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Production of compost and its utilization

Dr. Jacques G. Fuchs, FiBL

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Production of compost and its utilization

- ⊗ *Basis of compost biology*
- ⊗ *Influence of compost on soil fertility and plant health*
- ⊗ *Quality management*
- ⊗ *Basis for compost appliance*

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Basis of compost biology

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Basis of compost biology

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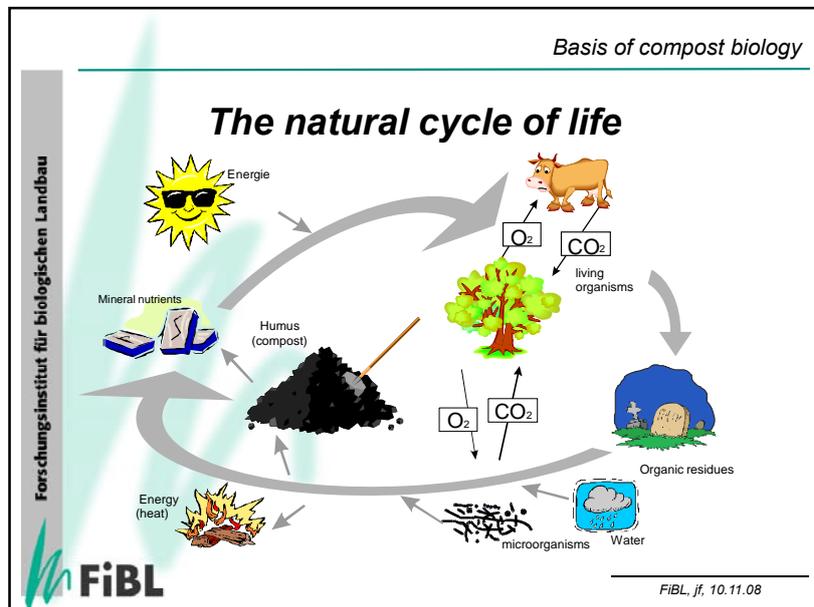
Basis of compost biology

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What means composting ?

The term „composting“ describes a natural process, in which microorganisms transform organic residues in stabilized products.

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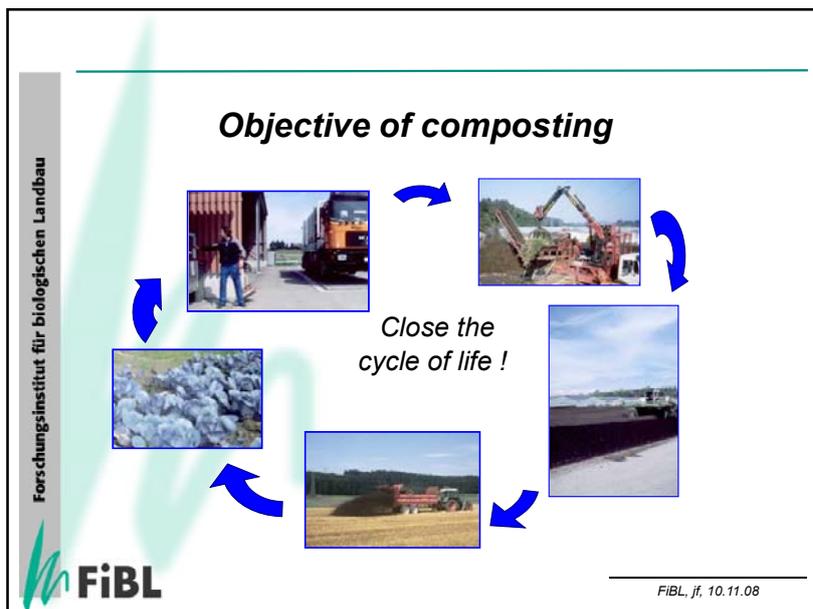
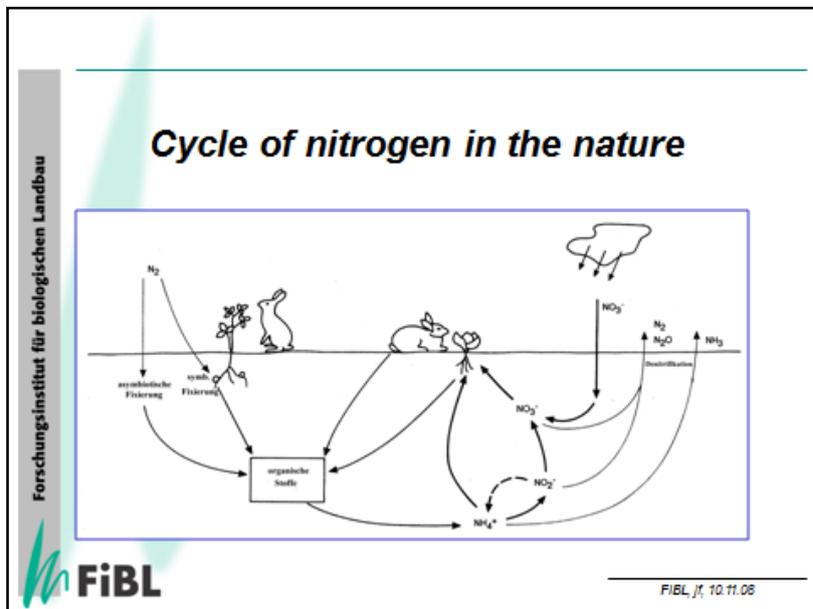
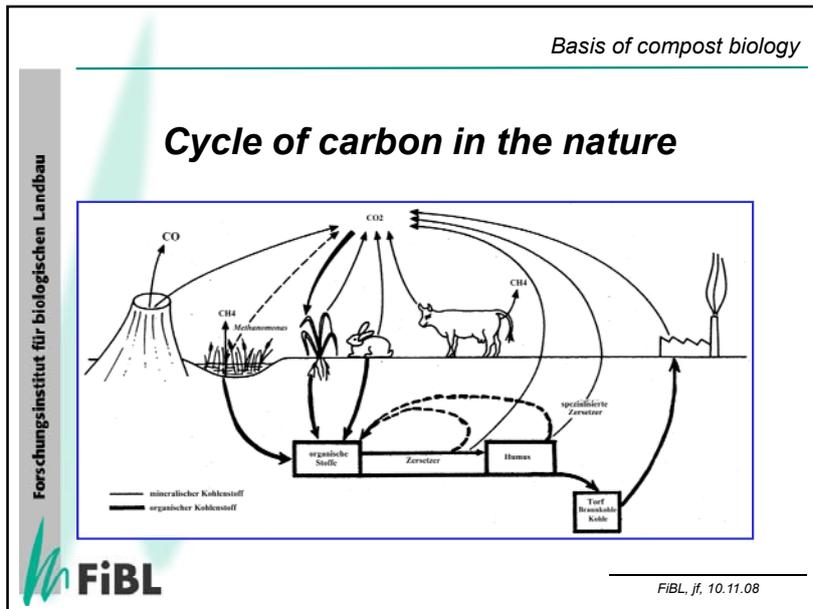
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In this cycle of life you have two elements, which are extremely important:

- Carbon
(source of energy)
- Nitrogen
(protein component)

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What can you compost ?

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What can you compost?

Theoretically all organic residues.

However, not each one is easy to handle, biodegradable, and free from toxics and pathogenic germs.

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Which product results after a professional composting?

a homogenous, microbiological active product, which is free from undesirable components:

compost !

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Ways of degradation for organic material:



anaerobic



aerobic

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Aerobic composting: how does it work ?

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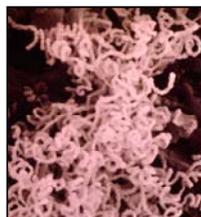
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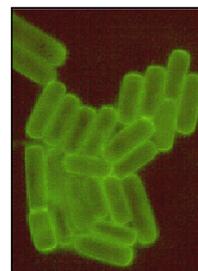
The microorganisms of composting



⇒ *Mushrooms*



⇒ *Actinomycetes*



⇒ *Bacteria*

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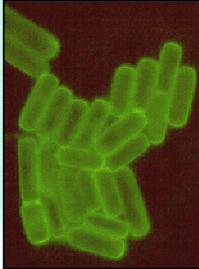


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The microorganisms of composting

1: Bacteria



- ⇒ aerobic / anaerobic
- ⇒ very active at the beginning of the process
- ⇒ responsible for the hot phase
- ⇒ can not abolish wood efficiently

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The microorganisms of composting

2: Mashrooms



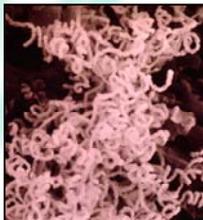
- ⇒ aerobic
- ⇒ abolish wood
- ⇒ creation of stabilized crumbs
- ⇒ important during maturity stage

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The microorganisms of composting

**3: Actinomycetes
(ray fungus)**



- ⇒ can abolish substances, which can not be abolish with bacteria or mashrooms, for example chitin
- ⇒ responsible for decomposition of difficult decomposable materials

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Aerobic composting: Rotting process

