FiBL
EXCELLENCE FOR SUSTAINABILITY

Research Institute of Organic Agriculture
Forschungsinstitut für biologischen Landbau
Institut de recherche de l'agriculture biologique

Quality management and compost use in order to improve plant growth and health.
Situation in Switzerland

Jacques Fuchs (jacques.fuchs@fibl.org)

Compost: quality management and use to improve plant growth and health

- Introduction
- Compost production and use in Switzerland
- Compost quality management: Swiss concept
- Benefits from utilization of compost
- Disease control with quality compost
- Compost quality management in practice
- Conclusions

Introduction

Introduction

- Biowaste compost production in Switzerland
  - Payment for taking over the green waste covers nearly the production costs (for minimal quality compost)
  - Costs for production of higher quality have to be covered with the sale of the compost
- Composting / biogas production / burning
  - Competition for input materials between composting and biogas production increases continuously
- Motivations for composting
  - Disposal of green waste ?
  - Soil fertility improvement ?

Introduction

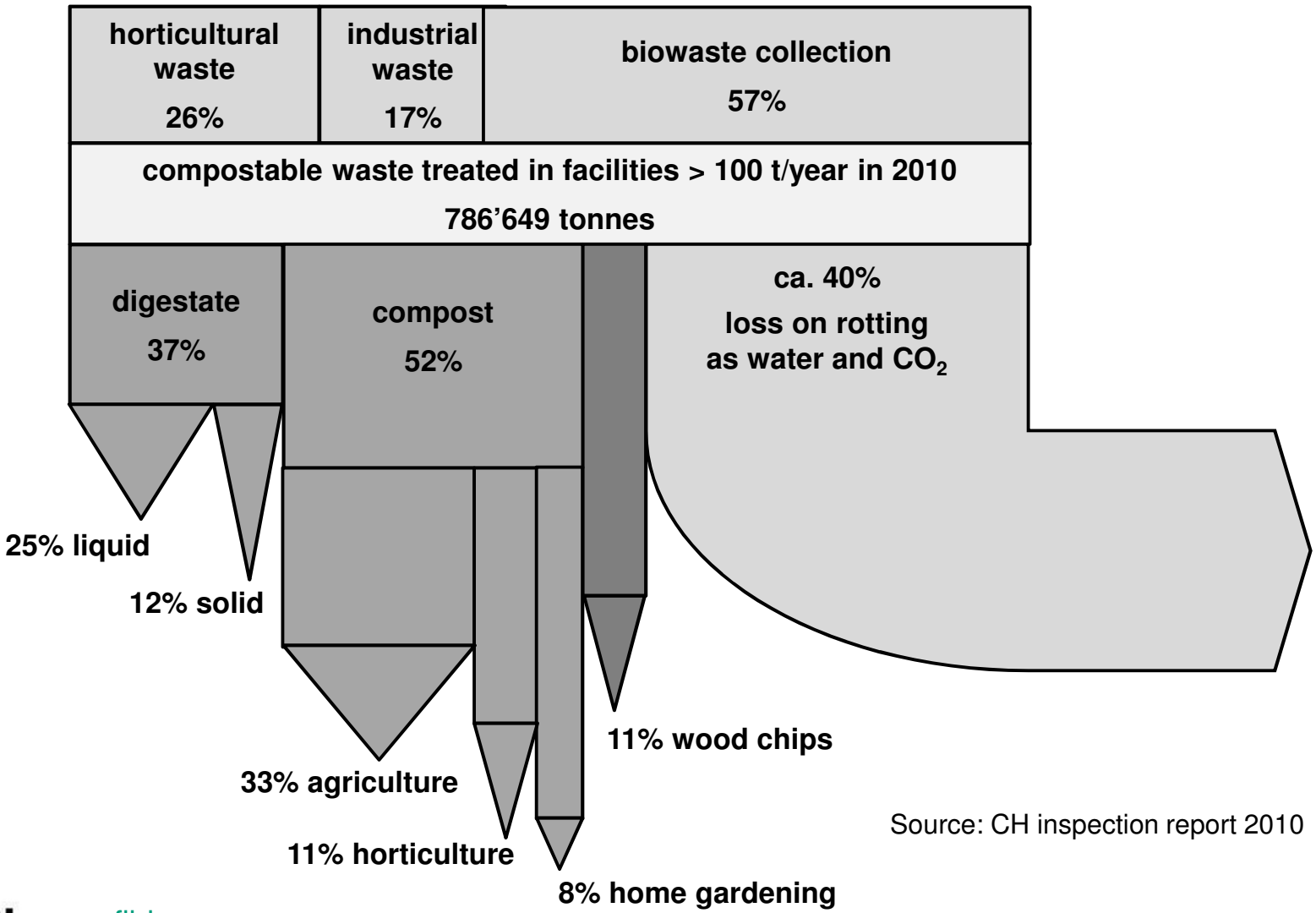
- **Compost user**
  - **Some users (among others horticultural producers) are convinced of the advantages of compost. They use compost to improve the fertility of their soils and to support the production of their plants.**
  - **Other users still consider compost as a waste product and are not willing to pay for it.**
  - **Compost producers have to work on the relationship with these users, to convince them of the positive effects of compost on soil and plants.**

