Fixing the benefits: Integrating pulses in the rotation
Carlin peas in flower
Carlin peas ripening
Lentil plants
Lentil / Camelina intercrop
Field (Fava) Beans
Fava Beans

Hodmedod's
Britain's pulse & grain pioneers
Phaseolus coccineus (Emergo)
Pisum abyssinicum (Abyssinian Peas)
Benefits and challenges of grain legumes in cropping systems

Christine Watson (SRUC/SLU)
Some issues

• We need alternative protein sources for food and feed

• We can use legumes to reduce dependence on fossil fuel based fertilisers

• Legumes provide biodiversity benefits

• Nobody’s perfect – achieving good and stable yields, losses of N and diseases, technology
Grain legumes in Europe

N balance across Europe (fixation – harvest, thousand t) in 2009: total 37 Gg

206 thousand t (Gg) of N fixed in Europe in 2009

586 thousand t N fixed by forage legumes in Europe in 2009

Baddeley et al 2014
Legume contributions.....

- Biological nitrogen fixation
- Not all about N - roots release organic acids (citric, malic) that can release bound forms of P
- Faba bean accessions differ 3x in P acquisition ability
- To inoculate or not to inoculate ..? That is the question!

Photo: Fred Stoddard
Legumes fix N— but also affect biodiversity and pest/disease management

• Break-crop effects
• Impact on soil biology
• Allow soil-borne diseases of cereals to die
• Different biology allows use of alternative weed & pest control chemistry & methods
• Support of pollinator populations
Pre-crop effects in rotations - Grain yields of wheat grown following a crop legume compared with a wheat after wheat treatment grown in the same experiment

The dashed line represents equal yields. Any points above the dashed line indicate yield improvements when a legume is the preceding crop. Fitted regression: Grain yield (wheat after legumes) = 0.92 + 1.06 x (wheat after wheat) \[r^2 = 0.69\].

Peoples et al. 2019
Are grain legumes yields inherently unstable?

Reckling et al. (2018)
Grain legume yields are as stable as other spring crops in long-term experiments across northern Europe. Agronomy for Sustainable Development 38, 63.

Comparison between spring-sown broad-leaved crops (sBL), spring-sown grain legumes (sGL), spring-sown cereals (sCR) and autumn-sown cereals (aCR)
Considerations and trade-offs

• Legume residues have a high N content, so a low C:N ratio, and break down rapidly
• Thus high potential for NO$_3^-$ leaching, N$_2$O emission after the crop
• But Rhizobium bacteria with the nosZ gene for Nitrous oxide reductase reduce N$_2$O release as residues break down – exploit this?
• Need to measure the environmental and economic impacts over a whole rotation – captures system effects
Nitrous oxide emissions - Pea cultivar matters - Edinburgh 2009

SRUC (Unpublished data)
Why intercrop?

Brooker et al. 2014 New Phytologist
Cereal/legume intercrops in Europe - challenges

**Growing:**
- Reduced fertiliser
- Reduced agrochem
- LER>1
- Yield stability +ve

**Harvest:**
- Efficient harvesting and separation
- Requires specialist machine settings
- Minimise broken grains

**In the mill:**
- Storage bins
- Drying
- Market

**Consumer:**
- Likes concept
- Allergy concerns

Photos: Laurent Bedoussac
Looking to the future

• Legumes provide a low cost alternative input of N to European agriculture

• Incentives to grow legumes sometimes work – CAP greening measures – EU area doubled over 7 years BUT production less than doubled

• Need to look at the systems level and from an interdisciplinary perspective – nutrition…..food security

• Prices are important and can fail to compensate for low yields

• Needs investment in breeding for yield, stress resistance, disease resistance, quality

• Needs education/KE - novice growers of grain legumes often have poor results
Legume Gap Project

• We will be carrying out a survey of faba bean and soya bean producers to look at issues associated with the yield gap.
• 8 EU countries
• Please help us!

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Environmental Stratification of Europe

Metzger et al (2005)

**NORTH WEST**
- Autumn-sown pea, faba bean, white lupin; spring-sown pea, faba bean, potentially vetches and lupins

**NORTH EAST**
- Spring-sown, cool-season crops: Pea, faba bean, potentially narrow-leafed lupin, lentil and vetches

**SOUTH**
- Cool-season, autumn-sown crops: pea, faba bean, lentil, chickpea, vetches, lupins; Irrigated spring sown soybean, common bean, cowpea

**CENTRAL**
- Warm-season crops: soybean, common bean; Spring-sown pea, faba bean, potentially lupins, lentil and vetches
Background to the farm

