Resilient and healthy organic farming systems – concepts, measurements and applications

EPOK Seminar
Research for sustainable organic farming — System perspectives, stakeholder cooperation and communication
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1. The role of health in organic agriculture

Health is central for organic (and non-organic) agriculture

- IFOAM organic principle of health
- Healthy products as consumers‘ motivation to buy organic products
- Hot debate in academia and in public about health benefits of organic products
- Debate about wellbeing and health of conventional vs. organic livestock

So what is health (in the OF context)?

- We need to agree on the meaning(s) of health so that we can promote it
1. The role of health in organic agriculture

Seven dimensions of health concepts

- Naturalist
- Normativist
- Negative
- Positive
- Reductionist
- Holist
- Chemical
- Ecological
- Anthropocentric
- Biocentric
- Materialist
- Vitalist
- Function
- Resilience

"Health‘ cannot be captured by a dictionary definition – it encompasses many different, diverging concepts.

## 1. The role of health in organic agriculture

<table>
<thead>
<tr>
<th>Terms used to define health</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Growth Paradigm:</strong> primarily oriented towards continued growth</td>
</tr>
<tr>
<td><strong>Function</strong></td>
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<tr>
<td><strong>Productivity</strong></td>
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<td><strong>Performance</strong></td>
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<td><strong>Provision</strong></td>
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<td><strong>Efficiency</strong></td>
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</table>

In farming contexts, health concepts diverge most notably in how much they **recognise system boundaries**.  

Vieweger & Döring 2015.  
*J Sci Food Agric* 95: 438–446
### 1. The role of health in organic agriculture

#### An approach to farm health

<table>
<thead>
<tr>
<th>Category</th>
<th>Metric</th>
<th>Source of case study data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Planned vegetation richness</td>
<td>Farm questionnaire</td>
</tr>
<tr>
<td></td>
<td>Livestock richness</td>
<td>Farm questionnaire</td>
</tr>
<tr>
<td></td>
<td>Avian indicator species</td>
<td>Researcher and farmer observation</td>
</tr>
<tr>
<td></td>
<td>Native/total ratio</td>
<td>Researcher and farmer observation</td>
</tr>
<tr>
<td>Species diversity</td>
<td>Richness of landscape elements</td>
<td>Farm maps/farm questionnaire</td>
</tr>
<tr>
<td></td>
<td>Percent non-crop</td>
<td>Farm maps/farm questionnaire</td>
</tr>
<tr>
<td></td>
<td>Percent rare landscape elements</td>
<td>Farm questionnaire</td>
</tr>
<tr>
<td></td>
<td>Yield average</td>
<td>Farm questionnaire</td>
</tr>
<tr>
<td></td>
<td>Market opportunities</td>
<td>Farm questionnaire</td>
</tr>
<tr>
<td>Ecosystem diversity</td>
<td>Percent of waterways buffered/sheltered</td>
<td>Farm maps</td>
</tr>
<tr>
<td></td>
<td>Percent of farm fields protected</td>
<td>Farm maps</td>
</tr>
<tr>
<td>Provisioning services</td>
<td>Percent continuous living cover</td>
<td>Farm questionnaire</td>
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<tr>
<td></td>
<td>Satisfaction</td>
<td>Farm questionnaire</td>
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<tr>
<td></td>
<td>Tenure</td>
<td>Farm questionnaire</td>
</tr>
<tr>
<td>Regulating services</td>
<td></td>
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<tr>
<td>Cultural services</td>
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</tr>
</tbody>
</table>

Although biodiversity & ecosystem services are important in OF, **central elements are missing** from this approach.

Quinn et al. 2012. *Int J Agric Sust*
The IFOAM Principle of Health

Organic Agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible.

1. Health of individuals and communities cannot be separated from the health of ecosystems - healthy soils produce healthy crops that foster the health of animals and people. Health is the wholeness and integrity of living systems.

2. It is not simply the absence of illness, but the maintenance of physical, mental, social and ecological well-being. Immunity, resilience and regeneration are key characteristics of health. [...]  

3. Organic agriculture is intended to produce high quality, nutritious food that contributes to preventive health care and well-being.

4. [...] it should avoid the use of fertilizers, pesticides, animal drugs and food additives that may have adverse health effects.”