⇒ process of decomposition

- intensive microbiological activity
- increasing in temperature
- extreme loss in volume
- naturally hygienisation

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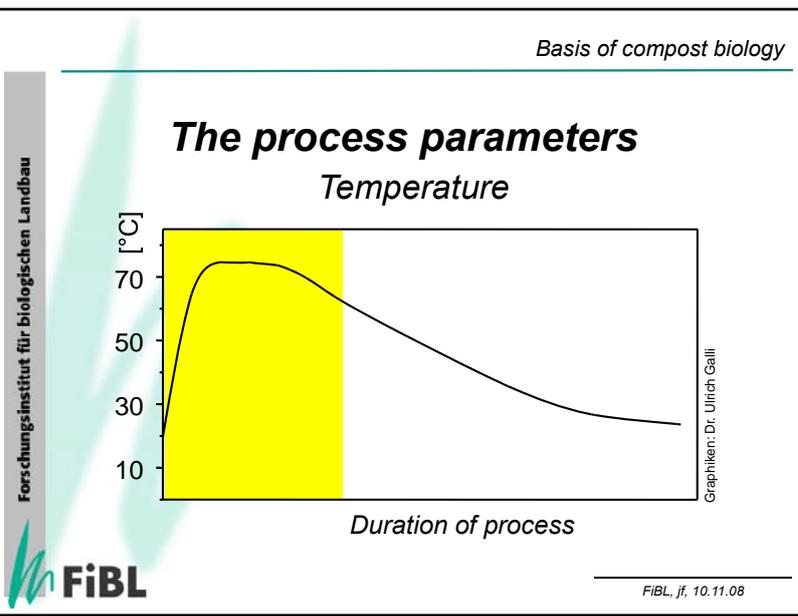
Aerobic composting: Rotting process

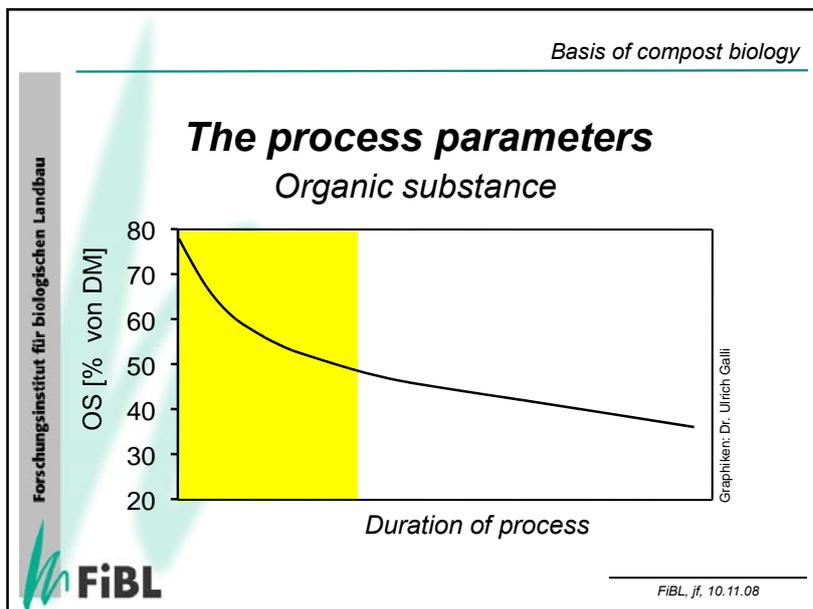
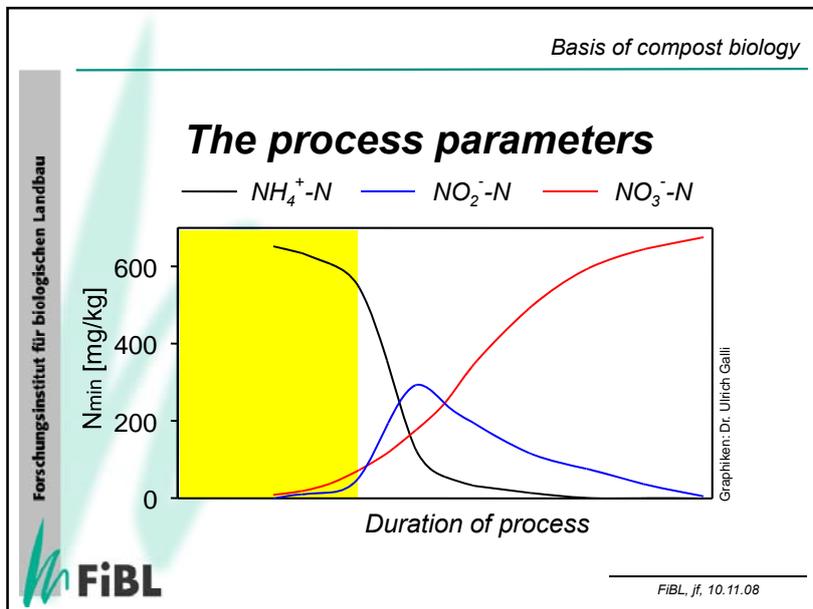
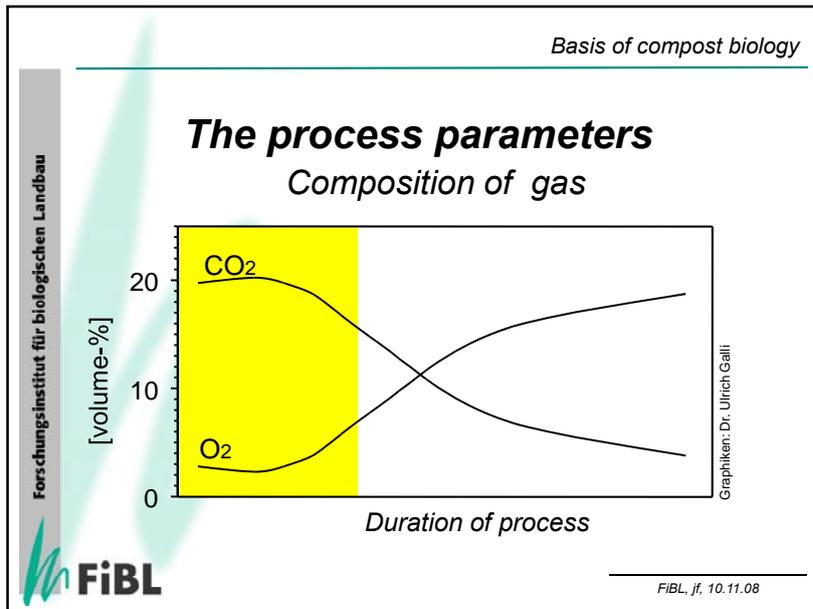
⇒ process of decomposition

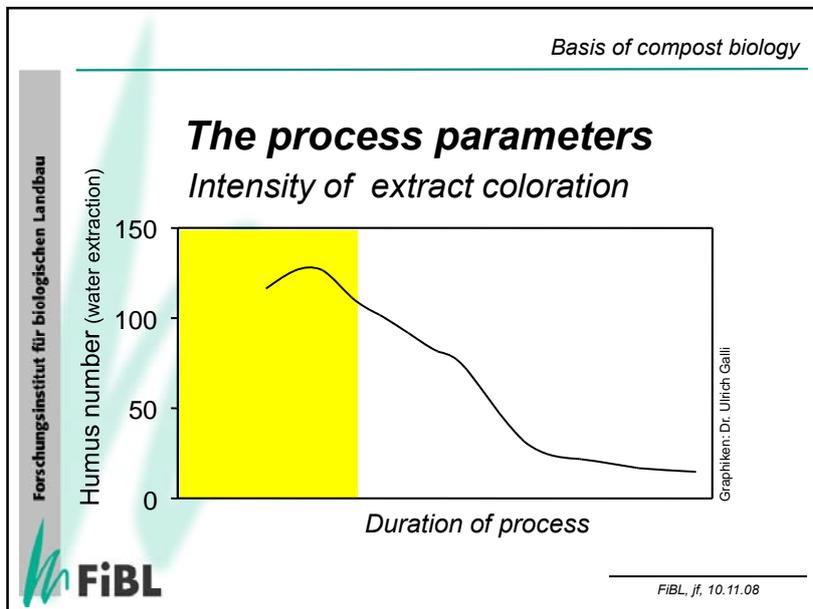
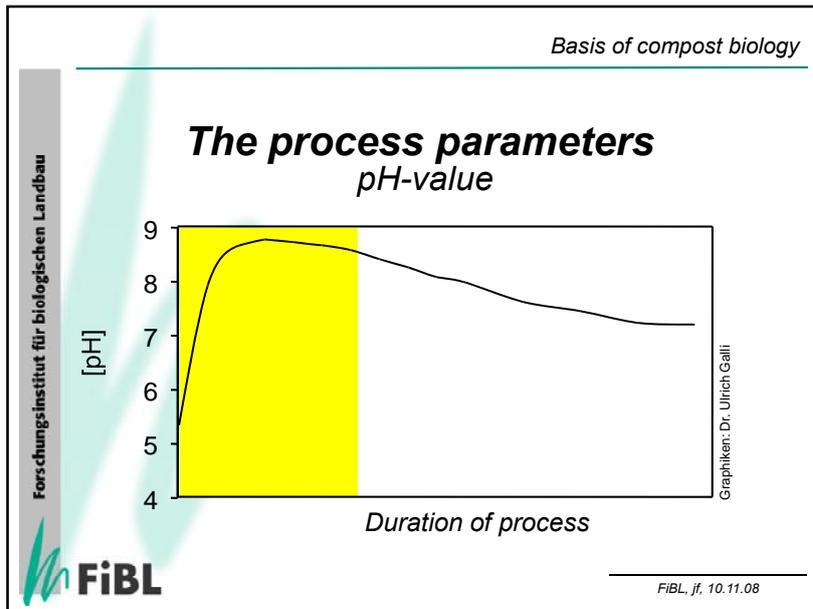
⇒ maturity stage

