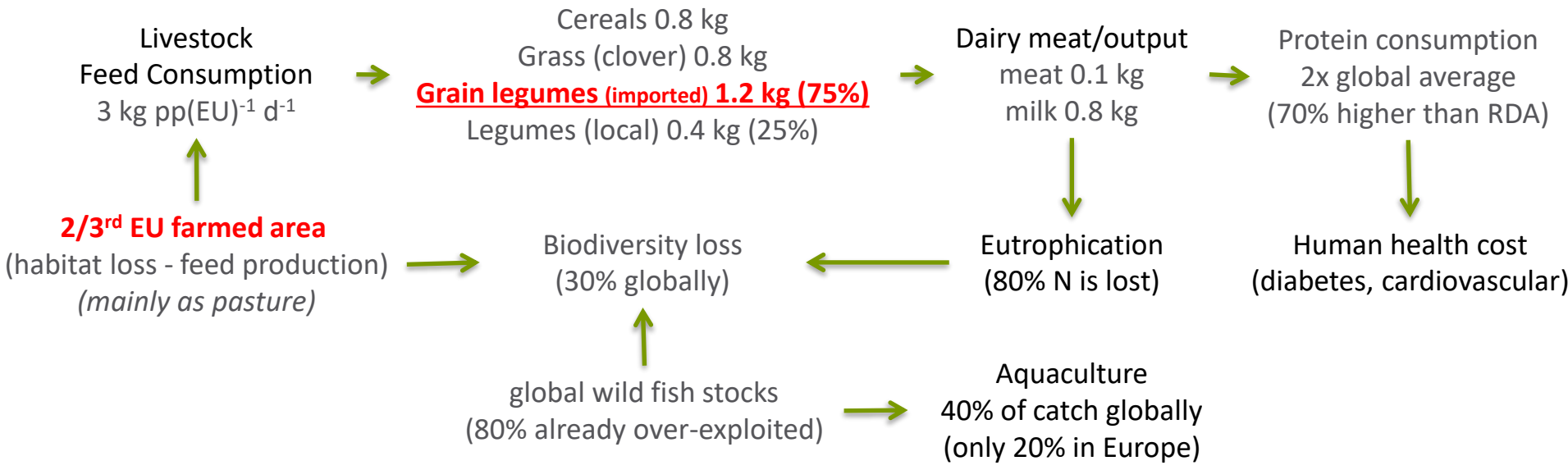
Transitions to greater legume inclusion in cropland: Defining opportunities and estimating benefits for the nitrogen economy

Geoffrey R. Squire, Nora Quesada, Graham S. Begg, Pietro P. M. Iannetta

Q - Why is the % of grain legume cultivation so low?

Grain legumes and the 3 P's

Paradox: *we have grain legume supported food- and feed- systems, but not home-grown*
Problems: *legumes are therefore forfeited, and problems persist beyond the farm gate*
Puzzle: *how might these complex series of local and global challenges be resolved?*



Q: How might domestic grian legume-based value-chains help resolve the 3 P's?

Schematic diagram developed and adapted by P. Iannetta from:
*Westhoek et al., 2011. The Protein Puzzle. Euro J Food Res Rev **1**, 123.*

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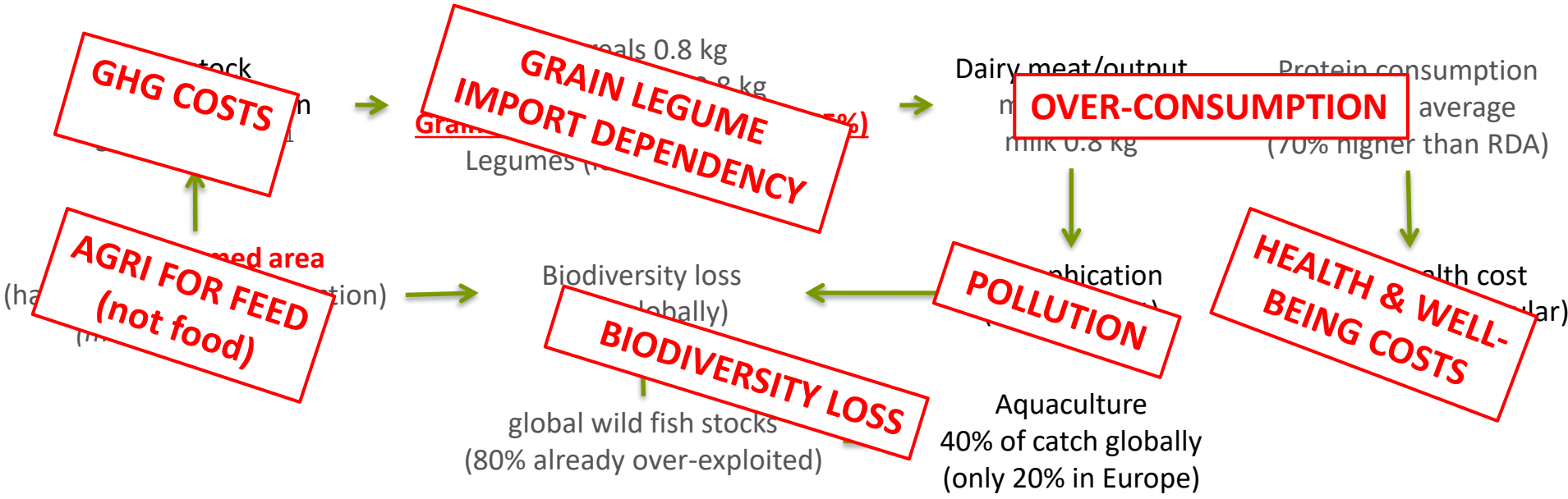

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A Quick History of Plant-Protein Planning in Europe

European Soy Declaration (17/07/17) – to expand soy cultivation in Europe

- originally signed by 14 countries, 4 more (Jan'18), Switzerland (Jan.'19)
- Some organisations objected e.g. ***Rejection of the European Soy Declaration***
  La Via Campesina, International Peasant (farmers) Movement
  Social and environmental impact assessment needed first

EUs Plant Protein Plan:

On the development of plant proteins in the European Union *(22/11/18)*

many organisations regarded this as an 'animal feed self-sufficiency plan'
encouraging misuse of "food-land"

- *Market developments and policy evaluation aspects of the plant protein sector in the EU (30/11/18)*
  "EU effort, … should instead focus their efforts on infrastructure for processing of plant proteins for food"

- National plant protein plans have been developed and implemented.
  - Protein-crop strategy for promoting the cultivation of pulses in Germany

Q's - What would a Scottish 'protein plan' look like?
- How/would this fit with a UK protein plan?
- What would implementation look like?

Progressing the ‘protein plan’:

more cautionary notes

- *move beyond sectoral approaches*
- *beyond crop diversification, yield and yield qualities*
- *build ex-farm gate capacities, broaden consumer experience*

Policy and funding analysis:

- Standing Committee on Agricultural Research (SCAR) Strategic Working Group on Food Systems
  - ***1ry-production over-focus***
  - No real interest in sustainability outside 1ry-producers
  - fragmented R&I investment

Q – Will a national protein plan accommodate sufficient strategic research focus on the protein (reactive nitrogen) economy?

