Review of research on legumes and grasses for forage and grazing
(Leg-Link /SOLID)

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Leg-Link Project

Using legume-based mixtures to enhance the nitrogen use efficiency and economic viability of cropping systems

• To demonstrate that:
  
  ◆ **species-rich legume-based leys** can maximise pasture productivity and other ecosystem services
  
  ◆ **Functional diverse plant species mixtures** can be optimised and fine-tuned to farm-specific needs
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- Replicated field experiments conducted over three years
  - Multiple locations across the UK
  - Trials tested the performance of 12 legume and 4 grass species
    - Sown in monocultures or mixtures
  - The study mixture was compared to farmer-chosen ley mixtures
1. Characteristics of legume species used

- No single species scored high on all evaluation criteria
- Large degree of functional complementarity among the legume species.

| Table S3. Ranks of species performance (WP1); high ranks show high performance; empty cells indicate lack of sufficient data. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Criterion** | **AC** | **BM** | **BT** | **CC** | **LT** | **LU** | **MP** | **RC** | **SC** | **SF** | **WC** | **WV** |
| Early development | 5 | 6 | 2 | 12 | 1 | 11 | 8 | 10 | 9 | 7 | 3 | 4 |
| Productivity | 7 | 9 | 8 | 6 | 1 | 10 | 3 | 12 | 4 | 5 | 11 | 2 |
| Weed suppression | 7 | 11 | 8 | 3 | 5 | 9 | 1 | 12 | 4 | 6 | 10 | 2 |
| Flowering | 6 | 11 | 8 | 8 | 2 | 2 | 1 | 6 | 2 | 2 | 8 | 1 |
| Pre-crop value | 5 | 8 | 10 | 3 | 7 | 12 | 2 | 11 | 4 | 6 | 9 | 1 |
| Resistance to decomposition | 5 | 4 | 9 | 1 | 10 | 3 | 7 | 6 | 8 | 2 |  |  |
| Perform. following crop | 7 | 9 | 10 | 2 | 4 | 11 | 1 | 8 | 3 | 6 | 12 | 5 |
| Average rank | 6.0 | 8.3 | 7.9 | 5.0 | 4.3 | 8.3 | 2.7 | 9.4 | 4.6 | 5.7 | 7.9 | 2.5 |

Legend:
- AC: Black Medic
- BM: Birdsfoot Trefoil
- BT: Lucerne
- CC: Red Clover
- LT: White Clover
- LU: Black Medic
- MP: Birdsfoot Trefoil
- RC: Lucerne
- SC: Red Clover
- SF: White Clover
- WC: Black Medic
- WV: Birdsfoot Trefoil
2. Benefits of mixing species

- Increased above-ground biomass compared to monocultures
- Productivity increases over time
- Greater stability of biomass production
- Effects are more profound on less fertile soils (low organic matter)
- Mixing species with different properties allows better weed control throughout the season.
2. Benefits of mixing species

- Greater resilience to variable weather, climate and management conditions
- Inclusion of species with slower N release can result in lower N losses and better utilisation
- Nitrogen losses from *White clover* and *Red clover* were 2–3 times greater than those from either *Black medic* or *Lucerne*
3. Species with useful characteristics

- Mixes with high agronomic productivity function containing both \textit{Lucerne} and \textit{White Clover}

- Overall performance improves by including a \textit{third or fourth} legume species

- The three best multifunctional mixtures all contained \textit{Black medic}, \textit{Lucerne} and \textit{Red clover}

- Some species show low performance (almost) everywhere: \textit{Meadow pea}, \textit{Winter vetch}, \textit{Large birdsfoot trefoil}
3. Key points for designing a mixture

- Consider **functional diversity** rather than **species diversity**

- Criteria for species choice include
  - Residue properties
  - Biomass potential
  - Response to management, climate and soil conditions
  - Nutritional value for livestock

- Some species show marked differences in performance depending on region (i.e. Sainfoin)
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Diverse swards and mob grazing for dairy farm productivity

- To assess the productivity and composition of grazing diverse swards
- To compare diverse sward productivity with that of ryegrass-white clover
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Measurements

- Forage Productivity

Ungrazed paddock

Grazed paddock
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Senescent

Broad leaves

Grass

Clover
Composition & DM Productivity (year 1)

Month of the grazing season

- Grass
- Clover
- Broad leaves
- Senescent
Composition & DM Productivity (year 2)

Month of the grazing season

- Grass
- Clover
- Broad leaves
- Senescent

Herbage Production (t DM per ha)
Forage DM Productivity

Total Production (year 1)

<table>
<thead>
<tr>
<th>Plant Species</th>
<th>tonnes</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass</td>
<td>5.79</td>
<td>56%</td>
</tr>
<tr>
<td>Clover</td>
<td>2.61</td>
<td>25%</td>
</tr>
<tr>
<td>Broad leaves</td>
<td>1.61</td>
<td>16%</td>
</tr>
<tr>
<td>Senescent</td>
<td>0.30</td>
<td>3%</td>
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</table>