- creation of stable humus
- development of positive characteristics of compost

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Basis of compost biology

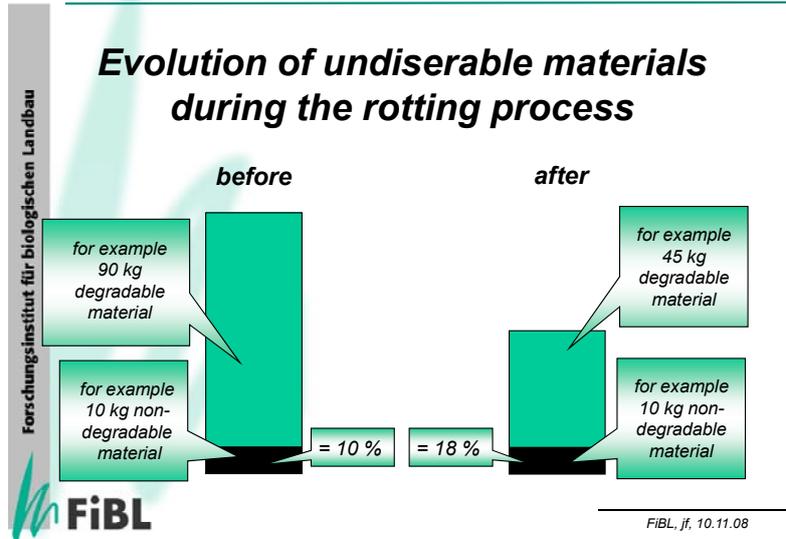
Evolution of undiserable materials
during the rotting process

⇒ **heavy metals**

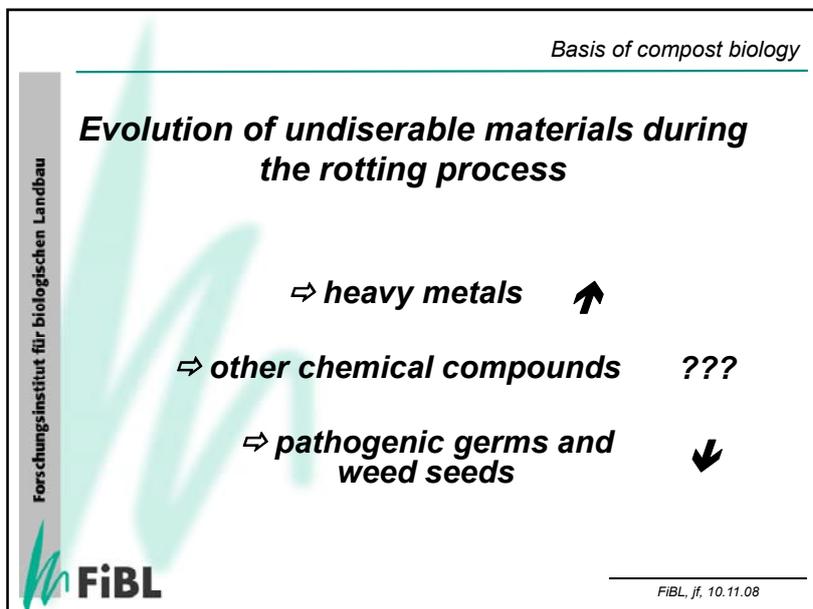
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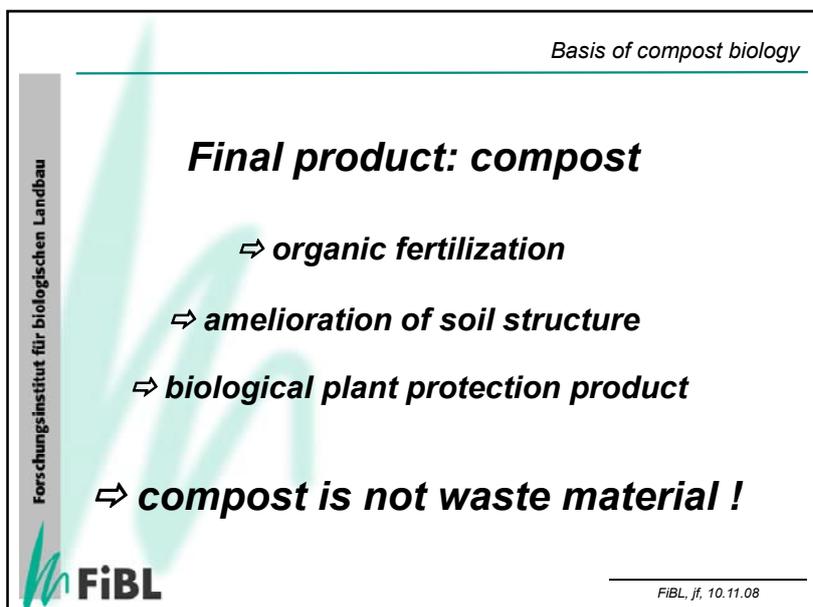
Basis of compost biology



Basis of compost biology



Basis of compost biology



Basis of compost biology

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Final product: compost

- ⇒ *organic fertilization*
- ⇒ *amelioration of soil structure*
- ⇒ *biological plant protection product*
- ⇒ **compost is not waste material !**

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Soil fertility and plant health

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**Influence of compost
regarding fertility of
the soil and plant
health**

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Soil fertility and plant health

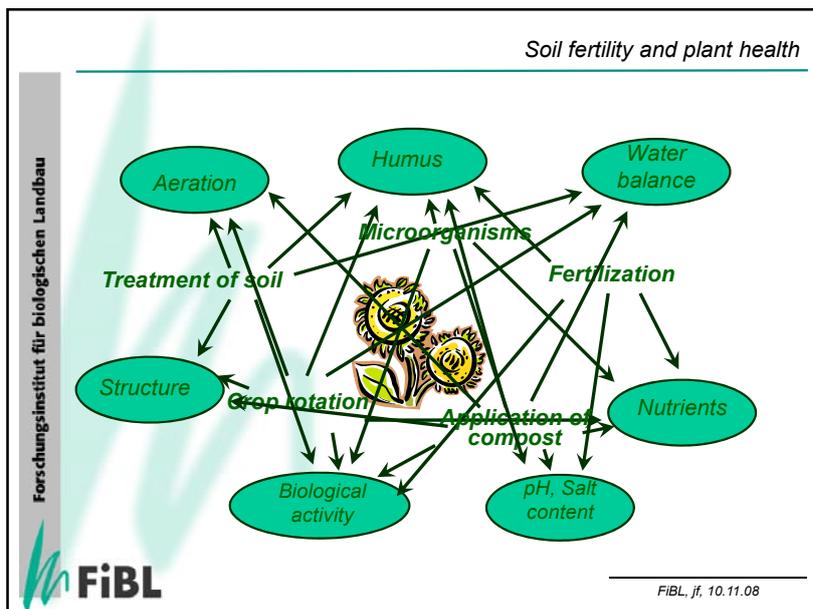
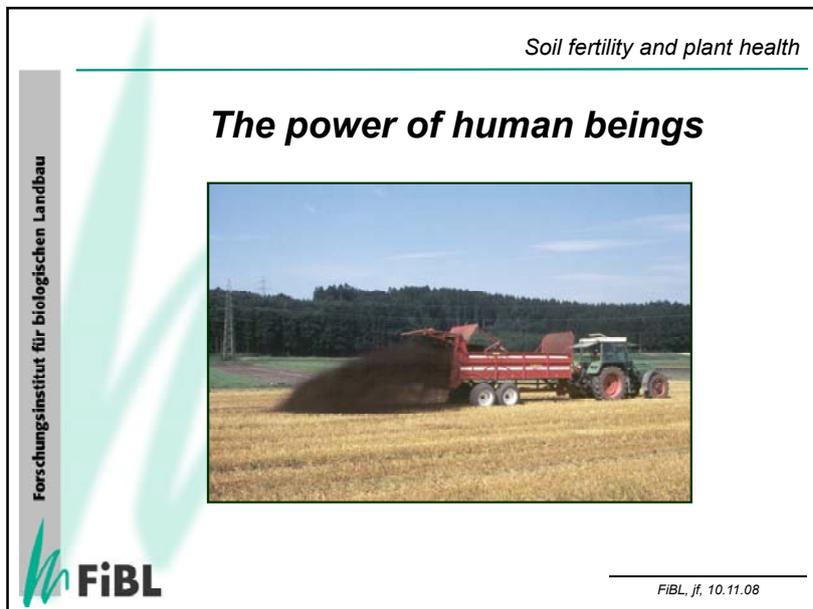
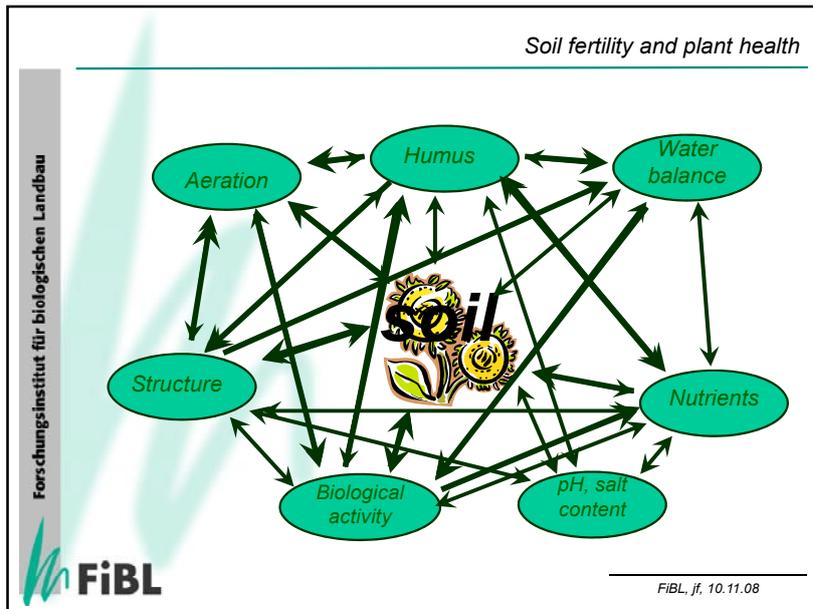
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**Soil factors, which influence plant
health**