How much legumes are enough?

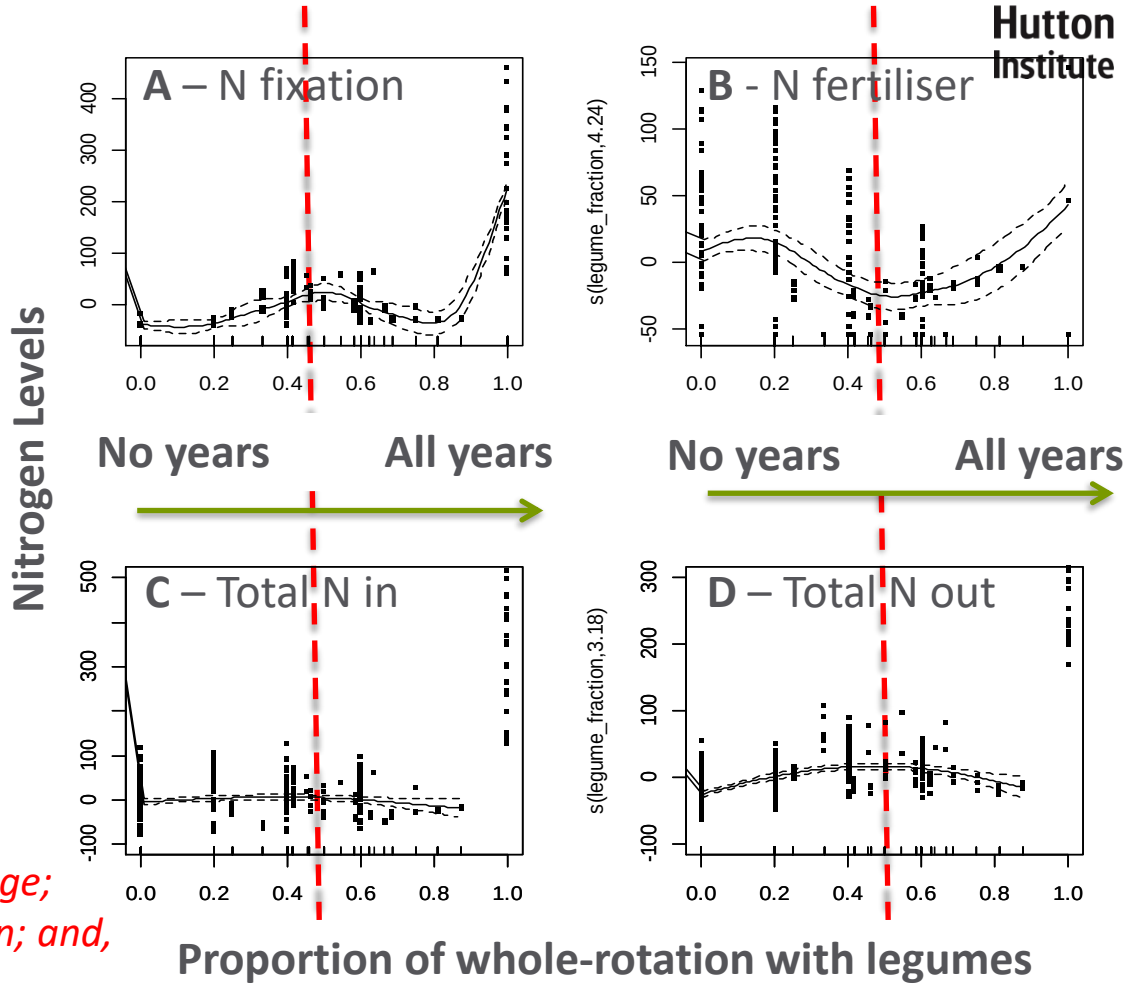
At 50% legume inclusion

A – Biological nitrogen-fixation peaked
($F_{6.38,327}$ = 73.846, P < 0.001)

B – Mineral N-fertiliser was lowest
($F_{3.22,330}$ = 19.019, P < 0.001)

C - N input was greatest
($F_{0.87,306}$ = 9.646, P = 0.003).

D - N output peaked



- ***Achieved at:***
  - *equal balance of grain and forage;*
  - *corage/cover crops use common; and,*
  - *intercropping common.*

Iannetta *et al.,* (2016) A comparative nitrogen balance and productivity analysis of legume and non-legume supported cropping systems: the potential role of biological nitrogen fixation. *Frontiers in Plant Science* **7**, 1700. doi: 10.3389/fpls.2016.01700

Q – How do we enable grain legume cultivation in a barley-based system?

- Beer and whisky contributes over **£10 billion** to UK tax revenues annual

- **Annually, over 65% of the arable area is cultivated with barley**
    - Rotation are barley dominated
    - Rotations are ‘feed’ not ‘food’ focused
        - ½ of to feed brewing (beer) & distilling (whisky) industries
        - ½ to feed animals (meat production mainly)

Developing the potential of field beans

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Salmon farming in the Scotland

- Scotland's second largest export, over £600m at farm gate
- **Salmon feed contains up to 70% vegetable protein**
  - very efficient feed Conversion (1.25)
- **To serve Scottish aquaculture we estimate that beans need grown on 1/12th of arable land**
- **Protein concentrate (over 50 % protein) is preferred**
  - currently faba beans are only ~28% protein