Total Production 10.3 100%

Total Production (year 2)

<table>
<thead>
<tr>
<th>Plant Species</th>
<th>tonnes</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass</td>
<td>7.84</td>
<td>71%</td>
</tr>
<tr>
<td>Clover</td>
<td>2.38</td>
<td>22%</td>
</tr>
<tr>
<td>Broad leaves</td>
<td>0.65</td>
<td>6%</td>
</tr>
<tr>
<td>Senescent</td>
<td>0.19</td>
<td>2%</td>
</tr>
</tbody>
</table>

Total Production 11.0 100%
Grass/Clover vs. Diverse Sward
(year 1)

Total Production (year 1)

<table>
<thead>
<tr>
<th>Ley</th>
<th>tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbal Mix</td>
<td>13.2</td>
</tr>
<tr>
<td>Grass/Clover</td>
<td>13.7</td>
</tr>
</tbody>
</table>

Herbage Production (t DM per ha)

Year 1  Year 2  Year 1  Year 2  Year 1  Year 2
May     July    September

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Grass/Clover

Grass/Clover
Grass/Clover vs. Diverse Sward (year 2)

Total Production (year 2)

<table>
<thead>
<tr>
<th>Ley</th>
<th>tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbal Mix</td>
<td>10.5</td>
</tr>
<tr>
<td>Grass/Clover</td>
<td>10.6</td>
</tr>
</tbody>
</table>

Herbage Production (t DM per ha)

Year 1 | Year 2 | Year 1 | Year 2 | Year 1 | Year 2 | Year 1 | Year 2
May    |        |        |        |        |        |        |        
July   |        |        |        |        |        |        |        
September |      |        |        |        |        |        |        

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ORC ELM FARM
Conclusions

- There was a large variation in herbage composition between months and years of sampling.
- No significant difference in DM yield was found between the two mixtures compared.
- Diverse swards can serve as a viable alternative to traditional pastures.
- Soil samples will be analysed later this year to determine Soil Organic Matter.
Thank you
Results – Forage Production Y2

The graph shows the herbage production (t DM per ha) for Herbal Mix and Grass/Clover for different months (May, July, September) in Year 1 and Year 2.
**Table S1.** Legume and grass species included in the trials: Scientific and common name; inoculation and seed rate (in kg/ha) in the monoculture plots (Monoc.) and in the All Species Mix (ASM).

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Scientific name</th>
<th>Common name</th>
<th>Inoc.*</th>
<th>Monoc.</th>
<th>ASM</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td><em>Trifolium hybridum</em></td>
<td>Alsike clover</td>
<td>C</td>
<td>10</td>
<td>1.25</td>
</tr>
<tr>
<td>BT</td>
<td><em>Lotus corniculatus</em></td>
<td>Birdsfoot trefoil</td>
<td>-</td>
<td>12</td>
<td>2.5</td>
</tr>
<tr>
<td>BM</td>
<td><em>Medicago lupulina</em></td>
<td>Black medic</td>
<td>L</td>
<td>15</td>
<td>2.5</td>
</tr>
<tr>
<td>CC</td>
<td><em>Trifolium incarnatum</em></td>
<td>Crimson clover</td>
<td>-</td>
<td>18</td>
<td>2.25</td>
</tr>
<tr>
<td>IR</td>
<td><em>Lolium multiflorum</em></td>
<td>Italian ryegrass</td>
<td>-</td>
<td>33</td>
<td>1</td>
</tr>
<tr>
<td>LT</td>
<td><em>Lotus pedunculatus</em></td>
<td>Large birdsfoot trefoil</td>
<td>-</td>
<td>12</td>
<td>2.5</td>
</tr>
<tr>
<td>LU</td>
<td><em>Medicago sativa</em></td>
<td>Lucerne</td>
<td>L</td>
<td>20</td>
<td>2.5</td>
</tr>
<tr>
<td>MF</td>
<td><em>Festuca pratensis</em></td>
<td>Meadow fescue</td>
<td>-</td>
<td>25</td>
<td>1.25</td>
</tr>
<tr>
<td>MP</td>
<td><em>Lathyrus pratensis</em></td>
<td>Meadow pea</td>
<td>V</td>
<td>75</td>
<td>3.25</td>
</tr>
<tr>
<td>PR</td>
<td><em>Lolium perenne</em></td>
<td>Perennial ryegrass</td>
<td>-</td>
<td>33</td>
<td>2.5</td>
</tr>
<tr>
<td>RC</td>
<td><em>Trifolium pratense</em></td>
<td>Red clover</td>
<td>C</td>
<td>18</td>
<td>2.5</td>
</tr>
<tr>
<td>SF</td>
<td><em>Onobrychis viciifolia</em></td>
<td>Sainfoin</td>
<td>-</td>
<td>80</td>
<td>5</td>
</tr>
<tr>
<td>TY</td>
<td><em>Phleum pratense</em></td>
<td>Timothy</td>
<td>-</td>
<td>10</td>
<td>0.5</td>
</tr>
<tr>
<td>WC</td>
<td><em>Trifolium repens</em></td>
<td>White clover</td>
<td>C</td>
<td>10</td>
<td>1.5</td>
</tr>
<tr>
<td>SC</td>
<td><em>Melilotus alba</em></td>
<td>White sweet clover</td>
<td>L</td>
<td>18</td>
<td>-</td>
</tr>
<tr>
<td>WV</td>
<td><em>Vicia sativa</em></td>
<td>Winter vetch</td>
<td>V</td>
<td>100</td>
<td>-</td>
</tr>
</tbody>
</table>