Compost production and use in Switzerland

Compost production and use in Switzerland

- Each year, more than 100 kg of biowaste per inhabitant are collected (total: about 1’000’000 tons).
- About 1/3 of this material is treated by AD (anaerobic digestion), while 2/3 are composted. The proportion of AD has risen significantly in the past years.
- About 70% of the produced compost or digestate are used in agriculture.

Compost production and use in Switzerland



Source: CH inspection report 2010

Compost production and use in Switzerland

› Field edge composting (~6%)

Compost production and use in Switzerland

› Windrow composting (~43%)

Compost production and use in Switzerland

› Windrow composting (~43%)

Compost production and use in Switzerland

› Box composting (~7%)

Compost production and use in Switzerland

› Hall composting (~6%)

Compost production and use in Switzerland

› Anaerobic digestion (AD) (~32%)

Compost production and use in Switzerland

› Co-digestion (~6%)

Compost quality management: Swiss concept

Compost quality management: Swiss concept

- **Minimum quality requirements: Swiss Legislation**
  - FAC guidelines 1995
  - Heavy metals, impurities, hygienisation: ORRChim

Compost quality management: Swiss concept

› Swiss Legislation: heavy metals

Element	Limit [g/t DM]	Limit organic production [g/t DM]
lead (Pb)	120	45
cadmium (Cd)	1	0.7
copper (Cu)	100	70
nickel (Ni)	30	25
mercury (Hg)	1	0.4
zinc (Zn)	400	200
chrome		70
chrome VI		0

Compost quality management: Swiss concept

- **Swiss Legislation: hygienization**
  - **List of materials, which can be composted or treated by anaerobic digestion**
  - **Compost:**
    - 3 weeks with temperature > 55° C, or
    - 1 week with temperature > 65° C, or
    - other technique with proof of efficacy
  - **Digestate:**
    - 24 hours with temperature > 53° C, or
    - other technique with proof of efficacy (for example pasteurization prior to AD)
    - risk material (need permission to be treated): 20 min, by 133° C

Compost quality management: Swiss concept

- **Minimum quality requirements: Swiss Legislation**
  - FAC guidelines 1995
  - Heavy metals, impurities, hygienisation: ORRChim
  - **Objective: no negative impact on the environment**

- **Swiss compost and digestate guidelines 2010**
  - Voluntary standard of the compost trade
  - Objective: To avoid problems in relation to utilization of digestate and compost
  - **Support for choosing the appropriate product, depending on the utilization**

Compost quality management: Swiss concept

- **Swiss compost and digestate guidelines 2010**
  - Five product classes
    - Digestate liquid for agricultural use
    - Digestate solid for agricultural use
    - Compost for agricultural use
    - Compost for field horticulture
    - Compost for covered cultures