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Effects of compost on the soil

- ♻️ Macro- und micro-nutrients
- ♻️ Organic matter

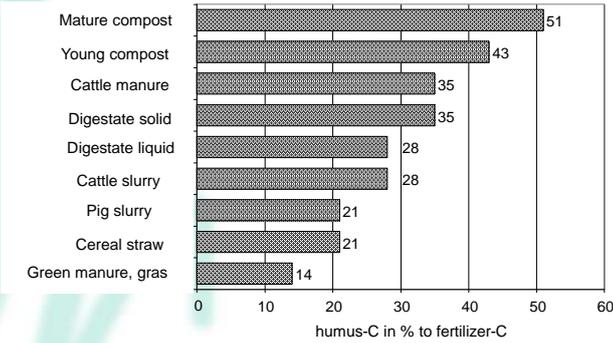
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Reproduction potential of humus



Fertilizer	humus-C in % to fertilizer-C
Mature compost	51
Young compost	43
Cattle manure	35
Digestate solid	35
Digestate liquid	28
Cattle slurry	28
Pig slurry	21
Cereal straw	21
Green manure, gras	14

Effectiveness of humus reproduction for organic carbon of different organic fertilizations (according to Reinhold 2006)

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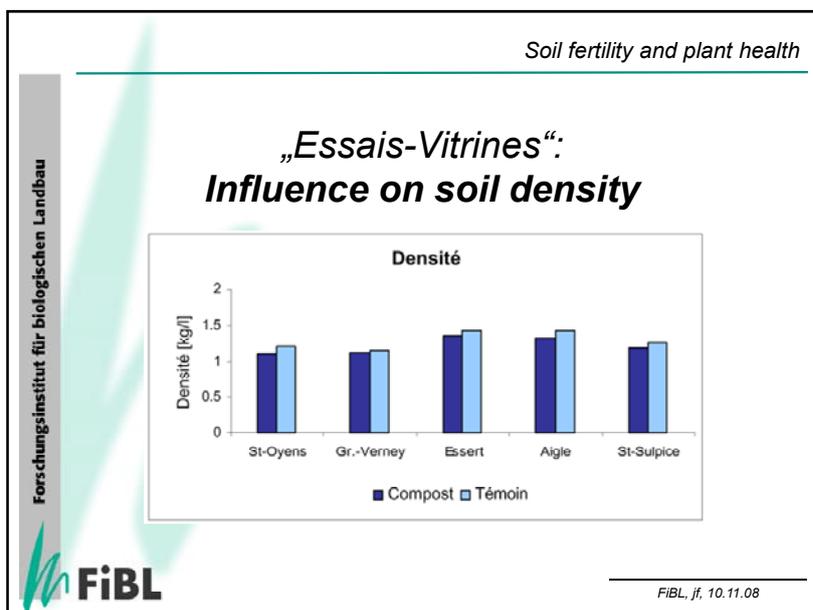
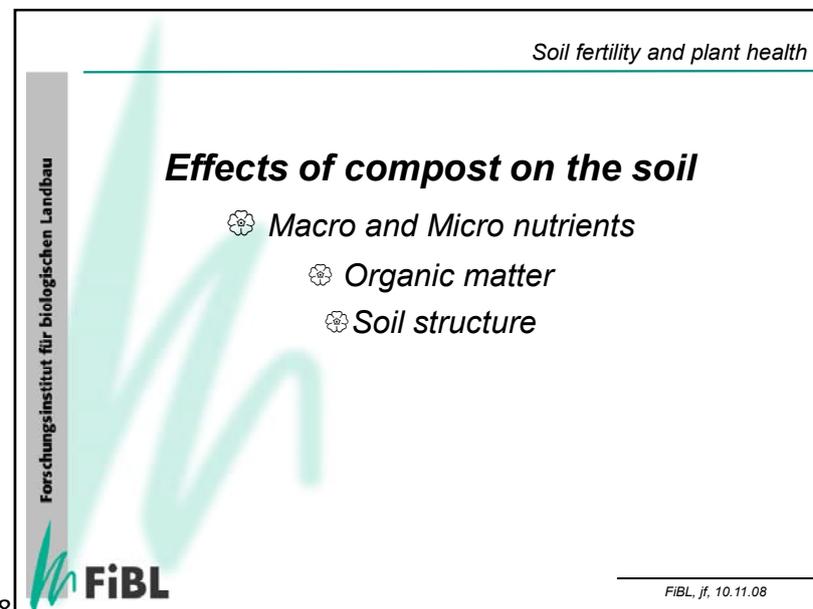
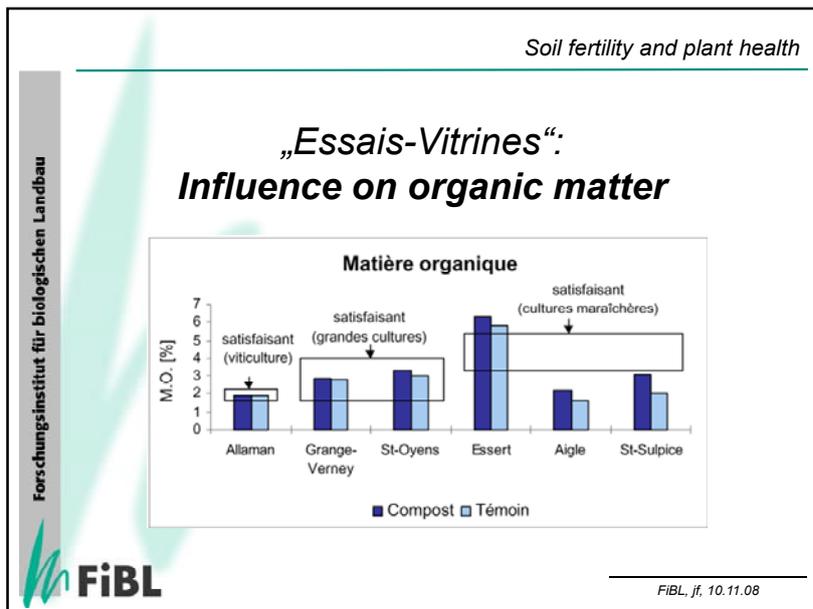
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Effectiveness of compost on soil-OM

Literature	Test duration	Compost quantity	Effect on OM-content of the soil [in % of control]
Aichberger and al., 2000	9 years	15-40 t FS / ha	+12%
Bragato and al., 1998	5 years	7,5-15 t FS / ha	+ 21 %
Jenkinson and al., 1987	140 years	Mist: 35 t /ha and year	+ 176 %
Kjellenberg and Granstedt, 2005	33 years	4 t FS / ha and year	+ 8 bis + 25 %
Compost Diffusion, 1999	7 years	40-100 m ³ / year	+10 % to 37 %