www.beans4feeds.hutton.ac.uk

Increasing the value of pulses

- *the parts are worth more than the whole*

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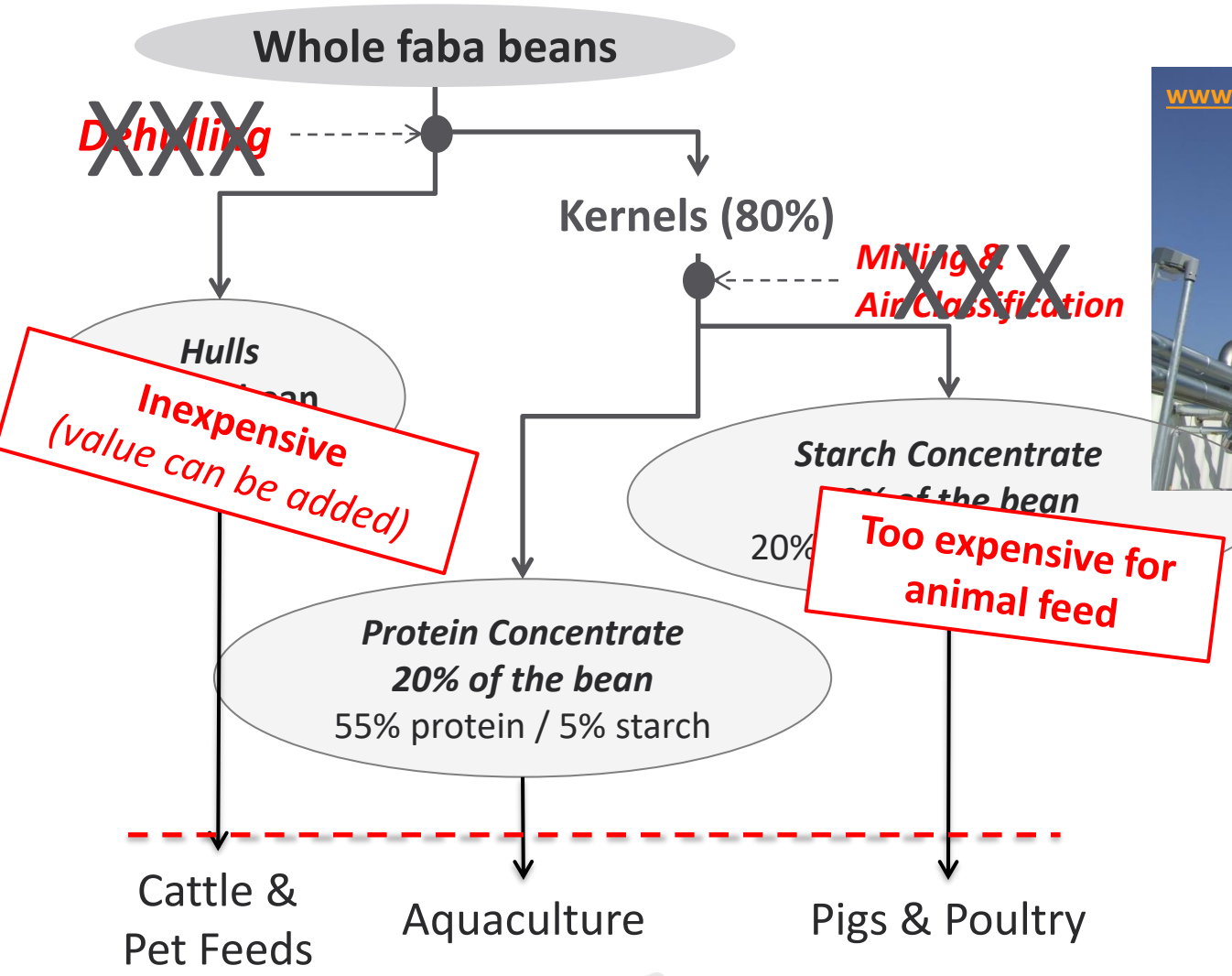


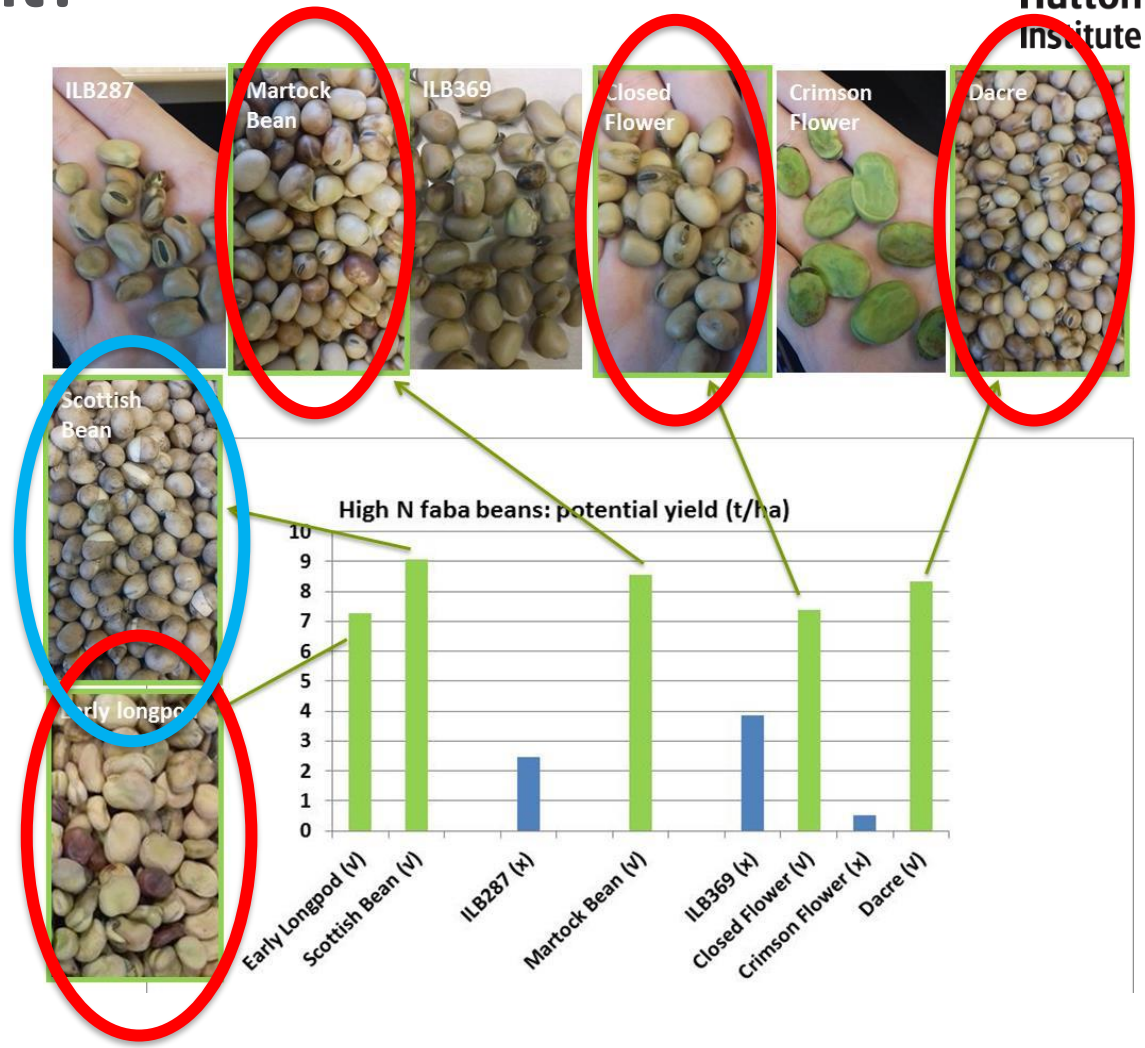
Air fractionation facility: *separating dehulled beans to starch and protein concentrates*

Select faba bean varieties with high protein content?