Compost quality management: Swiss concept

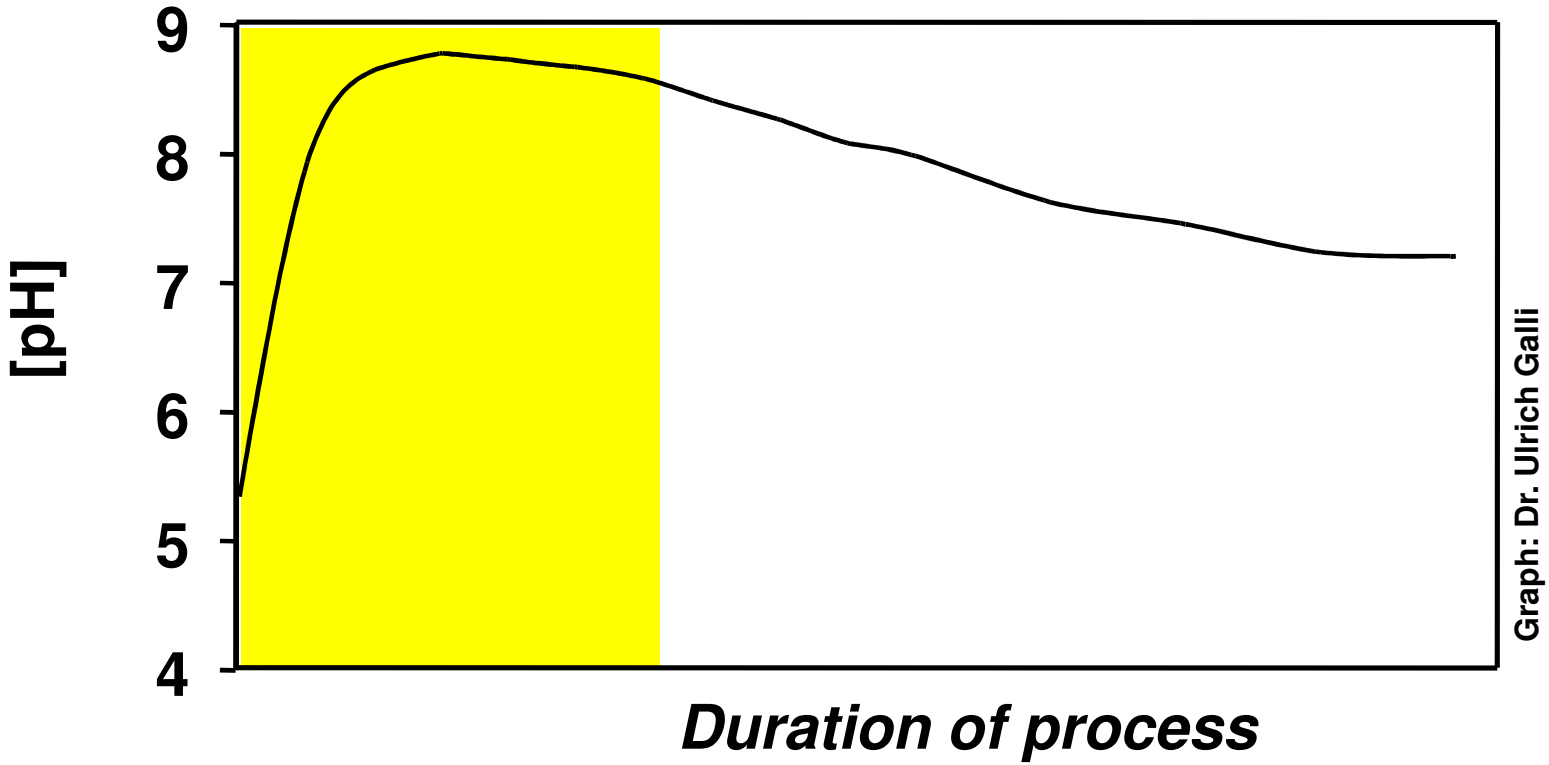
› Swiss compost and digestate guidelines 2010

Criteria	Composts and digestates for agricultural use			Compost for horticultural use	
	Digestate liquid	Digestate solid	Compost	Compost for field horticulture	Compost for covered cultures
DM (dry matter) [% FM]	X	X	X	*> 50 %*	*> 55 %*
OM (organic matter) [% DM]	X	X	X	*< 50 %*	*< 40 %*
pH	X	X	X	**< 7.8**	**< 7.5**

Minimal requirements; *recommendation*; X: has to be mentioned; (X): mention recommended