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Effects on soil structure

• **z.B. Compost Diffusion, 1999: soil density: - 6%**

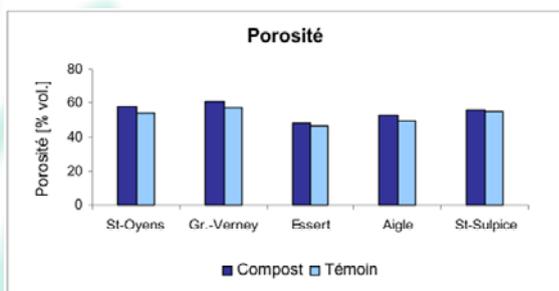
- Soil treatment: easier and economy of diesel
 (observations from FiBL in a test of appliance of compost in fruit growing confirmed this fact)

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„Essais-Vitrines“: Influence on porosity



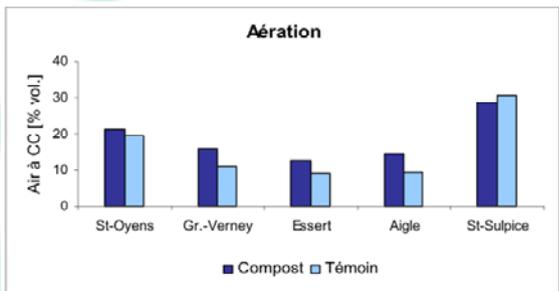
Location	Compost	Témoin
St-Oyens	58	52
Gr.-Verney	60	55
Essert	48	45
Aigle	52	48
St-Sulpice	55	52

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„Essais-Vitrines“: Influence on aeration



Location	Compost	Témoin
St-Oyens	22	18
Gr.-Verney	15	10
Essert	12	8
Aigle	14	9
St-Sulpice	28	30

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Effects of compost on the soil

- ☼ Macro- and micro-nutrients
- ☼ Organic matter
- ☼ Soil structure
- ☼ Water balance

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„Essais-Vitrines“: Influence on water capacity

Réserve d'eau

Location	Compost (RFU [% vol.])	Témoin (RFU [% vol.])
St-Oyens	~8	~6
Gr.-Verney	~7	~6
Essert	~7	~6
Aigle	~14	~12
St-Sulpice	~6	~5

■ Compost □ Témoin

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Effects on water capacity

- **Compost Diffusion, 1999: + 8%**
- **Eyras and al., 1998: +20 bis +25%**
- **Gagnon and al., 1998: +3 bis +5%**
- **Shiralipour and al., 1996: + 3% bis +16%**

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Effects of compost on the soil

- ☼ Macro- und micro-nutrients
 - ☼ Organic matter
 - ☼ Soil structure
 - ☼ Water balance
 - ☼ Erosion protection

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Effects on erosion

- **Diminution of wind-erosion**
 - Hartmann, 2002: -30 to -50%
 - De Vos, 1996: same erosion with 4 Beaufort without compost and 6-7 Beaufort with compost
- **Diminution of water-erosion**
 - Ojeda and al., 2003: -50%
 - Bazzoffi and al., 1998: -10 to -50%

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Effects of compost on the soil

- ☼ Macro- und micro-nutrients
 - ☼ Organic matter
 - ☼ Soil structure
 - ☼ Water balance
 - ☼ Soil protection
- ☼ Influence on soil microflora

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**„Essais-Vitrines“:
Influence on plant diseases**

- ☼ Mildew on radish ↓
- ☼ *Alternaria* on tomatoes ↓
- ☼ Root rot on salad ↓
- ☼ Grey mould on vine ↑ ?

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7. Compost / digestate and plant health

Literature	type of compost	Compost quantity	effects
Boulter and al., 2002	mature compost from dung and bark	5 or 10 tons per hectar	grass / <i>Fusarium nivale</i> & <i>Typhula ishikariensis</i> : same effect as Quintozene)
LaMondia and al., 1999	mashroom-compost	15 tons/hectar	potatoes / <i>Verticillium dahliae</i> & <i>Pratylenchus penetrans</i> : + 60% to +138% saleable potatoes
Carrera and al., 2007	dung-/ leaves compost	5, 10 and 20 Tons / Hectar	tomatoes / deseases on leaves: +30% to +60% surplus
Schulte-Geldermann and al., 2008	mature compost	5 t TS/ha	potatoes/ <i>Rhizoctonia solani</i> : +13 to + 40% more salable potatoes
Compost Diffusion, 1999	green compost	40-100 m ³ / year	different plants / deseases: diminution of deseases, except <i>Botrytis</i> on vines.

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Compost and plant health



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Compost and plant health



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How does compost influence plant health?

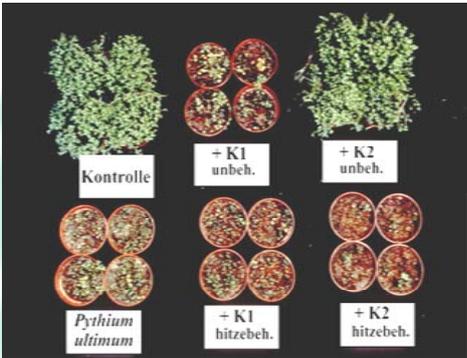
- ♻️
Indirect influence
 - macro- and micro nutrients
 - stabilized organic substance (humus)
 - amelioration of soil structure
 - amelioration of water balance
- ♻️
Direct influence
 - compost microflora influences soil microflora

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Compost ≠ compost



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Potencial of high-graded compost relizable in praxis

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1. Compost in culture substrates



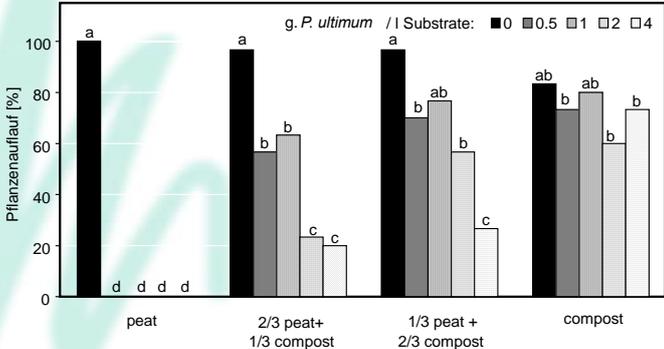
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1. Compost in culture substrates

g. *P. ultimum* // Substrate: ■ 0 ■ 0.5 ■ 1 ■ 2 ■ 4



Substrate	0	0.5	1	2	4
peat	100 (a)	0 (d)	0 (d)	0 (d)	0 (d)
2/3 peat+ 1/3 compost	100 (a)	60 (b)	65 (b)	25 (c)	20 (c)
1/3 peat + 2/3 compost	100 (a)	70 (b)	80 (ab)	60 (b)	30 (c)
compost	85 (ab)	75 (b)	80 (ab)	60 (b)	75 (b)

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1. Compost in culture substrates

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1. Compost in culture substrates

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1. Compost in culture substrates

- ☼ *Micro-biological buffering*
- ☼ *Diminution of a germ invasion*
- ☼ *Reduction of disease intensity*
- ☼ *Protection of seedling production*

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2. Compost after soil steaming



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2. Compost after soil steaming



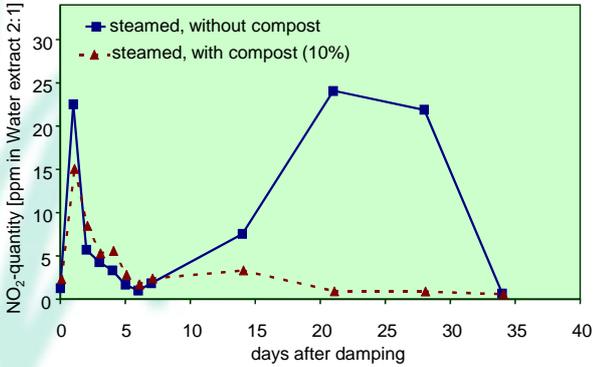
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2. Compost after soil steaming



Days after damping	steamed, without compost	steamed, with compost (10%)
0	0	0
1	23	15
2	6	5
3	2	3
4	1	2
5	2	3
14	8	4
21	24	3
28	22	2
35	1	1

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2. Compost after soil steaming



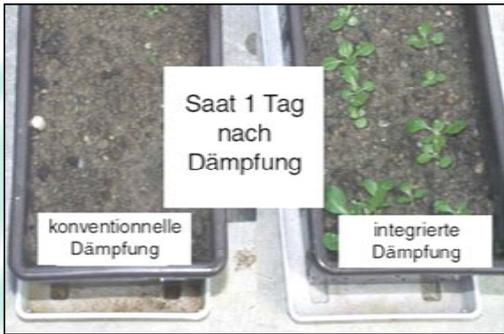
Pflanzung 1 Tag nach Dämpfung

u: Boden ungedämpft iD: nach integrierter Dämpfung
kD: nach konventioneller Dämpfung

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2. Compost after soil steaming



Saat 1 Tag nach Dämpfung

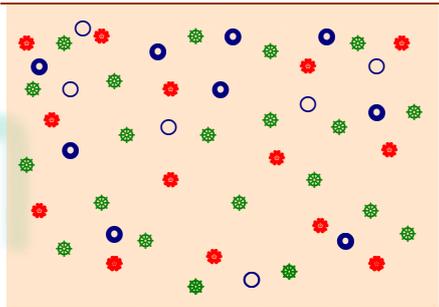
konventionelle Dämpfung integrierte Dämpfung

