N supply in stockless organic cereal production under northern temperate conditions. Undersown legumes, or whole-season green manure?

Anne-Kristin Løes, Bioforsk Organic Food and Farming
Trond M. Henriksen, Hedmark University College
Ragnar Eltun, Bioforsk Arable Crops

Outline

- Background
- Aim
- Experimental design
- Cereal yields
- N balance
- Conclusions
Background

• Large and increasing demand for organic cereals (food and fodder)
• Main challenges for organic cereal production:

  - Soil structure
  - Nutrient supply, especially N
  - (Perennial) Weeds
Aim

- Is repeated undersowing of clover in cereals a well functioning green manuring strategy for commercial grain production on stockless organic farms?
Experimental design

- Two sites, Kise and Apelsvoll
- 6 treatments, 4 replicates, 2002-06
- 2006 = residual effect, barley
- 2002-05 = repeated undersowing vs one year of green manure (2003)
- Mixing of grass and clover seed
<table>
<thead>
<tr>
<th>Treatment</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oats</td>
<td>Spring wheat</td>
<td>Oats</td>
<td>Spring wheat</td>
<td>Spring barley</td>
</tr>
<tr>
<td>0 Control, weed harrowed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Undersown ryegrass</td>
<td>Ryegrass</td>
<td>Ryegrass</td>
<td>Ryegrass</td>
<td>Ryegrass</td>
<td></td>
</tr>
<tr>
<td>3 Undersown clover</td>
<td>Red clover</td>
<td>White</td>
<td>Red clover</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>4 Undersown mix</td>
<td>Red clover and ryegrass</td>
<td>White and ryegrass</td>
<td>Red clover and ryegrass</td>
<td>White and ryegrass</td>
<td></td>
</tr>
<tr>
<td>5 Green manure mix</td>
<td>Red clover and tim., ley</td>
<td>Red clover and tim., ley</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Green manure red clover</td>
<td>Red clover</td>
<td>Red clover, ley</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No text = only cereals. Yellow = cereals. Clover = green. Undersown species = text.
Records

- Yields of cereals and straw
- Aboveground biomass (AGB)
  - weeds
  - undersown crop(s)
  - cereals
  
  *Recorded in early spring (end of April) - Mid Summer (early July) - harvest (early Sept.) - late autumn (late Oct.)*

- NPK in AGB, % of dry matter (DM)
- Mineral N in soil ($N_{\text{min}}$)
  
  *Early spring and late autumn*
Field at Apelsvoll, June 2004. Photo Trond M. Henriksen.

Treatment 0: Weed harrowed, not included in main experiment.
Treatment 1: No undersowing, tr. 2 ryegrass undersown.
## Cereal yields

**Tons ha\(^{-1}\) (15% water), average for both sites**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Starting year, 2002</th>
<th>Average 2003-05</th>
<th>Residual effect, 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T / ha</td>
<td>Relative %</td>
<td>T / ha</td>
</tr>
<tr>
<td>1</td>
<td>2.98 a</td>
<td>100</td>
<td>2.96 a</td>
</tr>
<tr>
<td>2</td>
<td>2.83 a</td>
<td>95</td>
<td>3.06 ab</td>
</tr>
<tr>
<td>3</td>
<td>2.53 a</td>
<td>85</td>
<td>3.86 b</td>
</tr>
<tr>
<td>4</td>
<td>2.69 a</td>
<td>90</td>
<td>3.76 ab</td>
</tr>
<tr>
<td>5</td>
<td>2.68 a</td>
<td>90</td>
<td>3.17 ab</td>
</tr>
<tr>
<td>6</td>
<td>2.65 a</td>
<td>89</td>
<td>3.23 ab</td>
</tr>
</tbody>
</table>

Within year or period, yields with different letters (a, b) are significantly different (p<0.05).
Accumulated N balance

N balance = kg N in AGB of undersown green manure in late October x 1.25 minus kg N in cereals removed in September. Average for both sites.
Conclusions

- Considerable effect of green manuring, on average 30% larger yields the year after undersowing of clover.
- Yield increase comes in the subsequent year.
- One year out of four with clover ley gives a large yield increase, but not enough to compensate one year without cereal yields.
- Combine whole-season green manure and undersown clover? Be aware of phytopathological risks! (nematodes, fungi, beetles).
- Without weed harrowing, undersowing increases the weed biomass. Combined harrowing and undersowing is desired.
- Negative accumulated N-balance - cereal yields removed more N than the green manure produced.
Modifications

• May low to medium concentrations of soil P and K decrease the potential of N fixation?

• Can we accept a larger part of the crop rotation used for green manure (e.g. 2 years of clover ley, 3 years of cereals = 40%)?

• If no, what can be an acceptable source of N for organic stockless farms?

• Suggestions: Meat and bone meal, human urine
Thanks for your attention
Kg N ha\(^{-1}\) in AGB of undersown rye grass (2), clover (3) or clover + rye grass (4) at Kise (K) and Apelsvoll (A)