- Family farm, approx. 550ha
  - 480ha arable, 10ha herbal ley, 60ha rough grazing
  - This year putting 200ha into legume fallows and 50ha more into herbal leys
  - My farm is worn out and needs a rest!
- Been farming at Fobbing Farm since 1954
- Heavy blue London clay – mostly grade 4 land
- Historically did a lot of veg for the London markets (inc picking peas)
- Like everyone else, we were encouraged to specialise, leading to combinable cropping
- Dad still keeps a small herd of store cattle, but mostly they keep to rough grazing
Key farm ethics

- Farming agro-ecologically - acting as close to nature as possible
- Zero-insecticides
- Low fertiliser use (about $\frac{2}{3}$ of "conventional")
- Aiming for half fungicide use on cereals, with no fungicides used on pulses
- Currently zero-till (for six years)
- Beginning organic conversion this year - still with aim to keep tillage to the minimum, and ensuring good soil cover all year round
- Will be establishing agro-forestry and a "wilded seam" running through the centre of the farm (about 20ha out of 240ha at home)
- Aim to ensure that 25% of farm in permanent cover
- My view: in order to make organic work, there needs to be a wealth of diverse ecological areas hyper-close to every cropped part of the farm
Key farm ethics

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“Rotation”

No actual rotation, but in the arable I grow:

• Modern wheat
• Oilseed rape
• Winter beans
• Spring peas
• Sometimes spring rape
• Sometimes spring linseed
• Heritage wheat
• Buckwheat
• Hemp
• Lentils
• Experimenting with heritage corn this year
• Keen to experiment with heritage “food” barley
Decision making for what I grow

- What does the farm need (agronomically)?
  - Heavy land doesn’t suit early seeded spring crops
  - Looking for crops I can establish up to end of May
  - Good vigour & weed suppression ability
  - Sensible harvest time

- What do we need to eat as humans?
  - Nutritionally what do we need?
  - Should be embracing the vegan movement (despite my belief in the "golden hoof")
  - Hence...need for pulses for protein
BUCKWHEAT
Why pulses?

- Moving away from growing “second cereals” due to carbon loading
- Trying to reduce overall fertiliser use in my system: breaking with linseed or oilseed rape still means using fertiliser
- I don’t believe in the adage that 40kgN is left behind after a dry combinable pulse crop, however the residue is very low in carbon and doesn’t hamper the next crop
Issues...

- Lots of potential insect issues - bruchid, pea moth, pea & bean weevil
- Human consumption market very prescriptive (hence a move from green to yellow peas)
- Soil borne diseases and nematodes, etc:
  - Picking peas in close rotation during '60s and '70s mean can’t grow peas any more on the home farm
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Questions I have…

✦ Could there be a human market for some of these less than perfect crops?
  • E.g., could we encourage the use of pulse flour?
✦ More research to be done on rotational gap between pulses
✦ What soil disease / pest commonalities are there between pulses?
  • E.g., I know that beans will tolerate pea cyst nematode
✦ Lots of benefits to intercropping of pulses, but more work needs doing on sorting technology
Growing pulses: Opportunities, challenges and solutions

Lentil / camelina intercrop, Hodmedod

Steve Belcher, PGRO
Alternate Pulses

• The FAO lists 11 types of pulses grown worldwide
• High in protein & low in fat
• N-fixing
• Dry pea
• Faba bean (dry)
• Lupin
• Chickpea
• Lentil
• *Phaseolus*

<table>
<thead>
<tr>
<th>Produce imports (t)</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>2019 to Au</td>
</tr>
<tr>
<td>Peas</td>
<td>58,378</td>
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<tr>
<td>Broad Beans</td>
<td>251</td>
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<tr>
<td>Chickpeas</td>
<td>39,241</td>
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<tr>
<td>Mung beans</td>
<td>8441</td>
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<tr>
<td>Small red beans</td>
<td>316</td>
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<tr>
<td>Kidney &amp; White Beans</td>
<td>69,078</td>
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<tr>
<td>Cowpea</td>
<td>2543</td>
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<tr>
<td><strong>Lentil</strong></td>
<td>18,117</td>
</tr>
<tr>
<td>Pidgeon pea</td>
<td>910</td>
</tr>
</tbody>
</table>

Source: Eurostat
Rotational challenges

- Probably best to consider the same as we do with peas and beans stick to 1 in 5 years rotation
- “Pulses are best grown following a cereal rather than a crop that can harbor pulse diseases such as botrytis, powdery mildew, aphanomyces root rot, and fusarium root rot caused by species specific to pulses. Pulse crops are susceptible to diseases that can overwinter in the soil and in stubble”.