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2. Compost after soil steaming

Before steaming



* : germs
* : useful micro-organism
* : viable weed seed
○ : nonviable weed seed

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2. Compost after soil steaming

Soil after steaming

Legend:
● : germs
● : useful micro organism
● : viable weed seed
○ : nonviable weed seed

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2. Compost after soil steaming

Soil after steaming

Legend:
● : germs
● : useful micro organism
● : viable weed seed
○ : nonviable weed seed

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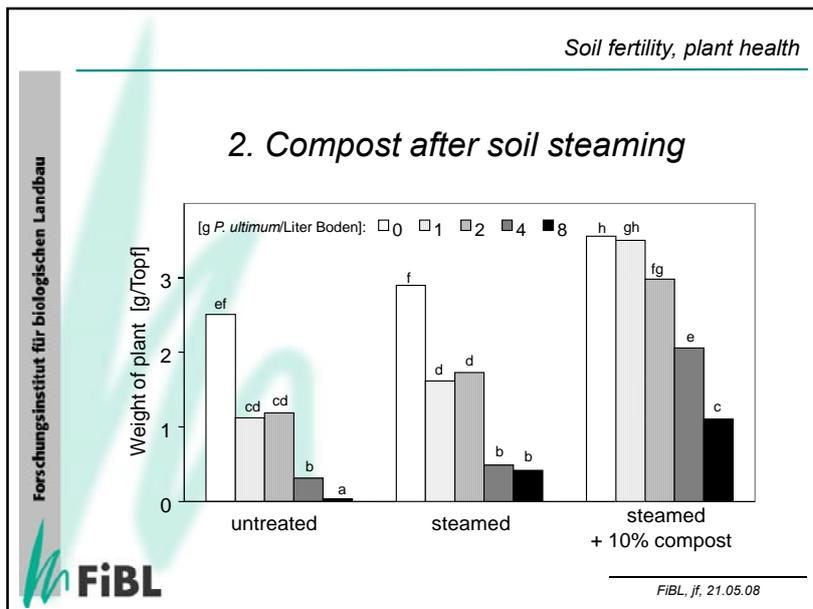
2. Compost after soil steaming

Soil after steaming + compost

Legend:
● : germs
● : useful micro organism
● : viable weed seed
○ : nonviable weed seed

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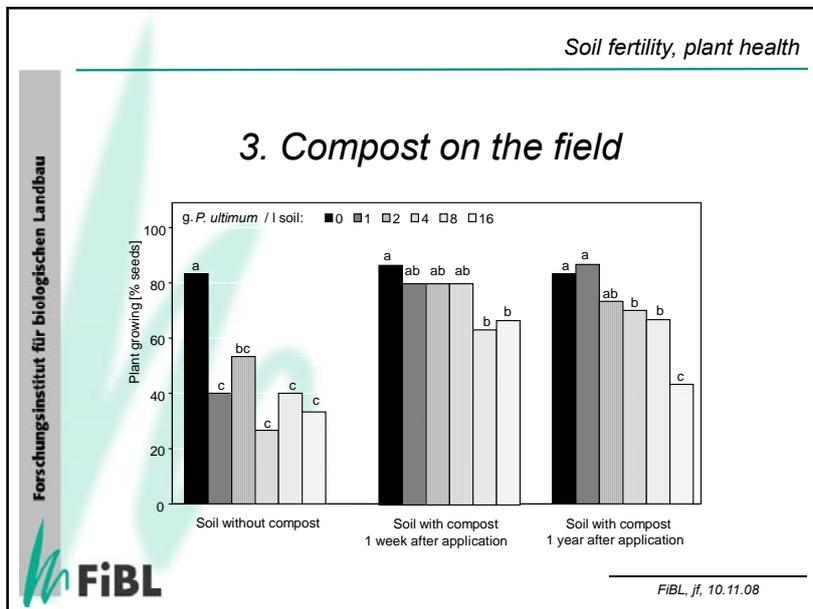
- Soil fertility, plant health
- ### 2. Compost after soil steaming
- ⊗ Soil detoxification
 - ⊗ Earlier plantation is possible
 - ⊗ Prevent soil from recolonisation with pathogens
 - ⊗ Longer steaming efficiency
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3. Compost on the field

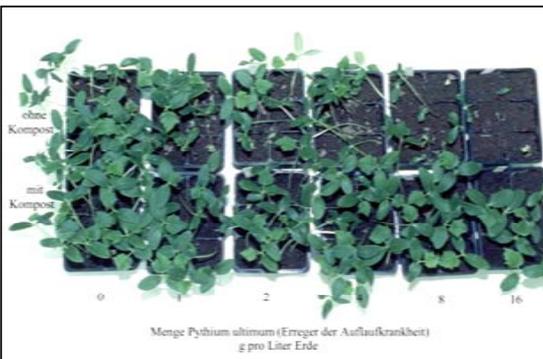


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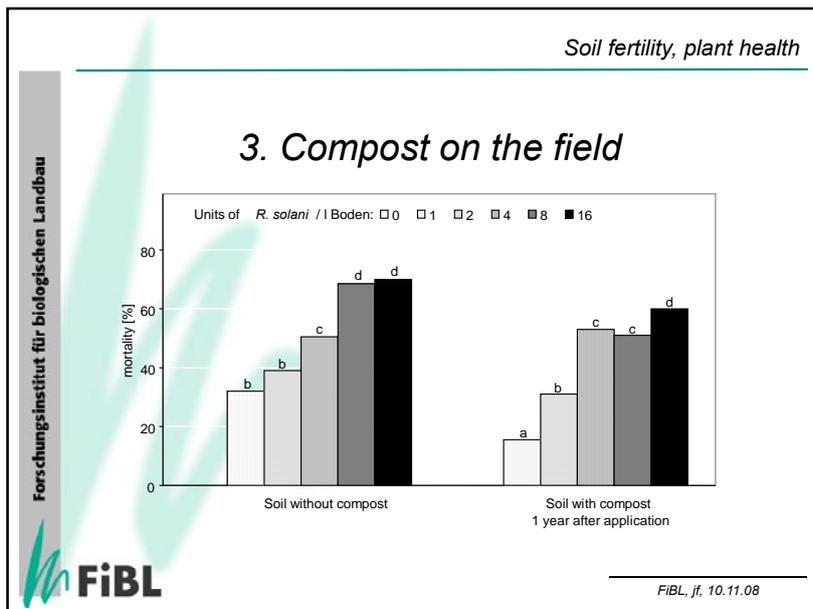
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3. Compost on the field



Menge *Pythium ultimum* (Erreger der Auflaufkrankheit)
g pro Liter Erde

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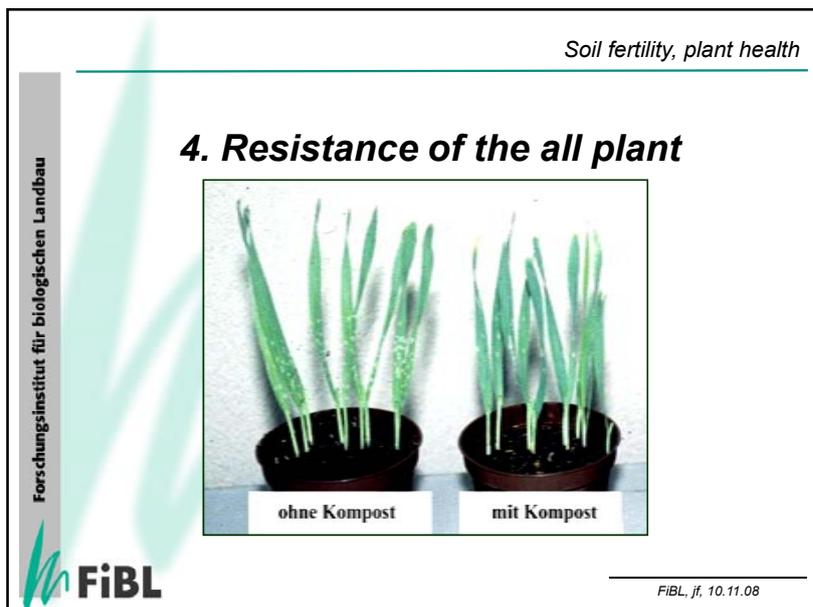
Soil fertility, plant health