- **4 high protein lines with good yields**

- **1 early flowering dwarf type "The Scottish Bean"**

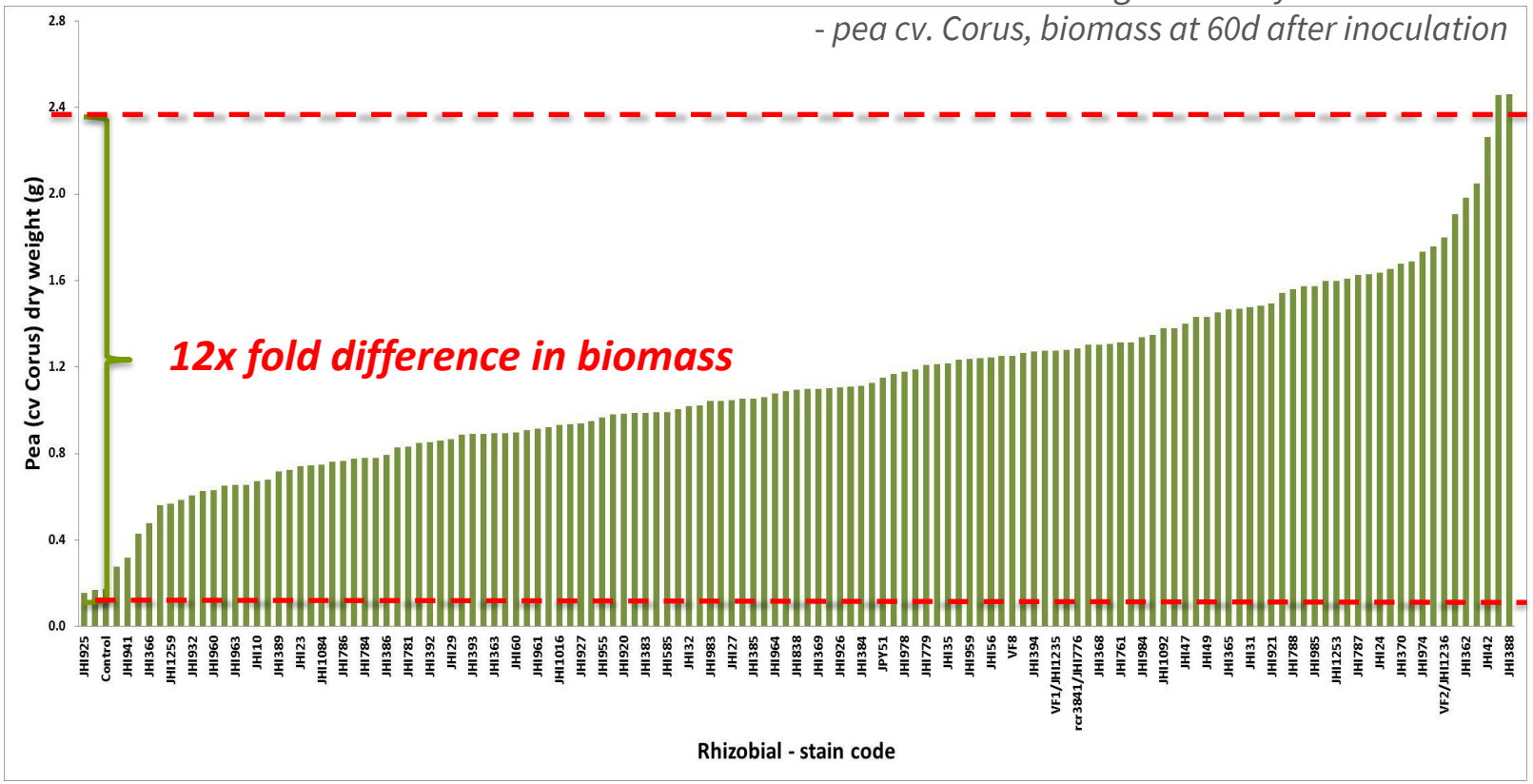
- All lines sent to Uni. Saskatchewan (Canada) for further breeding



Impact of ‘elite rhizobia’ on pea biomass

Controlled environment screening to identify ‘elite rhizobia’

- pea cv. Corus, biomass at 60d after inoculation



Q – can improved growth be translated to improved yield and yield qualities?

Develop novel crops (for Scotland)

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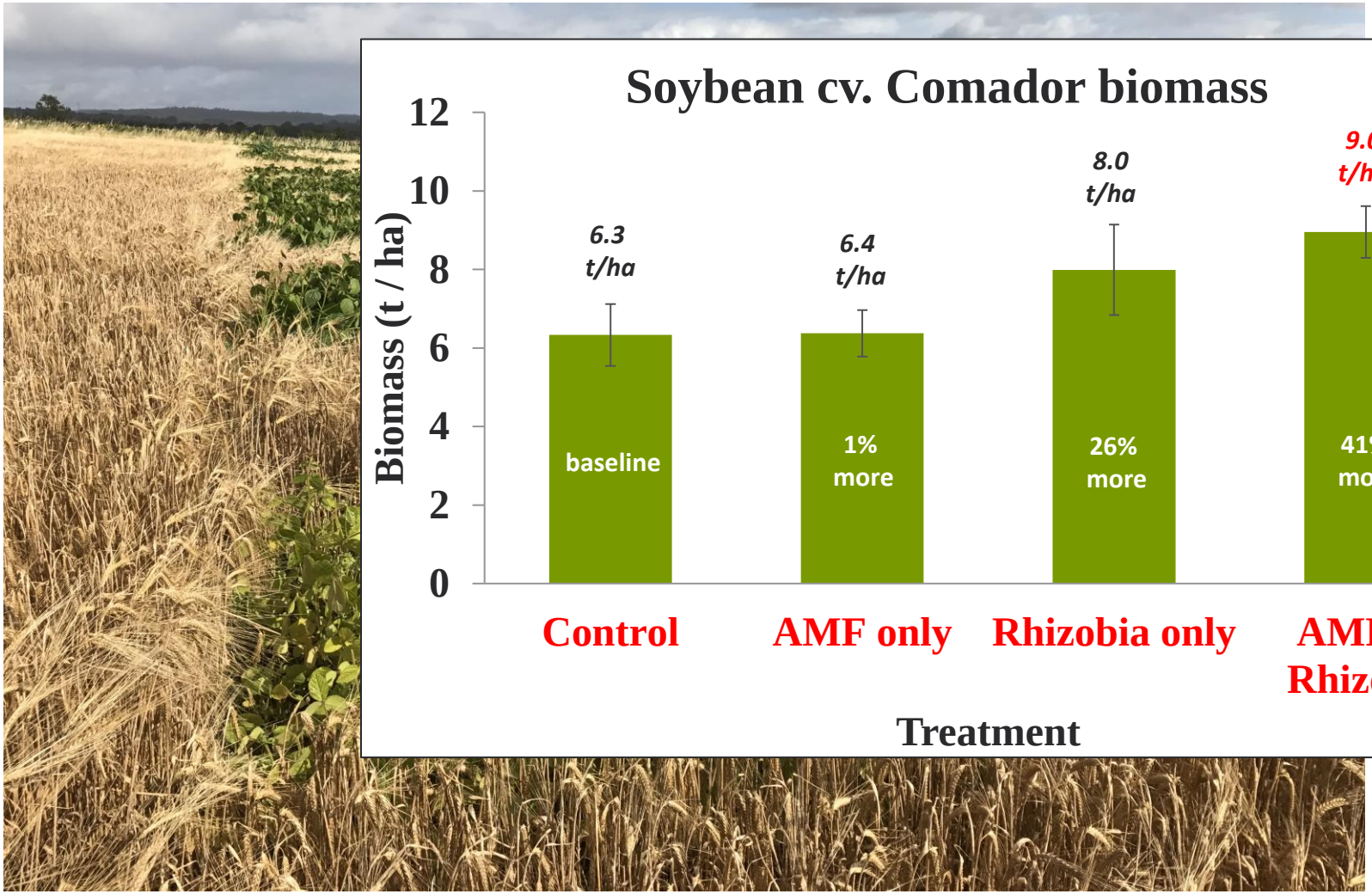

