Organic and biodynamic cultivation

- a possible way of increasing humus capital, improving soil fertility and providing a significant carbon sink in Nordic conditions

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http://www.jdb.se/sbfi/
In Sweden most arable land is found where there are sedimentary soil types below the high coast-line after last ice time 10 000 years ago.

Map with simplified high coast-line (HK), Area above the HK and under the HK.
To day land continues to rise 3 mm a year in this part of central Sweden and it is possible to follow how soil formation take place along the sea. Factors: Climate, topography and geology.
Pictures showing main soil profile types in Sweden. The ongoing leaching in *podzol soils* results in the characteristic layer of bleached soil. Brown soils is result of a more strong reverse process through basic nutrient components uptake of the vegetation and fast decomposition on surface.
Reduced recycling caused by increasing separation of animal production:

• The average use of artificial macro nutrients increase (in Sweden N in fertilizers increased from 20 kg to 80 kg per ha and year 1950 - 1980).

• Decreasing humus, soil fertility and trace element contents on specialised crop farms

• Increasing surplus and nutrient losses on specialised animal farms
Specialised crop farms
Specialised animal farms

200 N
(Imported fodder, soya and fertilizers)

150 N

50 N
Ecological recycling agriculture (ERA)
The Biodynamic agricultural organism. The recycling from the growing of legume crops whereas the crop residues are directly incorporated in the soil and the recycling via fodder and the on-farm animal manure (Source: Granstedt, 1992).
One of the biodynamic farms in Järna converted 1967
Long term experiment

- **K-experiment in Järna from 1958 - 1990**
  Quality of agricultural food products and soil under different fertilizing conditions. Report: [www.jdb.se/sbfi](http://www.jdb.se/sbfi/)

- **UJ (Ultuna-Järna) - experiment 1971 - 1979**
  Quality of agricultural food products and soil comparing farming systems - biodynamic and conventional

- **Skilleby long-term on farm trial started in 1991 and still continuing**
  Soil fertility, yield, nutrient economy and product quality with different use of the manure within the farming system
K-experiment in Järna from 1958 - 1990

• Materials and methods
  • K-experiment
  • The long-term K field trial was run with one crop rotation without replications but with each crop each year from 1958 – 1990: 1) Summer wheat, 2) Ley with legumes, 3) Potatoes and 4) Beets
  • The 8 different treatments include:

• K1. Biodynamic (BD) composted manure (content N/P/K, 80/38/76) and BD field preparation
• K2. Biodynamic composted manure without the BD field preparation
• K3 Raw farm yard manure
• K4 Raw farm yard manure and mineral fertilizer (NPK)
• K5 No manure or fertilizer
• K6 Low mineral fertilizer (NPK)
• K7 Medium mineral fertilizer (NPK)
• K8 High mineral fertilizer (NPK, 117/36/81)
Carbon in the topsoil increased with 20% during 29 years (an increase of 25 ton per ha calculated to a depth of 60 cm) in the biodynamic treatment.
The Biodynamic Research Institute

**UJ trial plan: 1971 – 1979,**

*two locations*, each crop each year and four replications

<table>
<thead>
<tr>
<th>Rotation</th>
<th>Conventional Without ley</th>
<th>Conventional With ley</th>
<th>Biodynamic Without ley</th>
<th>Biodynamic With ley</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>A2</td>
<td>B1</td>
<td>B2</td>
<td></td>
</tr>
<tr>
<td>1. Summer wheat</td>
<td>Summer wheat + in sown ley</td>
<td>Summer wheat</td>
<td>Summer wheat + in sown ley</td>
<td></td>
</tr>
<tr>
<td>2. Barley</td>
<td>Ley with clover/grass</td>
<td>Barley</td>
<td>Ley with clover/grass</td>
<td></td>
</tr>
<tr>
<td>3. Potato</td>
<td>Potato</td>
<td>Potato</td>
<td>Potato</td>
<td></td>
</tr>
</tbody>
</table>