* Inoculated with clover inoculant (C), lucerne inoculant (L) or vetch inoculant (V).
Mod grazing is characterised by **high grazing pressure for a short time** to remove forage rapidly as a management strategy.

- Pastures are allowed to grow taller than the traditional height (i.e. long resting periods).
- Animals consume and trample the sward for a short period of time (i.e. are moved to a new paddock within 24h).
4. Species with useful characteristic

» **Red clover** (*Trifolium pratense*)
  High yield
  High yield of subsequent crop

  Performance 9.4

» **White clover** (*Trifolium repens*)
  High yield
  High yield of subsequent crop

  Performance 7.9
4. Species with useful characteristics

- **Black medic** (*Medicago lupulina*)
  - Resistance to decomposition (lignin content and C:N ratio)
  - High yield of subsequent crop
  - Performance 8.3

- **Birdsfoot trefoil** (*Lotus corniculatus*)
  - High yield
  - High yield of subsequent crop
  - Performance 7.9
4. Species with useful characteristics

» **Lucerne** *(Medicago sativa)*
  - High yield
  - Resistance to decomposition
  - High yield of subsequent crop
  - Prefers high pH
  - Performance 8.3

» **Sainfoin** *(Onobrychis viciifolia)*
  - Moderate yield
  - Resistance to decomposition
  - Performance 5.7
4. Species with useful characteristics

» **Crimson clover** (*Trifolium incarnatum*)
  
  High yield
  High value for pollinators
  
  Performance 5.0
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Diverse swards and mob grazing for dairy farm productivity

- **Diverse swards consist of**
  - 10 grass species
  - 6 legumes and
  - 5 herbs

- **Mob grazing was introduced as an approach to increase Soil Organic Matter**
1. Characterisation of legume species

- No single species scored high on all evaluation criteria
- Large degree of functional complementarity among the legume species.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>AC</th>
<th>BM</th>
<th>BT</th>
<th>CC</th>
<th>LT</th>
<th>LU</th>
<th>MP</th>
<th>RC</th>
<th>SC</th>
<th>SF</th>
<th>WC</th>
<th>WV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early development</td>
<td>5</td>
<td>6</td>
<td>2</td>
<td>12</td>
<td>1</td>
<td>11</td>
<td>8</td>
<td>10</td>
<td>9</td>
<td>7</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Productivity</td>
<td>7</td>
<td>9</td>
<td>8</td>
<td>6</td>
<td>1</td>
<td>10</td>
<td>3</td>
<td>12</td>
<td>4</td>
<td>5</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Weed suppression</td>
<td>7</td>
<td>11</td>
<td>8</td>
<td>3</td>
<td>5</td>
<td>9</td>
<td>1</td>
<td>12</td>
<td>4</td>
<td>6</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Flowering</td>
<td>6</td>
<td>11</td>
<td>8</td>
<td>8</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Pre-crop value</td>
<td>5</td>
<td>8</td>
<td>10</td>
<td>3</td>
<td>7</td>
<td>12</td>
<td>2</td>
<td>11</td>
<td>4</td>
<td>6</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Resistance to decomposition</td>
<td>5</td>
<td>4</td>
<td>9</td>
<td>1</td>
<td>10</td>
<td>3</td>
<td>7</td>
<td>6</td>
<td>8</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perform. following crop</td>
<td>7</td>
<td>9</td>
<td>10</td>
<td>2</td>
<td>4</td>
<td>11</td>
<td>1</td>
<td>8</td>
<td>3</td>
<td>6</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Average rank</td>
<td>6.0</td>
<td>8.3</td>
<td>7.9</td>
<td>5.0</td>
<td>4.3</td>
<td>8.3</td>
<td>2.7</td>
<td>9.4</td>
<td>4.6</td>
<td>5.7</td>
<td>7.9</td>
<td>2.5</td>
</tr>
</tbody>
</table>
Leg-Link Project
- Conclusions and implications -

1. Characteristics of legume species used

- Range of currently used species in farms is relatively narrow:
  - White Clover / Red Clover

- Several other species show great potential to increase the productivity and provision of ecosystem services
  - Black medic, Birdsfoot trefoil, Crimson clover, Lucerne, Sainfoin
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Measurements

- Forage Productivity
- Herbage composition
- Yield comparison Grass/Clover and Diverse Sward
- Evaluate the Plate Meter method for DM determination