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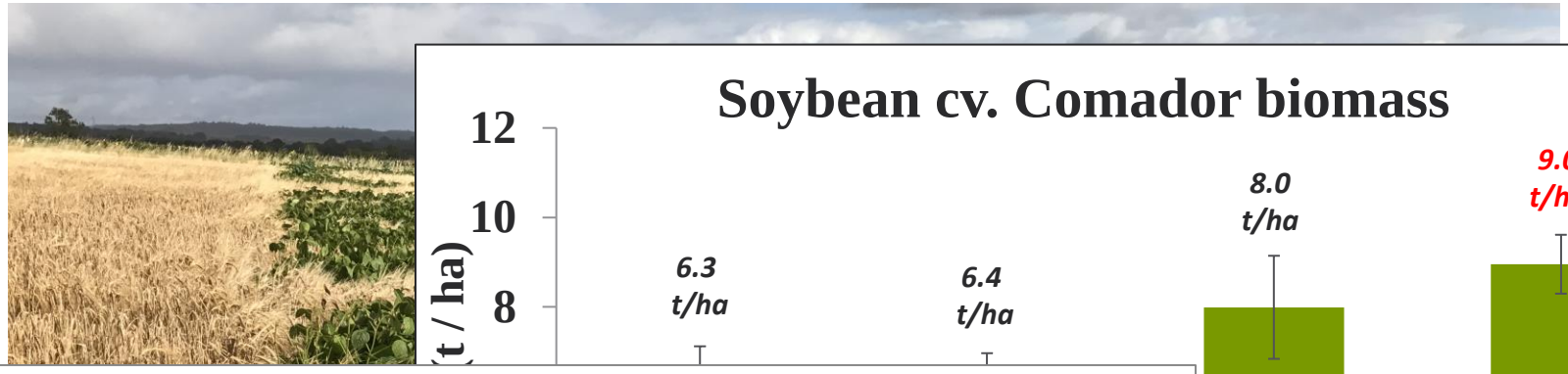
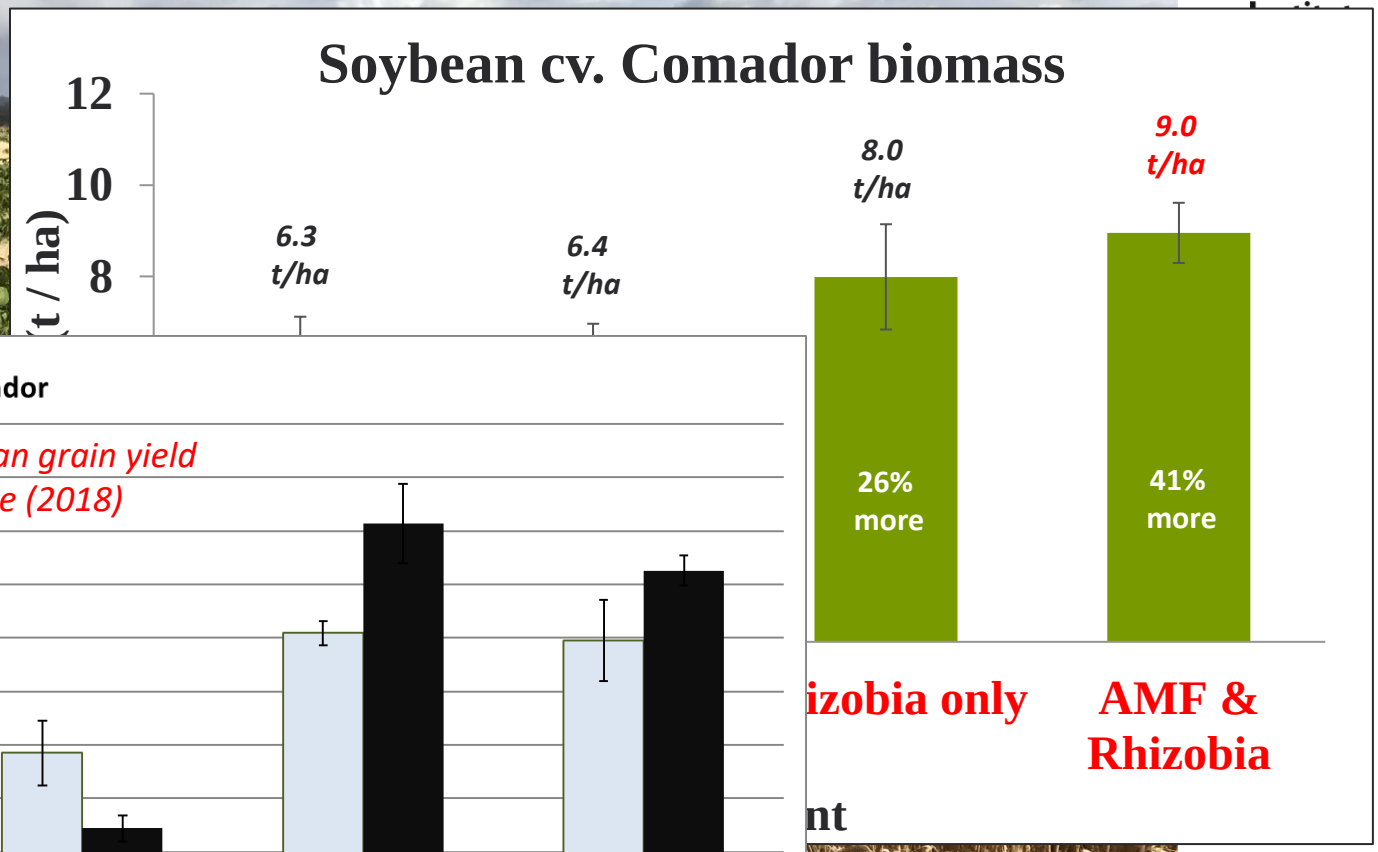
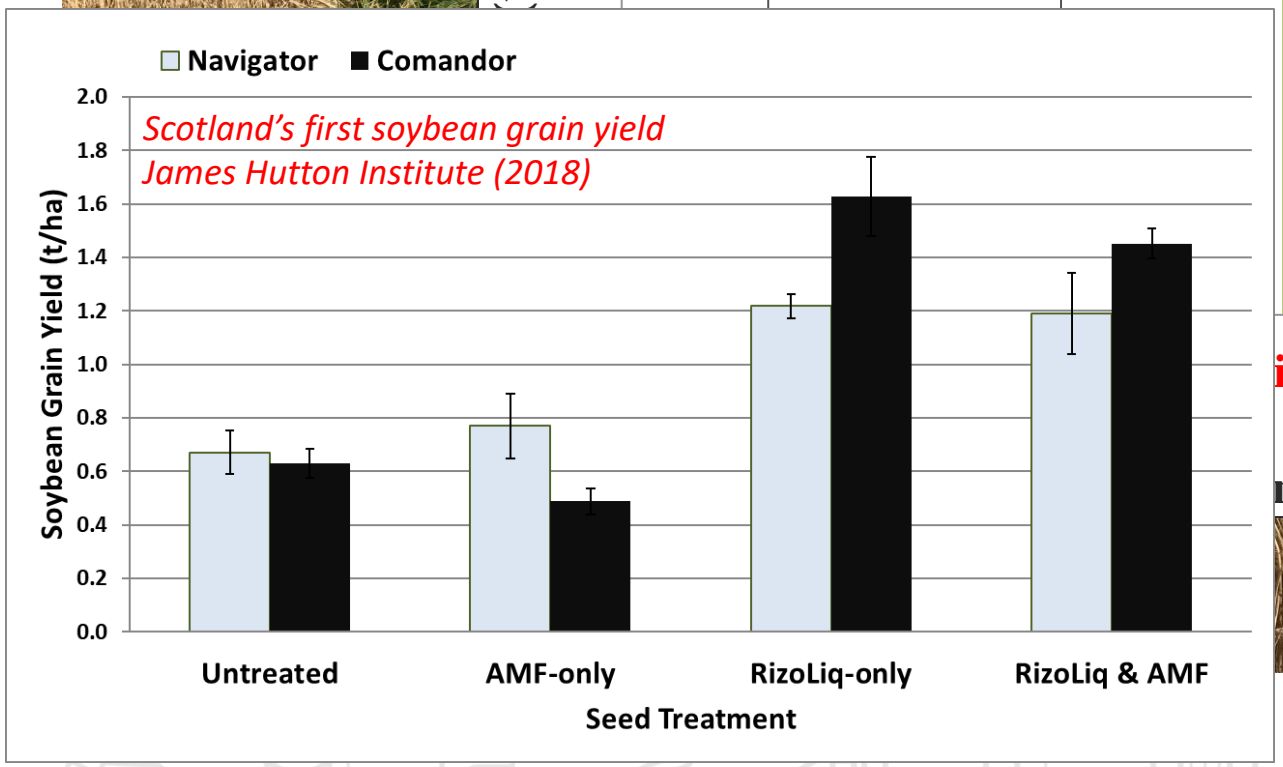