*) Ultuna, Uppsala trial, Dlouhý (1981); Järna trial, Pettersson (1982).
Soil carbon increase (with 10 % during 10 years) only when both leys (one year of three) and the farmyard manure were included.
Skilleby on farm long term study 1991 -

The prototype farm Yttereneby – Skilleby in Järna)

• The animal density is adjusted to the own feed on 84% and crop for sale on 16% of the farm area (0.6 AU/ha)

Yttereneby and Skilleby 2003

<table>
<thead>
<tr>
<th>Import ---→</th>
<th>Recycling</th>
<th>Export</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed</td>
<td>Milk</td>
<td></td>
</tr>
<tr>
<td>Seed</td>
<td>47 cows, 39 heifers, 10 calves, 29 sheep</td>
<td>Meat products</td>
</tr>
<tr>
<td>Own feed &gt; 84% of the area</td>
<td>0.6 AU / ha</td>
<td></td>
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</tbody>
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450 m³ urine + 600 m³ manure + dung/urine pasture

Biogas

Bread grain

Ecological recycling agriculture / ERA
Rotation Skilleby experimental farm
1. Summer crop + ins
2. Ley I
3. Ley II
4. Ley III
5. W. wheat
Farm own manure (0.6 au/ha)

On farm long term experiment from 1991
- non-composted and composted manure
- with and without biodynamic preparation (split plot design)
- three levels: 12.5 (0), 25 (normal) and 50 tons per ha
- 2 – 4 replicates on the five rotation fields
Experimental plan from 1991

<table>
<thead>
<tr>
<th>Main plot</th>
<th>Treatments winter wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>Not composted manure 12.5 ton (0 from 1995)</td>
</tr>
<tr>
<td>F2</td>
<td>25 ton</td>
</tr>
<tr>
<td>F3</td>
<td>50 ton</td>
</tr>
<tr>
<td>K1</td>
<td>Composted manure 12.5 ton (0 from 1995)</td>
</tr>
<tr>
<td>K2</td>
<td>25 ton</td>
</tr>
<tr>
<td>K3</td>
<td>50 ton</td>
</tr>
</tbody>
</table>

Subplots:

+ BD preparation each plot each year

- Without BD preparation

Skilleby long-term trial started in 1991 and still continuing
Soil carbon content in topsoil (0 – 20 cm) Skilleby HV1 1991 and 2000. C1 (12.5) 0 tons; C2 25 tons and C3 50 tons composted farmyard manure without (-) and with (+) BD treatments.
Calculated and measured values from Skilleby long term experiment.

The observed carbon content increased with 4450 kg C per ha (from 47 850 to 52 300) during 9 years.
Soil carbon content in topsoil (0 – 20 cm) Skilleby HV2 1992 and 2007. C1 (12.5) 0 tons; C2 25 tons and C3 50 tons composted farmyard manure
Conclusions

• Degradation of soil humus and soil fertility and the emission of carbon from soils are consequences of agricultural specialization to farms with no animal production integrated with grasslands and recycling.

• To rebuild humus content and soil fertility, farming systems based on the integration of crop and animal production with both grassland (clover-grass leys) and recycling of manure are necessary.

• Emissions of greenhouse gases resulting from soil degradation can be stopped and agricultural land can be a significant carbon sink (400 – 800 kg C per ha and year) for a long period of time through such an Ecological Recycling Agriculture.
• Additional pictures only if it is a need for discussions
The percentage of humus (soil organic matter = SOM) in the top soil with different proportions leys after three periods of six-year crop rotations in long term trials in northern Sweden (Persson, 1994)
Humus content (Corg) after 21 years in DOK trials comparing conventional, organic and biodynamic treatments. In the Swiss DOK trials comparing to biodynamic, organic and conventional treatments in FiBL with start 1977. BIODYN (Biodynamic), BIOORG (Organic), CONFYM (Conventional with manure) and CONMIN (Conventional with only mineral fertilizer). DOK-experiment (Mäder et al, 2002; 2006, Fliessbach 2007)