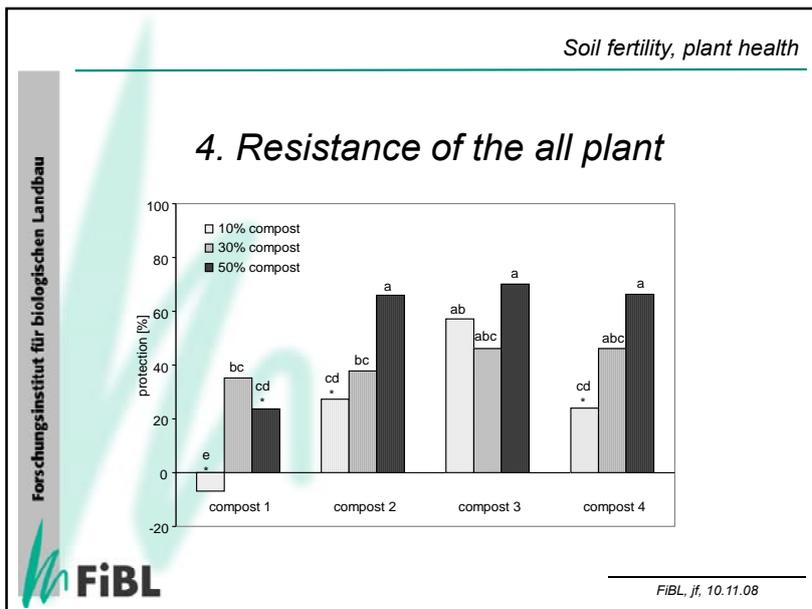
3. Compost on the field

♻️ *Diminution of plant diseases*

♻️ *The more intensive the soil utilization, the more clear is the positive effect of compost*

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Soil fertility, plant health

**High- graded compost:
An absolutely
high-graded fungicide !**

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Quality management, process management

Biology and quality management

*Quality management of the product,
and consequently of its sales*

**From collecting of green waste
to utilization of the final
product**

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Quality management, process management

Compost quality and its assurance

- ☼ Compost ≠ compost
- ☼ The adequate quality for the suitable utilization
- ☼ Compost production is not a random generator

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Quality management, process management

Factors of quality management

- ☼ Concept of green manure collection
 - ☼ Mixture of raw materials
 - ☼ Composting system
 - ☼ Process management
 - ☼ Storage of end-material

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Quality management, process management

Concept of green manure collection



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Quality management, process management

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Mixture of raw materials

- ♻️ C:N-ratio („available“)
- ♻️ Structure, moisture

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Mixture of raw materials

- ♻️ C:N-relation („available“)
- ♻️ Structure, moisture

structure-rule of thumb

1/3 rough wood
1/3 medium-fine, fibrous material
1/3 material, nearly without structure

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Mixture of raw materials

shredded wood,
seaving rest material
from compost, snipped
bark

- ♻️ C:N-relation („available“)
- ♻️ Structure, moisture

structure-rule of thumb

1/3 rough wood
1/3 medium-fine, fibrous material
1/3 material, nearly without structure

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Mixture of raw materials

- ☼ C:N-relation
- ☼ Structure

shredded branches, wood fibres, straw, foilage, switch grass, reed, peat from consumed potting compost

Structure-rule of thumb
 1/3 rough wood
 1/3 medium-fine, fibrous material
 1/3 material, nearly without structure

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Mixture of raw materials

- ☼ dung, grass, rumen contents, vegetables manure („available“)
- ☼ manure

Structure-rule of thumb
 1/3 rough wood
 1/3 medium-fine, fibrous material
 1/3 material, nearly without structure

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Mixture of raw materials

- ☼ C:N-relation („available“)
- ☼ Structure, moisture
- ☼ Utilization of additives

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powdered clay
earth
enzymes
microorganisms
fertilizer
etc.



- ♻️ Structure and moisture
- ♻️ Utilization of additives

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Composting system



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Composting system

*You can produce good
compost with a lot of systems,
but you can produce bad
compost with all systems*

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Process management

⇒ **Control processes**

⇒ **If necessary, take actions**

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Process management

1. *Composition of the initial mixture*



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Process management

2. *Regulation of water content*



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Process management

3. Regulation of aeration




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Process management

4. Compost turning




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Quality management, process management

Process management

5. Utilisation of additives



⇒ Fertilizer

⇒ Enzymes and microorganisms

⇒ Earh, clay, rock meal

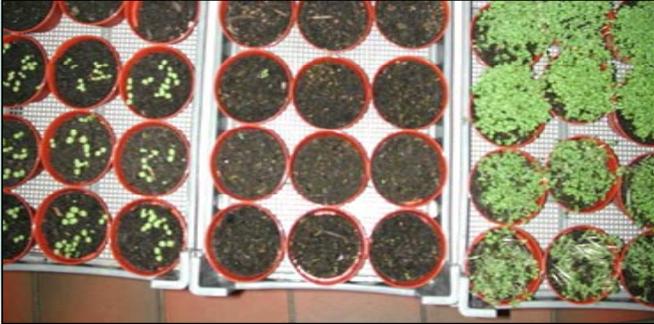
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Quality management, Rotteführung

**Problem:
inadequate process management**



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Quality management, process management

Storage

Professional storage with assured oxygen transfer



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Quality management, process management

Problem: inaccurate storage



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Quality management, process management

Evaluation of compost quality



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Quality management, process management

Evaluation of compost quality

1. With own senses

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Quality management, process management

Evaluation of compost quality



Fist test

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Quality management, process management

Evaluation of compost quality



Smelling test

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This slide illustrates a 'Smelling test' for compost quality. It features a photograph of two men, one with a white beard, examining a small amount of compost held in a hand. The text 'Smelling test' is overlaid on the image. The slide includes the FiBL logo and the text 'Forschungsinstitut für biologischen Landbau' on the left side.

Quality management, process management

Evaluation of compost quality



Degree of degradation, structure, compost granularity

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This slide illustrates the 'Degree of degradation, structure, compost granularity' test. It features a photograph of a pile of dark brown compost with a red tool (likely a soil probe) inserted into it. The text 'Degree of degradation, structure, compost granularity' is overlaid on the image. The slide includes the FiBL logo and the text 'Forschungsinstitut für biologischen Landbau' on the left side.

Quality management, process management

Evaluation of compost quality



Contaminant in compost

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This slide illustrates the 'Contaminant in compost' test. It features a photograph of a pile of compost with a white plastic bag visible, indicating a contaminant. The text 'Contaminant in compost' is overlaid on the image. The slide includes the FiBL logo and the text 'Forschungsinstitut für biologischen Landbau' on the left side.

Quality management, process management

Evaluation of compost quality



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Quality management, process management

Evaluation of compost quality

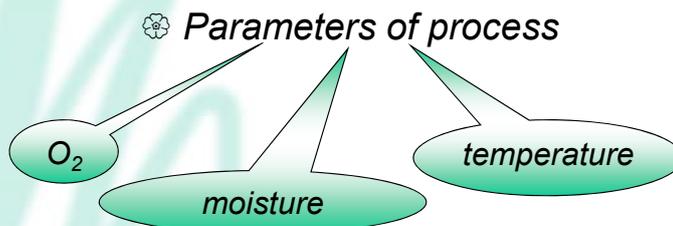
2. With simple analysis

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Quality management, process management

Evaluation of compost quality



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Quality management, process management

Evaluation of compost quality

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The diagram features a central text 'Parameters of process' and 'Chemicals and physicals analysis' with a recycling symbol. Surrounding this are five callout bubbles: 'pH', 'Salt content', 'NO₂, NO₃, NH₄', 'DM, OM', and 'Sulfide'. The FiBL logo is at the bottom left.

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Quality management, process management

Evaluation of compost quality

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The diagram features a central text 'Parameters of process' and 'Chemicals and physicals analysis' with a recycling symbol. Surrounding this are two callout bubbles: 'Phytotoxicity tests' and 'Disease suppressivity tests'. The FiBL logo is at the bottom left.

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Quality management, process management

Chemical analysis on the composting plant

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A photograph showing a person in a white lab coat working in a laboratory. The person is using a pipette to transfer liquid into a multi-well plate. Various pieces of laboratory equipment, including a blue pipette dispenser, glass beakers, and a scale, are visible on the lab bench.

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Chemical analysis on the composting plant

- ☼ *Simple laboratory needed*
- ☼ *Analysis of parameters, which are important for the user*
- ☼ *Formation necessary, to be able to execute and interpret the analysis*

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Quality management, process management

Phytotoxicity tests



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Quality management, process management

Phytotoxicity tests

- ☼ *Plants react on global compost quality*
- ☼ *Persons who execute tests with their compost will obtain another relation to the products*
- ☼ *Public relations*

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Quality management, process management

Phytotoxicity tests

- ☼ Different plants react in various ways on the compost quality

salad, beans, cress closed, cress opened, raygras

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Quality management, process management

Phytotoxicity tests

- ☼ Different plants react in various ways on the compost quality

size of the pot, quantity of seeds, reference substrate, compost, seeds quality

- ☼ Apply standardized biotests

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Quality management, process management

Phytotoxicity tests

- ☼ Different plants react in various ways on the compost quality
- ☼ Apply standardized biotests
- ☼ Execute the tests in a professional way

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Quality management, process management

Results have to be comparable

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Biotests: results are not always foreseeable

pH: 7.6
Redox: 23.7
Salz: 4.2
NH₄⁺: 384
NO₂⁻: 0
NO₃⁻: 0



pH: 8.0
Redox: 23.7
Salz: 5.1
NH₄⁺: 100.3
NO₂⁻: 0
NO₃⁻: 0

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Disease suppressivity tests



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Biotests: quality insurance for superior appliance