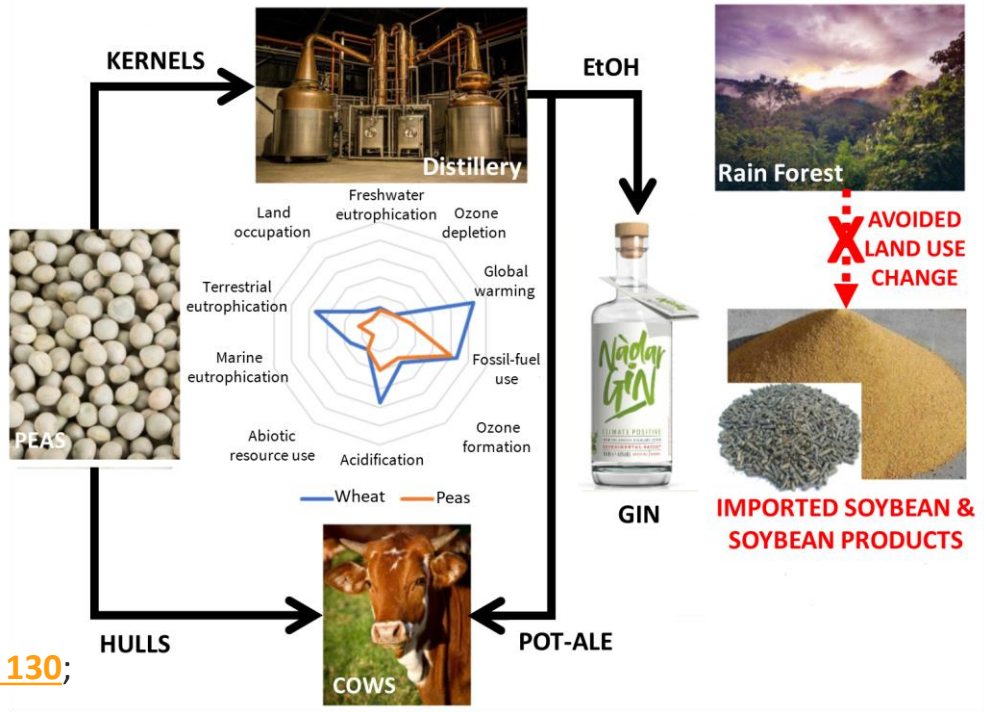
Just the tonic: the power of local

A life cycle analysis (LCA) for neutral spirit (gin) made from peas

Scottish pea-gin environmental impact was

- < wheat-gin in 12/14 impact categories
- 12% lower global warming potential
- 2.2kg CO_2-eq avoided L^{-1} pea gin

- Arbikie farm now over 20 % grain legume cover
- Nadar gin and vodka, now best-selling products



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Q - What might be achieved if the big brewers and distillers diversified their crop choice to include pulses from local growers?

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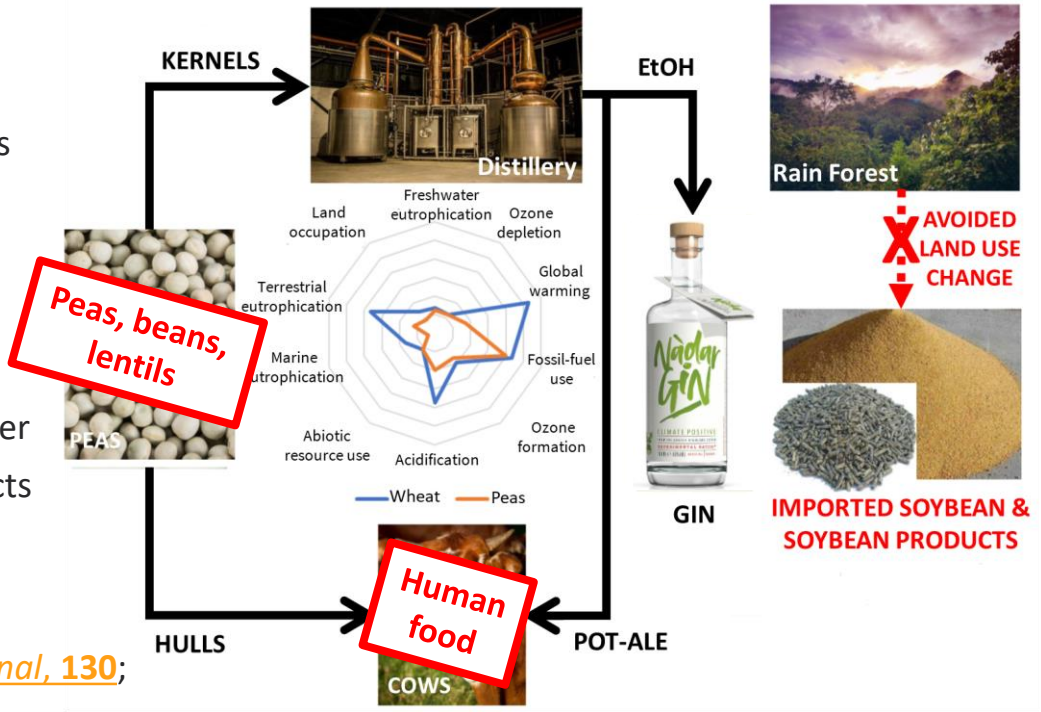

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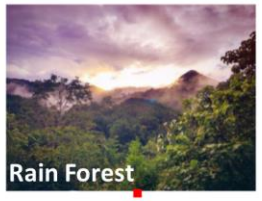