Lady Eve Balfour (1898-1990)

IFOAM 2005
Health in the domains of soil, plant, animal, man and ecosystem

• *Linking up* the domains: Indivisibility
  - Do not separate domains – always consider all domains together; or
  - ’Healths‘ of different domains are physically or ecologically linked (‘transmission of health’)

• But the meaning of health may not be the same for the different domains.
1. The role of health in organic agriculture

Health links among the domains

<table>
<thead>
<tr>
<th>Approach</th>
<th>Links among domains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physiological</td>
<td>• Nutrients (e.g. nitrogen)</td>
</tr>
<tr>
<td></td>
<td>• Toxins (e.g. heavy metals)</td>
</tr>
<tr>
<td></td>
<td>• Drugs</td>
</tr>
<tr>
<td>Microbiological</td>
<td>• Microbial communities inhabiting subjects of different domains</td>
</tr>
<tr>
<td></td>
<td>• Transmittable diseases shared by farm animals and humans</td>
</tr>
<tr>
<td>Behavioural</td>
<td>• Health effects of relationship between livestock and humans</td>
</tr>
<tr>
<td>Cultural</td>
<td>• Health concepts, paradigms</td>
</tr>
<tr>
<td>Political</td>
<td>• Common policies and regulations</td>
</tr>
<tr>
<td></td>
<td>• approaches to risk assessment</td>
</tr>
<tr>
<td>Economic</td>
<td>• Econometric methods</td>
</tr>
</tbody>
</table>

‘Health’ links are present but **very diverse** and not based on one single transmission mechanism

Survey among organic farmers from the UK: How did the health in your system change over time?

Changes in 'health' are observed in different domains - but criteria remain incomplete, unconnected and are not validated.

*multiple responses possible, post-hoc classification of responses; total number of responses: 237; total number of respondents: 28

unpublished data, A. Vieweger et al. 2015
Is organic farming really focussing on health?

- Research and practice are more focused on production and productivity: health is *secondary*: if it is not related to productivity, it is more or less neglected.
- This is particularly true for (farm) system level, i.e. where the different domains come together.
- **Concepts and criteria** of health in the organic community are vague.

All this *impedes promotion of health* on organic farms.

**Renewed efforts are needed** to promote health, both in research in practice.

Multidisciplinary workshop on health in organic farming

Can resilience be used as a unifying criterion of health?
2. Measuring health through resilience

Can resilience be used as a unifying criterion of health?

1. How is the term „resilience“ currently used in the literature on health?

2. How is resilience defined?

3. Is resilience a potentially useful criterion of health? What are its advantages and disadvantages?

4. Does resilience provide links between the different domains of soil, plant, animal, and man?

Photo from the website of the First International Symposium on Societal Resilience, Virginia, 2010
2. Measuring health through resilience

Resilience in the health literature

2. Measuring health through resilience

What is resilience?

Latin ‘resilire’ meaning ‘to jump back’.

Some definitions

• **Materials:** The ability to return to the original form or position after being bent, compressed, or stretched.

• **Organisms:** The ability to recover readily from illness, depression, or adversity.

• **Soils and ecosystems:**
  • The ability of a system to return to its original state after being disturbed;
  • The amount of disturbance that a system can absorb before it changes its structure;
  • The ability of a system to remain functional when under external stress.
2. Measuring health through resilience

What is resilience?

„Static resilience“

More resilient

Less resilient

„Engineering resilience“ or „Dynamic resilience“

„Ecological resilience“ after Holling (1973)

Regimes of system

Attractors

A1

A2

2. Measuring health through resilience

Can resilience be a useful criterion of health?

Advantages
1. Measureable
2. More concrete than fuzzy term of health
3. Is already shared among domains
4. Topical

Support to move towards a dynamic formulation of human health, “based on the resilience or capacity to cope and maintain and restore one’s integrity, equilibrium and sense of wellbeing” (Huber et al. 2011 BMC)

Limitations?
1. Concept is not unified among disciplines.
2. It might become “too popular” (like sustainability).
2. Measuring health through resilience

Can resilience be a useful criterion of health?

- Christmas
- Dieting

(weight vs. days)
Can resilience be a useful criterion of health?

2. Measuring health through resilience

- Christmas
- Dieting
- Food shortage

Resilience impeding health

Resilience supporting health
Does resilience provide a link between the domains?

