Working on soil quality
a win-win for
agriculture and water management

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Content

• Short introduction Louis Bolk Institute
• Risk management and resilience
• Importance of soil quality
• Measures for improvement soil quality
• Effect of measures
Louis Bolk Institute

- Independent research Institute on agriculture, human nutrition and human health
- Participatory research and systems approach ('making systems work', 'bottom-up')
Introduction

Small holder dairy farming

Mob grazing with herders

Agro-ecological intensification

Soil ecosystem services under grassland
Programme soil quality, grassland and ecosystem services

- Production (quantity and quality)
- Water (quantity and quality)
- Climate mitigation and adaptation
- Biodiversity and habitat
Its all about risk

Agriculture:
• Capital intensive
• High risk
• Relatively low return on investments

“Normal” economy
• With high risk, there is a chance for high return on investments

Van Eekeren & Bestman, 2012; Erisman et al., 2015
- Risk oriented
- Limited variability
- Continuous monitoring and direct intervention
- High use of external inputs
- Static equilibrium
- High long-term risk

After Ten Napel et al. 2006
Current risk management model leads to societal problems

Amongst others:
- Water quality
- Water quantity
- Resistance to antibiotics
- Loss of biodiversity and habitat
Combined with other developments risk only increases

Amongst others:
• Climate change
• Price fluctuation of inputs and milk
Its all about risk

Agriculture:
• Capital intensive
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“Normal” economy
• With high risk, there is a chance for high return on investments

Van Eekeren & Bestman, 2012; Erisman et al., 2015
Resilient agricultural system

- System oriented
- Makes use of variability
- Enhances self-regulation - indirect management
- Dynamic equilibrium
- Low long-term risk

After Ten Napel et al. 2006
Transition towards a resilient agriculture

Subsidies

Agricultural Nature Management

Control model

Transformation of the system

Resilient model

New business models
Soil important for resilience
Soil = Capital and buffer
Importance soil quality for agriculture and water management

Agriculture
- Production
  - Quantity
  - Quality
- Costs
- Controle of risk

Water management
- Water quantity
  - Water supply in drought
  - Peak discharge
- Water quality
  - Nutrients
  - Pesticides
  - Antibiotics
How?

See....

Understand....

Act....
Working on water and soil quality is working on an integral package of:

1. Water characteristics
2. Soil structure
3. Organic matter
4. Soil chemical
5. Roots
6. Soil biota
Red line presentation

- Per element of soil quality
- Effect on water quantity and quality
- Which management
- Land-use (grassland and arable land)
Long-term crop rotation experiment in Belgium

Experiment established in 1966
Four treatments:

1. Permanent grassland since 1966;
2. 3 years temporary grassland in rotation;
3. 3 years temporary arable land in rotation;
2. Working on soil structure

Soil structure works on water quantity and quality via:

• Improved water infiltration
• Improved water holding capacity
• Deeper rooting
• Reduced run off nutrients, antibiotics and pesticides
• Improved nutrient use

Win-win for agriculture and water management
Water infiltration and soil structure

Deru e.a., 2012
Effect land-use on soil structure

Permanent grassland
Temporary grassland
Temporary arable land
Permanent arable land

Crumbs
Sub-angular
Angular

Crumbs
Sub-angular
Angular
Prevention soil compaction

• Drainage
• Ground water level
• Timing
• Machine choice
• Tyre choice
• Tyre pressure
• Etc.
Reduction of soil compaction
3. Working on soil organic matter

SOM works on water quantity and quality via:

- Improved soil structure
- Improved water holding capacity
- Binding of nutrients, pesticides and antibiotics

Win-win for agriculture and water management
Soil organic matter and water

Increase in vol% / Soil Organic Matter %

Wosten et al., 2016
Working on soil organic matter: Land use

Balance between Supply and Decomposition

<table>
<thead>
<tr>
<th>Type</th>
<th>Supply</th>
<th>Decomposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arable land</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Grassland</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>
Effect land-use on Soil Organic Matter