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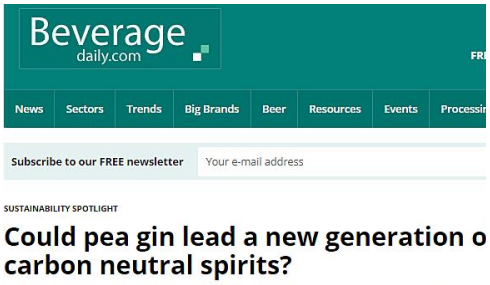

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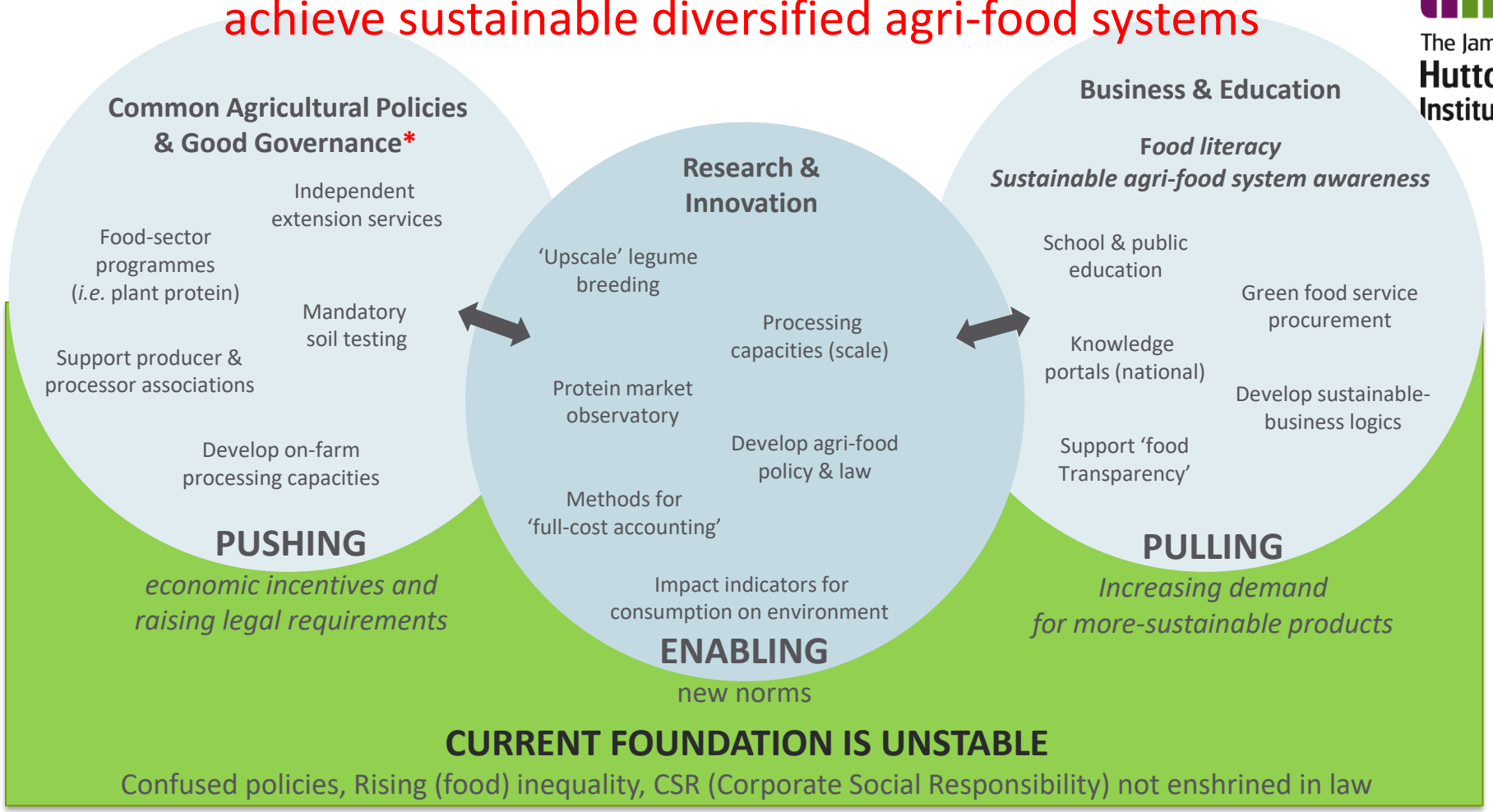
CoolBeans® Faba bean IPA

(gluten free, vegan)

Brewers Spent-Grains

- **Currently:** brewers pay for uplift, for AD
- **Future?** - *barley-bean coproduct trialled as poultry feed*
  - *bean-based beer LCA is underway*
  - *spent grain can be used for food (not just feed)*

Push-, pull- and enabling -capacities are required to achieve sustainable diversified agri-food systems



This illustration features in Vasconcelos et al., (2020) The push-, pull- and enabling-capacities necessary for legume grain inclusion into sustainable agri-food systems and healthy diets. *World Review of Nutrition and Dietetics* **121,** *https://*doi:10.1159/000507498.