Examples

• Soil functional recovery after compaction disturbance: improved plant health
• Healthy soil leads to quicker degradation of pesticides: lower health risk for humans

Counterexample

• Plants recover from climatic stress through compensatory growth: → yield secured but not necessarily any effects on animal or human health

Unclear

• Plants respond to fungal infection with higher level of defense (induced resistance): → effects on animal or human health currently not well known or debated

Resilience is a useful criterion for health in agricultural contexts but it has its limitations and it should not be used as the sole criterion of health.
Determinants of resilience:

What can be done to promote resilience on organic farms?

- Soil organic matter management
- Selection of crop species
- Increased plant diversity

“Soil stability (resistance and resilience) [...] is related to soil properties such as organic matter, aggregation, the quantity and quality of carbon inputs and, to a lesser extent, clay content and soil pH."

“There is no general soil response to disturbance because stability is particular to the disturbance and soil history.”

3. Applications in farming systems

Resilience in agronomy
Compensatory growth through plasticity of yield components

Data: Berlin Dahlem 'E-Feld' Long-Term yield observations (non-organic), unpublished
3. Applications in farming systems

An example of ‘static’ resilience in wheat through genetic diversity

What can be done to promote health on organic farms?

Plant health in wheat

Grain yield (t ha⁻¹)

Proportion of leaf area diseased (%)

Winter wheat, Harvest 2008, Wakelyns Agroforestry

Döring et al. 2010. Organic Research Centre Bulletin 99: 4
3. Applications in farming systems

What can be done to promote health on organic farms?

Organic farmers’ survey: „Please describe how you made your farm healthier over the years. Which methods or strategies did you use?“

Numbers in brackets show number of respondents out of 28; post-hoc classification of responses; data from Vieweger et al. 2015, unpublished
4. Conclusions

1. Health is a central proclaimed aim of organic farming but currently not (very) high on the agenda.

2. Resilience, like health, has many meanings but it has a common conceptual core among all domains and can be used as a one criterion of health.

3. There is already good understanding of how to promote health on (organic) farms in separate domains.

4. However, health at the farming system level – bridging the domains – is not well understood.

5. Research is needed to investigate the links between the ‘healths’ of different domains.

Thank you for your attention!

The research presented was supported by Ekhaga foundation, Sweden.
What is resilience?

Response:
- rebuild, recover
- absorb, cope, adapt, buffer
- resist, withstand

Response:
- immediate situation, unique, or singular event, new system, new operating conditions
- significant change, unanticipated event
- perturbation, disturbance, disruption, extreme natural event, forced changes
- danger, negative impact, hazard stress, shock, damage, adversity

Disturbance severity:
- low
- high
What is resilience?

Table 2. Calculation of resistance and resilience indices

<table>
<thead>
<tr>
<th>Resistance</th>
<th>Resilience</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{D_0}{C_0} )</td>
<td>( \frac{D_x}{C_0} )</td>
<td>Kaufman (1982)</td>
</tr>
<tr>
<td>( \frac{D_0}{C_0} \times 100 )</td>
<td>( \frac{D_x}{C_0} )</td>
<td>Sousa (1980)</td>
</tr>
<tr>
<td>( \left( C_x - \frac{C_x}{D_x} \right) \times 100 )</td>
<td>( \left( C_x - \frac{C_x}{D_x} \right) \times 100 )</td>
<td>Griffiths et al. (2000)</td>
</tr>
<tr>
<td>( \left| \frac{D_x}{C_x} \right| - 1 \times 100 )</td>
<td>NC</td>
<td>Chaer et al. (2009)</td>
</tr>
<tr>
<td>1 - ( \frac{2</td>
<td>C_0 - D_0</td>
<td>}{C_0 +</td>
</tr>
<tr>
<td>[ \int_0^x f(t) \frac{dt}{x} ]</td>
<td>[ \int_x^j f(t) \frac{dt}{(j-x)} ]</td>
<td>Zhang et al. (2010)</td>
</tr>
<tr>
<td>NC</td>
<td>( \sqrt{\sum_{i=1}^n (D_x)^2/C_x} )</td>
<td>O’Neill (1976)</td>
</tr>
</tbody>
</table>

\( C \), variable measured in the control soil (undisturbed) at time 0 (immediately after disturbance) or at time \( x \) after disturbance; \( D \), variable measured in disturbed soil at time 0 (immediately after disturbance) or at time \( x \) after disturbance; NC, not calculated.