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Basis of compost application

Compost:

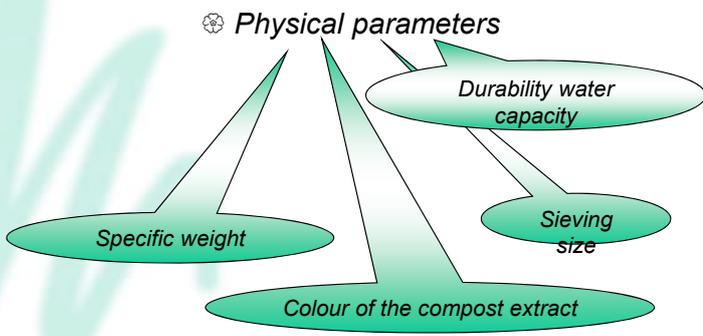
Use the right thing at the right place

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Basis of compost application

Characteristics of compost

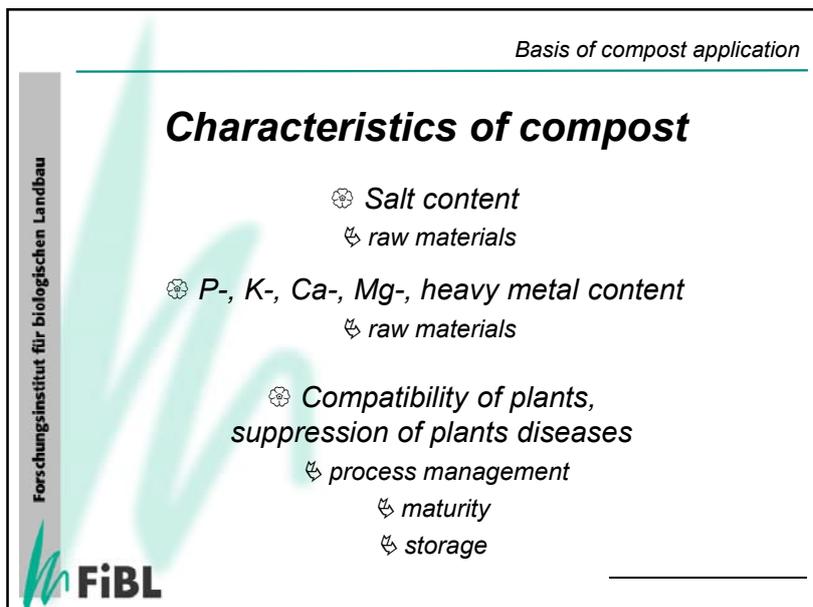
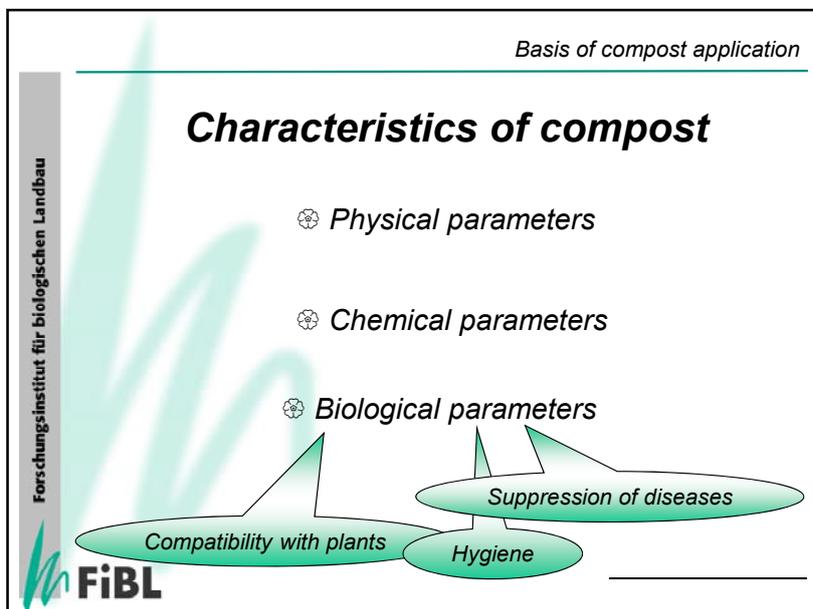
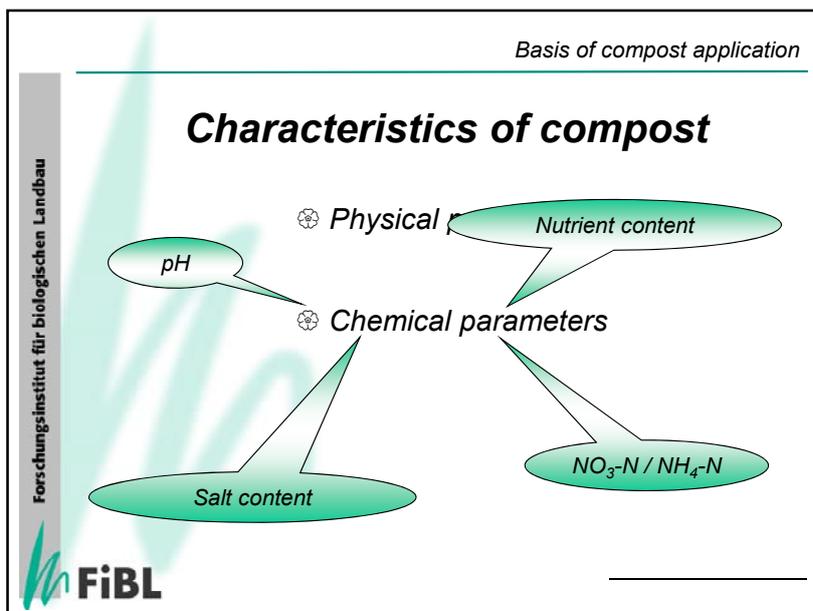


Physical parameters

- Specific weight
- Durability water capacity
- Sieving size
- Colour of the compost extract

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Basis of compost application

Chemical characteristics of compost
(BAFU-compost project 2002-2007; Median (minimum; maximum))

pH	8,1 (7,5; 8,7)
Salt [mS/cm]	2,5 (0,9; 6,6)
P₂O₅ [kg/t DM]	6,9 (3,0; 20,2)
K₂O [kg/t DM]	13,3 (2,6; 33,6)
Ca [kg/t DM]	58,6 (23,0; 91,5)
Mg[kg/t DM]	6,4 (3,6; 13,3)
N-total [kg/t DM]	14,8 (8,5; 26,0)
NO₃-N [g/t DM]	60,8 (0,0; 2338,4)
NH₄-N [g/t DM]	153,0 (0,0; 3424,0)
NO₃-N / NH₄-N	0,3 (0,0; 500,0)

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Basis of compost application

What means quality ?

- ☼ „Quality is fitness for use“ (ISO)
- ☼ Quality is always customer oriented
- ☼ Definition of Quality standards
- ☼ Control systems for quality standards
- ☼ Declaration on the products

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Basis of compost application

ASCP - quality guidelines 2001

- ☼ Compost / digestate for agriculture
- ☼ Compost for outdoor gardening
- ☼ Compost for plant cultivation and private gardener

(www.vks-asic.ch oder www.biophyt.ch)

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Basis of compost application

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Compost: limits of application (CH)

25 tons DM/ ha and 3 years

Balance of fertilisation

Recultivation: 75 tons DM / ha und 8 years



Basis of compost application

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Application of compost

To incorporate only superficially

Output in autumn, winter or spring (compost choice !)



Basis of compost application

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Application of compost



- ☼ **Technique**
- ☼ **Fertilization**
- ☼ **Irrigation**
- ☼ **Choice of compost**



Basis of compost application

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Choice of compost



- ☼ **Utilization**
- ☼ **Moment of utilization**
- ☼ **Methode of utilization**
- ☼ **Costs / gain**



Basis of compost application

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For example: Agriculture




*Young compost,
hygienic
undoubtedly,
microbiological
active, nutrient-
rich*



Basis of compost application

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For example: Recultivation




*Wooden compost
structure-rich,
hygienic
undoubtedly,
microbiological
active, improving
water balance of the
soil and protecting it
against erosion*



Basis of compost appliance

For example: viticulture

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*Wooden compost ,
rough filtered,
structure-rich,
microbiological
active, improving
water balance of
the soil and
protecting it against
erosion*

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Basis of compost application

For example: gardening

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*Mature compost,
with stabilized
structure, not too
much salt, medium
fine sieved, with
good regulation
potential of water
balance, no azote
immobilization*

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Basis of compost application

For example: vegetable gardening

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*Mature compost,
rich on nutrients,
with balanced
microbiological
activity and a high
suppressive
potential*

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Basis of compost application

For example: culture substrates



Mature compost with stabilized structure, low-salt, with neutral pH-value, fine sieved, with good durable water capacity, rich on available azote with stabilized balanced microbiological activity

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Compost:



Professionalität und Qualität

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www.fibl.org



www.biophyt.ch

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