***Good-governance should ensure the creation, protection, and fair-distribution of wealth.**

Articles of interest

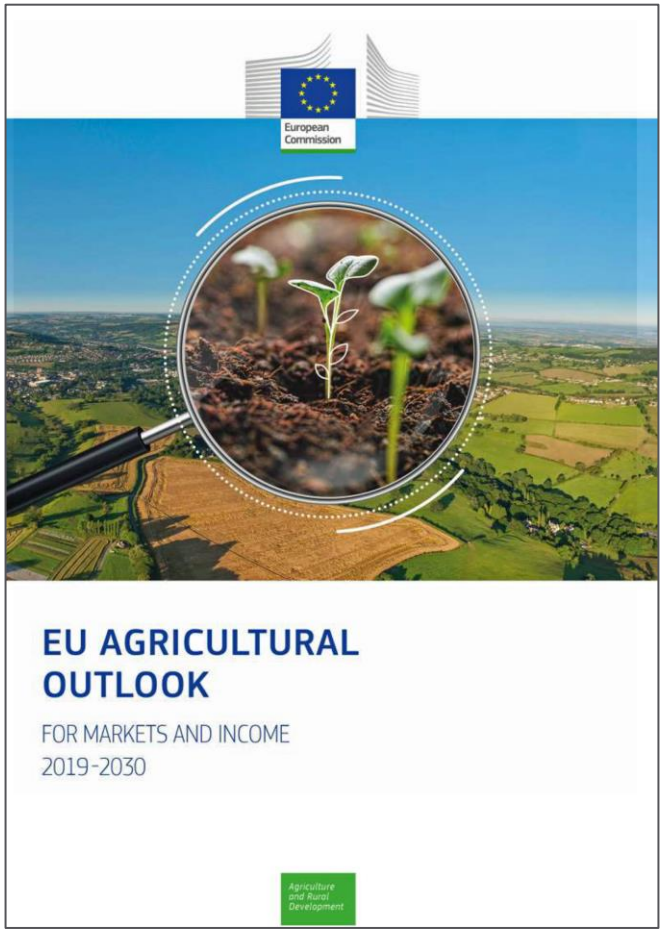
Published

- Black *et al.,* (2019). **Assessing the influence of the inclusion of field bean (*Vicia faba* L.) on the taste and overall impression of beer**. *Journal of Brewing and Distilling* **125**, 310-314.
- Leinonen at al., (2019). **Lysine supply is a critical factor in achieving sustainable global protein economy.** *Frontiers in Plant Science, doi.org/10.3389/fsufs.2019.00027.*
- Vasconcelos *et al.,* (2019). **Editorial: transitions to sustainable food- and feed-systems**. *Frontiers in Plant Science* (Plant Nutrition), *https://*doi.org/10.3389/fpls.2019.01283.
- Vasconcelos *et al.,* (2020). **The biology of legumes and their agronomic, economic, and social impact**. In, *'The Plant Family Fabaceae: Biology and Physiological Responses to Environmental Stresses'.* Hasanuzzaman, Mirza, Susana Araújo, and Sarvajeet Singh Gill, eds. Springer Nature, 2020. ISBN 978-981-15-4751-5. https://doi.org/10.1007/978-981-15-4752-2.
- Leinonen *et al.,* (2020). **Regional land use efficiency and nutritional quality of protein production**. *Global Food Security,* **26***.*
- Black *et al.,* (2020). **Utilisation of low-nitrogen barley for production of distilling-quality malt**. *Journal of the American Society of Brewing Chemists.*
- Black *et al.,* (2020). Optimised processing of faba bean (*Vicia faba* L.) kernels as a brewing adjunct. *Journal of the Institute of Brewing*, In press.

In final preparation

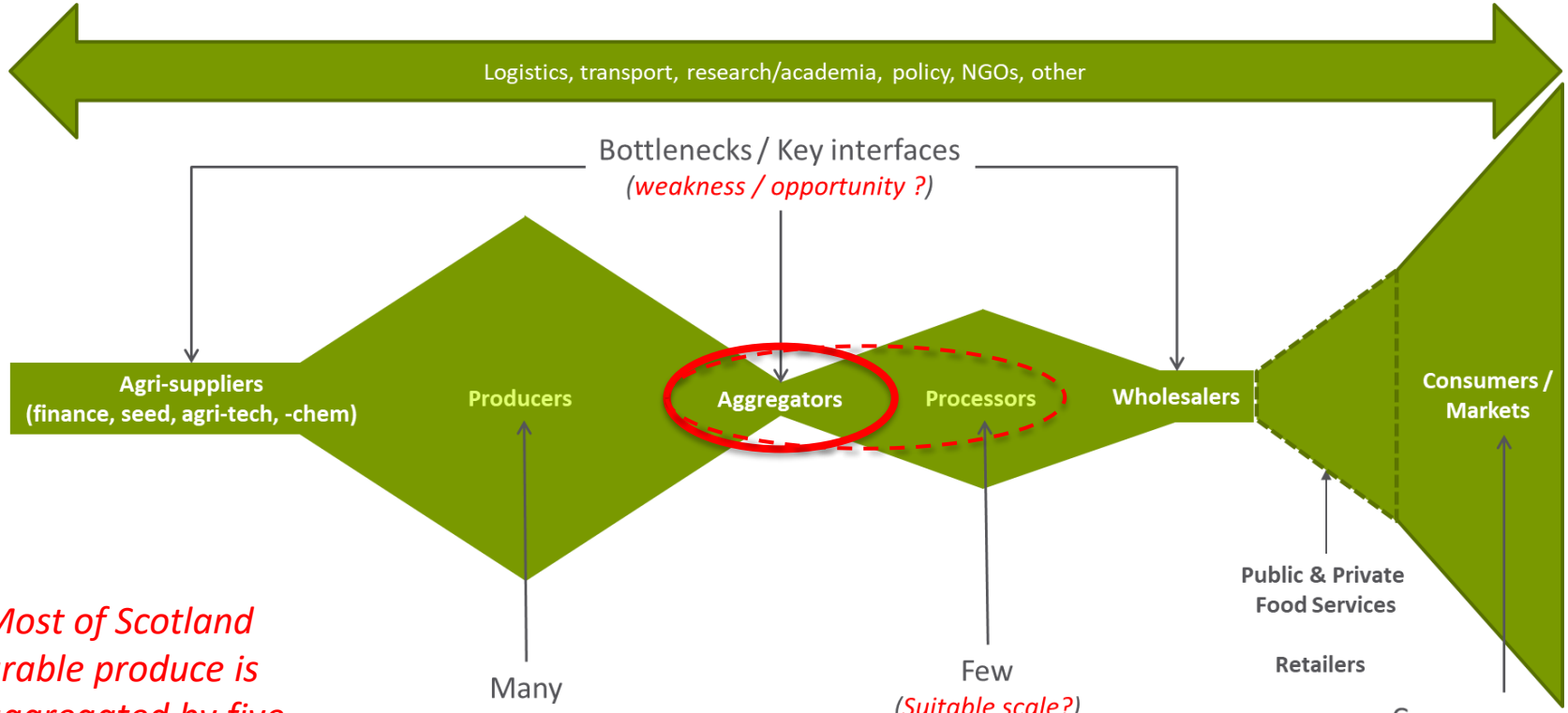
- Centofanti *et al.,* (2020). Legumes-based food- and feed-value systems and their relation to protein-security and environmental-protection policies.
- Balázs *et al.,* (2020). Delphi study on policy interventions promoting the production of legumes in food- and feed-systems.

EU Agricultural Outlook for Markets and Income 2019-2030



- **Grain legume cropped area will increase up to 70% ~2.5 million ha by 2030**
- Consumer-, environmental-, and animal-**health concerns will drive EU farmers to produce more plant protein**
- **Alternative production systems will drive market-development** *e.g.* local, organic, GM-free, other certified products
- ***Q - Are all the Scotland's stakeholders, from farm-to-fork, supported to ensure we capitalise on this transformation?***

Q - Taking a strategic view of the grain legume value chain?



Most of Scotland arable produce is aggregated by five companies

Simpsons Malt buy-out of WN Lindsay

Wednesday, November 25th 2020

THE COURIER.CO.UK

Malting leader acquires grain merchant group

by Nancy Nicolson November 13 2020, 4.59pm

BUYOUT: Simpsons will take over WN Lindsay's four grain stores in Scotland, including this one at Stracathro in Angus.

The market for Scotland's malting barley will be concentrated in fewer hands next year with the news that Simpsons Malt has purchased the grain merchanting business of WN Lindsay Ltd.

- WN Lindsay is Scotland biggest grain aggregator (barley mainly, and pulses)
- WN Lindsay *was* placed to up-scale grain-legume supported cropped systems across the arable north-east of Scotland
- WN Lindsay *was* increasing its focus on sustainability of food- & feed-systems – improving crop qualities, soil function *etc*

Q - Will a 'barley for malting' focused company retain the same grain-legume (i.e. sustainability- and resilience-oriented) ambitions?

The James Hutton Institute is supported by
Rural & Environment Science & Analytical Services (RESAS),
a division of the Scottish Government

TRUE

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Website: www.true-project.eu
Email: info@true-project.eu
Facebook/Twitter: @TrueLegumes

Legumes in Transition (online conf.) Joint with www.legvalue.eu	*- Policy Dialogue event* ***- Legume Innovation Network (launch)***

TRUE is funded by the European Union's Horizon2020 Research and Innovation Programme
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