Compost quality management: Swiss concept

› **Evolution of pH during composting process**



Compost quality management: Swiss concept

› Swiss compost and digestate guidelines 2010

Criteria	Composts and digestates for agricultural use			Compost for horticultural use	
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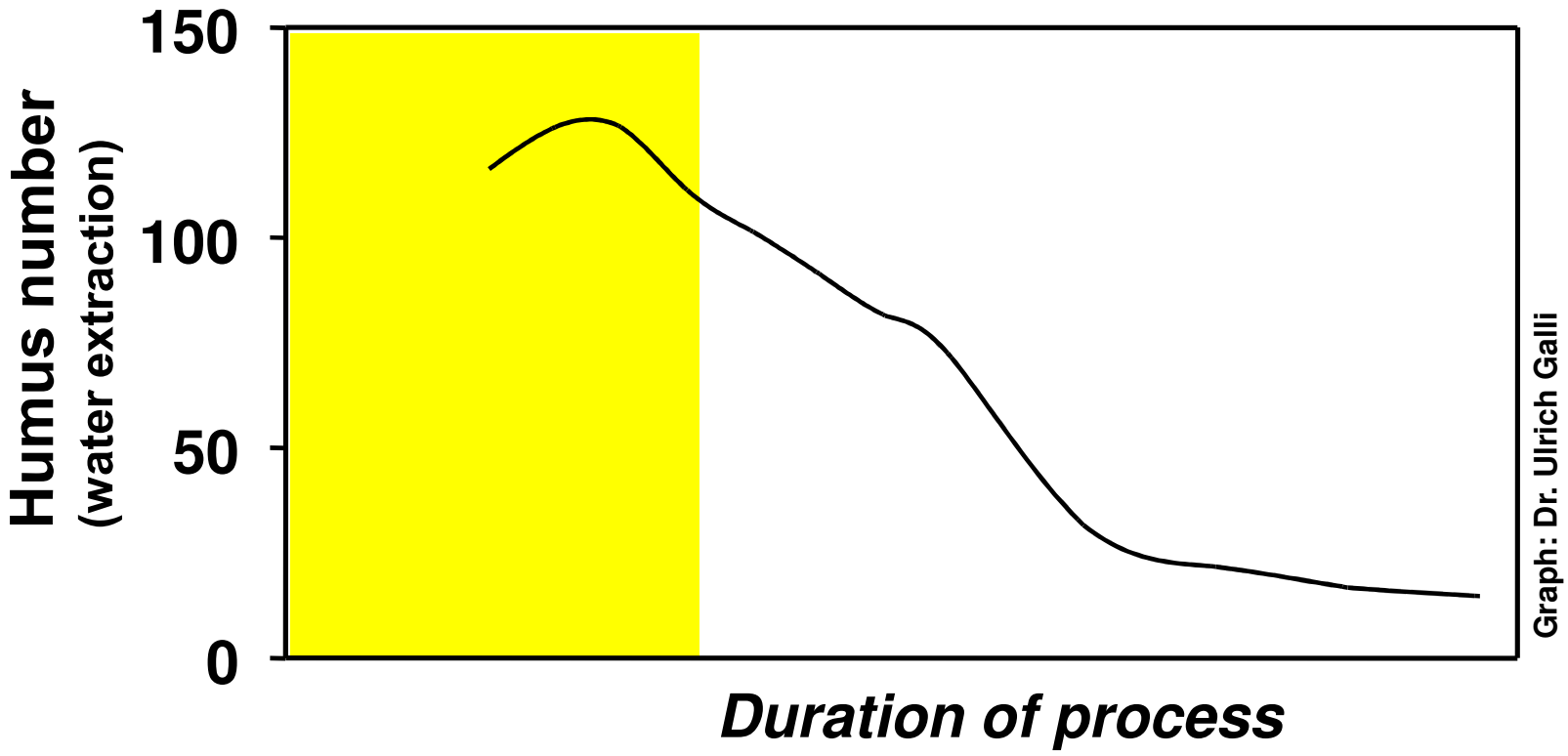
OM (organic matter) [% DM]	X	X	X	*< 50 %*	*< 40 %*
pH	X	X	X	**< 7.8**	**< 7.5**
Particle size [mm]		X	X	*< 25*	*< 15*
Coulor of extract		(X)	< 1.0	**< 0.5**	**< 0.2**

Minimal requirements; *recommendation*; X: has to be mentioned; (X): mention recommended

Compost quality management: Swiss concept

› **Evolution of the coloration of compost extract during composting process**



Compost quality management: Swiss concept

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OM (organic matter) [% DM]	X	X	X	*< 50 %*	*< 40 %*
pH	X	X	X	**< 7.8**	**< 7.5**
Particle size [mm]		X	X	*< 25*	*< 15*
Coulor of extract		(X)	< 1.0	**< 0.5**	**< 0.2**
Salinity [g KCleq/kg DM]	X	X	X	**< 20**	**< 10**