On average 6.1% 3.3% 3.5% 2.1%
Reducing decomposition
Minimal tillage
Increasing supply

- Roots
- Crop residues (varieties, harvesting methods)
- Organic manure
- Compost
- Green manure crops
4. Working on roots

Roots work on water quantity and quality via:

- Improved soil structure
- Increase supply organic matter
- Food for soil biota
- Intensive rooting; P utilization
- Deeper rooting; N and water utilization

Win-win for agriculture and water management
Deeper rooting more water available

In Australia rule of thumb:
Each 10 cm rooting depth, 0.5 ton grain production per ha

Faber, et.al. 2012.
Intensive rooting improved P utilization

Soil P status

Root length density cm per cm$^3$
Work on roots: Agronomy

Improving rooting via:
- Species and cultivars
- Soil management
- Fertilisation etc.
- Others

Brochure: Back to the roots [www.louisbolk.nl](http://www.louisbolk.nl)
Van Eekeren et al., 2011
Working on roots: Breeding
Two varieties of rye grass
6. Working on soil biota

Soil biota work on water quantity and quality via:

- Improved soil structure
- Deeper rooting
- Direct relation with water infiltration
- Suppression of soil disease
- Decomposition of pesticides and antibiotics
- Capturing of nutrients

Win-win for agriculture and water management
Fungal hyphe for water stable particles

Tisdall and Oades, 1979
Ecological groups of earthworms

- **Epigeic**
- **Endogeic**
- **Anecic**
Especially anecic species increase water infiltration

Bouche and Al-Addan, 1997
Effect on number of earthworms

Number of earthworms per m²

Permanent grassland
Temporary grassland
Temporary arable
Permanent arable

2002
2003
2004
Effect on ecological groups

- Permanent grassland
- Temporary grassland
- Temporary arable
- Permanent arable

- Anecic
- Endogeic
- Epigeic

0% 20% 40% 60% 80% 100%
Effect on water infiltration

Van Eekeren et al, 2008
Working on soil biota for example earthworms

Measures for stimulating numbers and species:

• Minimising disturbance and tillage
• Quantity food
• Quality food
  – N for endogeic earthworms
  – C for epegeic earthworms
• Stability food
### Summary of effect land-use on six elements of soil quality

<table>
<thead>
<tr>
<th>Element</th>
<th>Permanent grass</th>
<th>3 years temporary grass-clover in rotation</th>
<th>3 years temporary arable in rotation</th>
<th>36 years arable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Organische matter</td>
<td>%</td>
<td>5,7</td>
<td>3,3</td>
<td>3,8</td>
</tr>
<tr>
<td>2. Soil structure</td>
<td>%</td>
<td>76</td>
<td>65</td>
<td>19</td>
</tr>
<tr>
<td>3. Roots</td>
<td>n/m²</td>
<td>1081</td>
<td>1813</td>
<td></td>
</tr>
<tr>
<td>4. Soil biota</td>
<td>helling</td>
<td>0,26</td>
<td>0,50</td>
<td>0,53</td>
</tr>
<tr>
<td>5. Water characteristics</td>
<td>Mm/s</td>
<td>2,7</td>
<td>1,1</td>
<td></td>
</tr>
<tr>
<td>6. Soil chemical</td>
<td>Kg N/ha</td>
<td>159</td>
<td>93</td>
<td>102</td>
</tr>
</tbody>
</table>

Van Eekeren et al. 2008
Results improvement soil quality

Groenendijk et al. 2015
Conclusions working on soil quality and water

- Most measures win-win for agriculture and water management
- Measures often are linked to each other (for example: improved rooting stimulates soil biota, improves soil structure, increases soil organic matter and improves water and nutrient utilisation)
- Land-use (grassland, arable and crop rotation) and than further prioritisation of measures on basis effect agriculture, water quality and water quantity is necessary
Stop burying your head in the sand but rather look more often under the grass sward