- Pest Management Strategic Plan for Pulse Crops (Chickpeas, Lentils, and Dry Peas) in the United States Summary of a workshop held on November 9-10, 2016 Bozeman, Montana
Potential for intercropping

Yield t/ha@15% MC Intercropping trials 2018/19

Yield t/ha@15%MC

1. P70 18
2. P70 19
3. S0 18
4. S0 19
5. P70 S0 18
6. P70 S0 19
7. P70 S0 18
8. P70 S0 19
9. P70 S0 18
10. P70 S0 19
11. S850 S0 18
12. S850 S0 19

Legend:
- Pea
- Oat
- Bean
Potential for intercropping
Intercropping with pulses: Insights from UK and Sweden

Katie Bliss, Organic Research Centre
Potential benefits of Intercropping pulses

- For the pulses..
  - Scaffolding
  - Harvestability
  - Weed control
  - Pest and disease dilution

- For its companion..
  - N / Protein?
  - Pest and disease dilution

Facilitation, resource sharing and complementarity (Brooker et al, 2015)
Triticale and Carlin peas, Greenacres Farm, Shropshire

**Motivations:** Scaffolding for peas; pea quality; weed suppression and harvestability

**Establishment:** 1 ha, 12m strips
Drilled 25th April 2018 in 2 passes

**Processing and use:** Separated with cleaner on farm.
Carlin peas for Hodmedods and triticale for animal feed
Triticale and Carlin peas, Greenacres Farm, Shropshire

Results

- Best harvestability in 30% RD treatment (75kg/ha)
- Repeated in 2019 with triticale at 20 and 40% RD
  - Suffered low yields – 40% too high
  - Foot rot - due to increasing legume in rotation?

30% RD triticale
Wheat and beans, Roundhill Farm, Wiltshire

**Motivations:** Weed suppression (especially wild oat), increase wheat protein, increase total yield (feed)

**Establishment:** 1 ha strips, wheat and beans in two passes

<table>
<thead>
<tr>
<th>Year</th>
<th>2018</th>
<th>2019</th>
</tr>
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<tbody>
<tr>
<td>Tundra</td>
<td><strong>Beans</strong> 125kg/ha</td>
<td><strong>Beans</strong> 200kg/ha</td>
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<tr>
<td>Malika</td>
<td><strong>Wheat</strong> 174kg/ha</td>
<td><strong>Wheat</strong> 100kg/ha</td>
</tr>
</tbody>
</table>

**Processing and use:** Harvested together and used as mixed feed for livestock
Wheat and beans, Roundhill Farm, Wiltshire

Results

- **2018**
  - **Weeds:** 74% less dry weed biomass in intercrop than monocrop
  - **Yield:** Mono Beans 0.59t/ha; Intercrop Beans 0.48t/ha beans 1.43t/ha wheat (wheat rate too high?)
  - 222% increase in total yield in intercrop—feed for livestock

- **2019**
  - **Weeds:** 73% less dry weed biomass in intercrop than monocrop
  - **Yield:** Monoculture crop destroyed due to high weed burden

**Wheat protein:** Intercrop 10.94 vs 10.67 in monocrop

**Hagberg:** 411 Intercrop vs 384 in monocrop

Wild oats in intercrop (left) mono (right)
Motivations: Oats for scaffolding and weed suppression

Establishment: Lentils (90kg/ha) and oats (40kg/ha) and monocultures

Results: Improved harvestability of lentils
Reduced weed biomass.
Same / Slightly increased lentil yield vs mono - 1.5t/ha. Slight increase in moisture
Intercropped oats sown at 40% of mono density have produced 60% of mono yields.

Processing and use: On-farm separation – (provides service to others) Human consumption – Nordisk Ravara
Other plant teams in the field....

2019

- **Beans and triticale** – Sonning Farm, Berks (Weeds, protein, yield)
- **Beans and oats** – Bockhanger Farm, Kent / PGRO (Weeds, bruchid, tissue analysis (N), LER, yield, RTV)
- **Lentils and linseed** – Bockhanger Farm, Kent (Lodging, weed control)
- **Peas and oats** – Sweden / SLU Remix (Manage In-field heterogeneity, yield)
- **Peas and beans / beans and oats** – PGRO Lincolnshire (Lodging, weeds, yield)
- **Carlin / Yellow peas and oats / barley / spelt** – Sonning Farm, Berks / ORC (Lodging, yield, weeds)

2020

- **Peas and oats / Lentils and oats** – Bockhanger Farm, Kent

Grey peas 190kg/ha and oats 150kg/ha drilled with system chameleon. Sweden
In summary....

- No silver bullet – find what works on your farm
- Large yield variation year on year – Trend towards overyielding
- Set key objectives for mixture - Priority crop?
- Some challenges – e.g competition, rotation effects and separation
- Speak to others who are doing it – join the Intercropping Field Lab!
Find out more….www.agricology.co.uk @agricology and YouTube channel! ☺