Minimal requirements; *recommendation*; X: has to be mentioned; (X): mention recommended

Compost quality management: Swiss concept

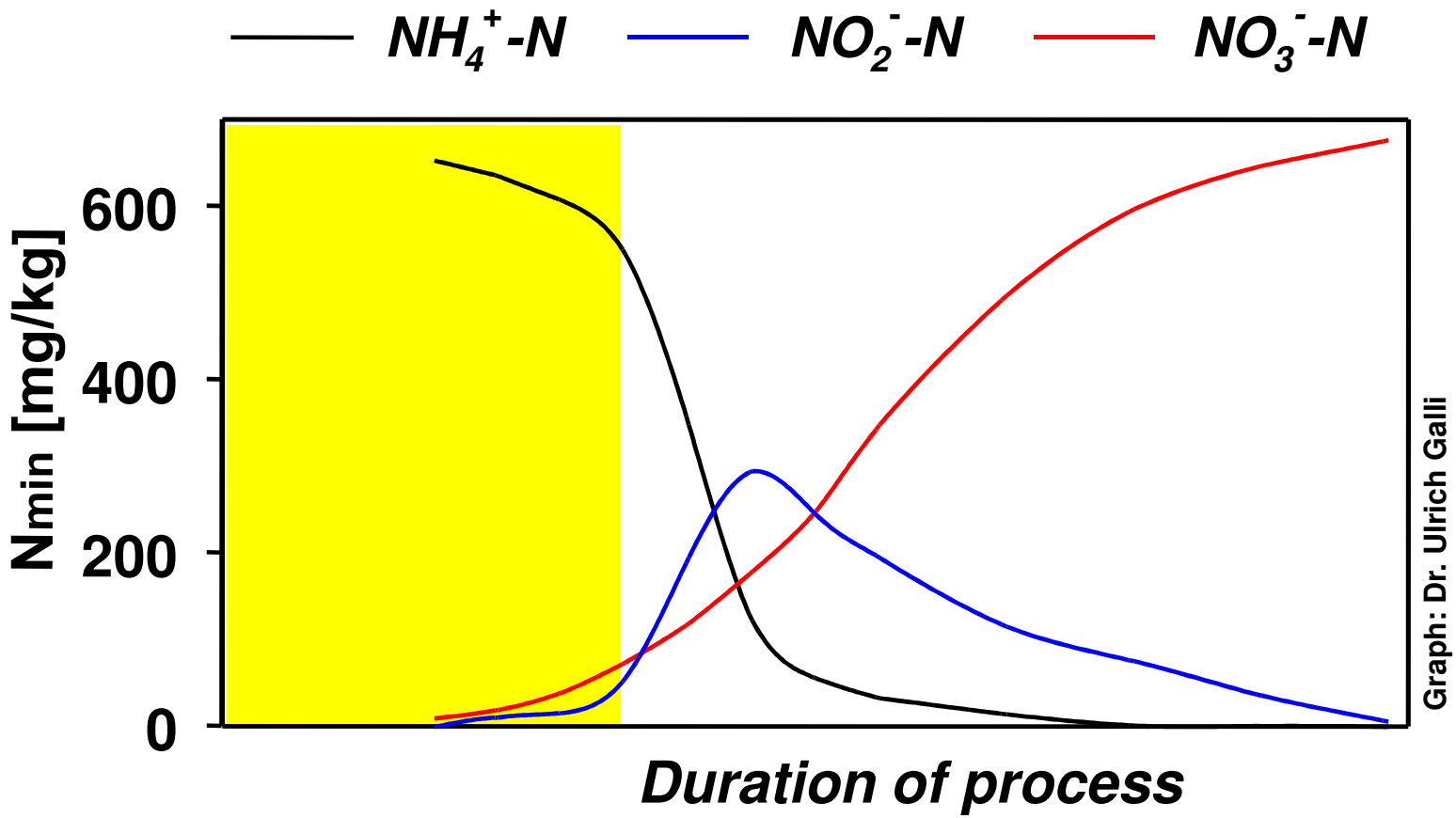
› Swiss compost and digestate guidelines 2010

Criteria	Composts and digestates for agricultural use			Compost for horticultural use	
	Digestate liquid	Digestate solid	Compost	Compost for field horticulture	Compost for covered cultures
Total nitrogen [g/kg DM]	X	X	X	*> 10*	*> 12*
Ammonium ($N\text{-}NH_4$) [mg/kg DM]	*> 3'000*	**> 600**	**< 600**	**< 200**	**< 40**
Nitrate ($N\text{-}NO_3$) [mg/kg DM]			X	**> 80**	**> 160**
Nitrite ($N\text{-}NO_2$) [mg/kg DM]			(X)	*< 20 mg/kg DW*	*< 10 mg/kg DW*

Minimal requirements; *recommendation*; X: has to be mentioned; (X): mention recommended

Compost quality management: Swiss concept

› Evolution of N_{min} during composting process



Compost quality management: Swiss concept

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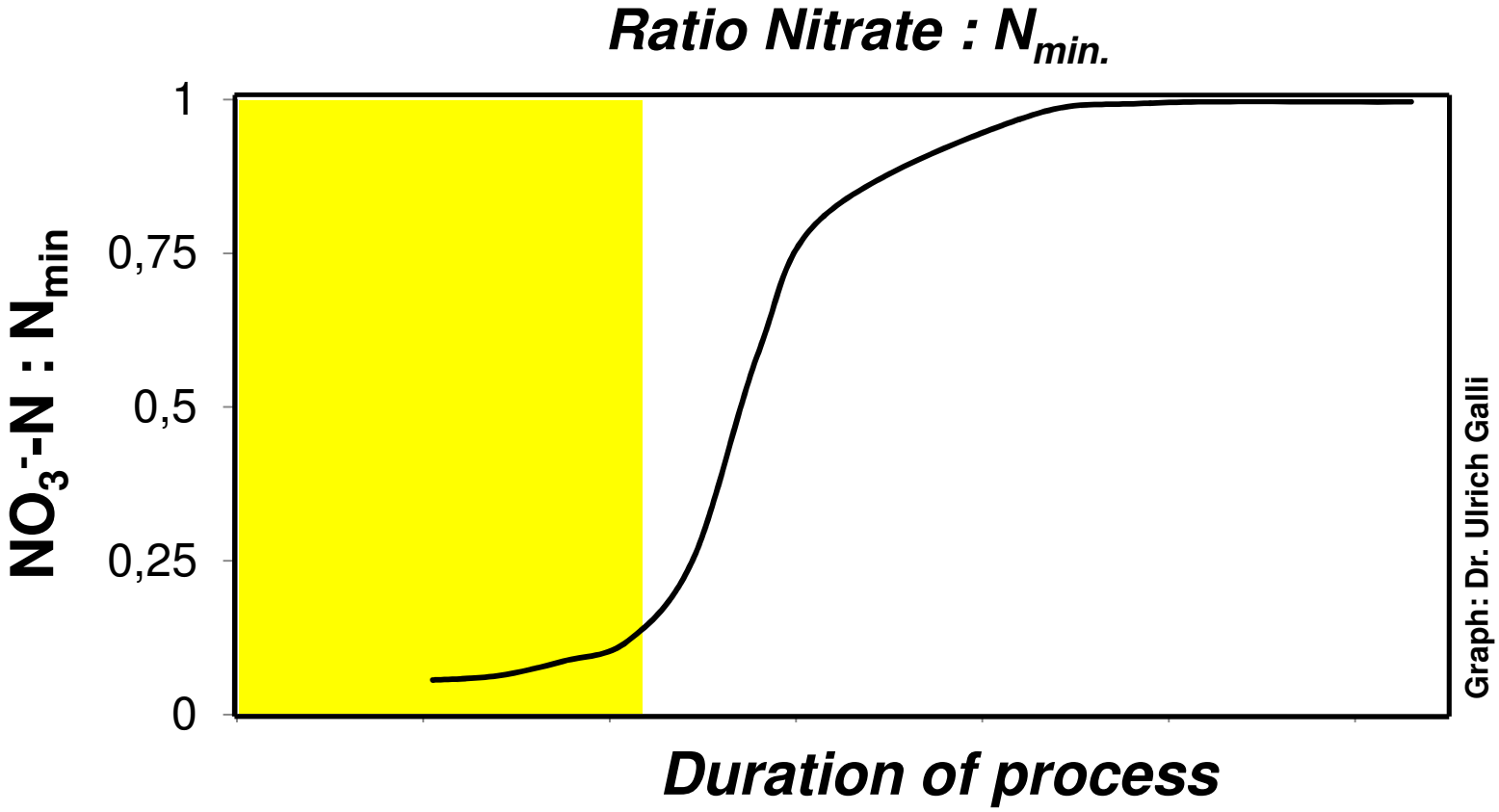
Nitrate ($N\text{-}NO_3$) [mg/kg DM]			X	**> 80**	**> 160**
Nitrite ($N\text{-}NO_2$) [mg/kg DM]			(X)	*< 20 mg/kg DW*	*< 10 mg/kg DW*
Nmin. [mg/kg DM]	*> 3'000*	*> 600*	*> 60*	*> 100*	*> 160*
$N\text{-}NO_3$/Nmin.			(X)	**> 0.4**	**> 0.8**

Minimal requirements; *recommendation*; X: has to be mentioned; (X): mention recommended

Compost quality management: Swiss concept

› Evolution of N_{min} during composting process



Compost quality management: Swiss concept

› Swiss compost and digestate guidelines 2010

Criteria	Composts and digestates for agricultural use			Compost for horticultural use	
	Digestate liquid	Digestate solid	Compost	Compost for field horticulture	Compost for covered cultures
Biotest cress open				**> 50% from control**	**> 75% from control**
Biotest cress closed			(X)	**> 25% from control**	**> 50% from control**
Biotest lettuce				*> 50% from control*	**> 70% from control**

Minimal requirements; *recommendation*; X: has to be mentioned; (X): mention recommended

Compost quality management: Swiss concept

- **Training programme**
  - Basic module
    - general overview of biowaste management
    - grounding in the legal basics
    - biological basics of composting
    - aspects of management of a composting plant

Compost quality management: Swiss concept

- **Training programme**
  - Quality module
    - process and quality control
    - simple chemical tests, plant tests
    - analysis and interpretation of results
    - installation of a simple laboratory on the composting plant

Benefits from utilization of compost

Benefits from utilization of compost

- **Effects of compost on the soil**
  - **Macro- und micro-nutrients**

Benefits from utilization of compost

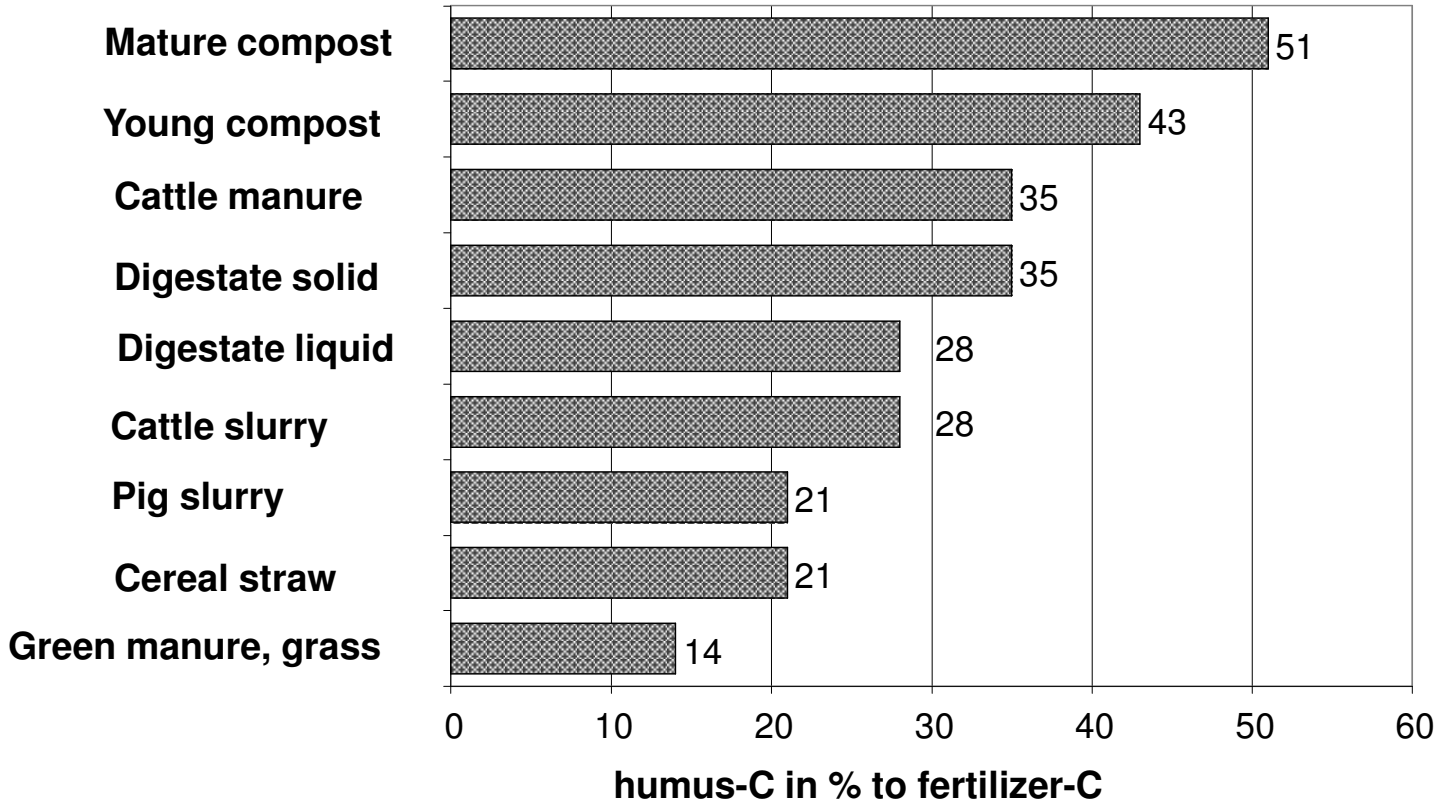
	Digestate for agricultural use	Compost for agricultural use	Compost for horticultural use	Compost for covered cultures
total N[g/kg DM] median (minimum; maximum)	**15.3** (9.4; 20.3)	**16.6** (8.7; 26.0)	**14.6** (9.2; 27.6)	**15.1** (8.6; 25.2)
total P[g/kg DM] median (minimum; maximum)	**3. 6** (2.0; 8.0)	**3.0** (1.7; 6.1)	**3.0** (1.3; 12.7)	**3.3** (2.1; 8.8)
total K[g/kg DM] median (minimum; maximum)	**12.5** (6.4; 20.8)	**12.0** (5.7; 25.2)	**11.6** (2.2; 20.7)	**10.7** (5.5; 27.8)
total Mg [g/kg DM] median (minimum; maximum)	**6.8** (3.7; 9.7)	**4.8** (3.6; 10.3)	**6.5** (4.4; 10.7)	**6.5** (4.4; 13.3)
total Ca [g/kg DM] median (minimum; maximum)	**46.6** (23.0; 57.8)	**53.1** (24.0; 83.7)	**64.0** 35.0; 91.5)	**44.5** (69.4; 29.5)
Total Fe [mg/kg DM] median (minimum; maximum)	**8.9** (3.7; 12.3)	**8.8** (2.9; 16.7)	**10.1** (5.4; 14.7)	**12.0** (6.1; 15.8)

Benefits from utilization of compost

- Effects of compost on the soil
  - Macro- und micro-nutrients
  - Organic matter

Benefits from utilization of compost

› Reproduction potential of humus



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

Benefits from utilization of compost

› Reproduction potential of humus

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

Benefits from utilization of compost

- Effects of compost on the soil
  - Macro- und micro-nutrients
  - Organic matter
  - Soil structure

Benefits from utilization of compost

- **Effects on soil structure**
  - **Reduced soil density**
    (e.g. 6% in the case of Compost Diffusion)
  - **Soil management is easier, saving of fuel**
    (observations of FiBL in a test of compost application in fruit growing)

Benefits from utilization of compost

- Effects of compost on the soil
  - Macro- und micro-nutrients
  - Organic matter
  - Soil structure
  - Soil porosity
  - Soil aeration
  - Water capacity

Benefits from utilization of compost

- Effects on water capacity of soil
  - Compost Diffusion, 1999: + 8%
  - Eyras and al., 1998: +20 to +25%
  - Gagnon and al., 1998: +3 to +5%
  - Shiralipour and al., 1996: + 3% to +16%

Benefits from utilization of compost

- Effects of compost on the soil
  - Macro- und micro-nutrients
  - Organic matter
  - Soil structure
  - Soil porosity
  - Soil aeration
  - Water capacity
  - Erosion

Benefits from utilization of compost

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

Benefits from utilization of compost

- Effects of compost on the soil
  - Macro- und micro-nutrients
  - Organic matter
  - Soil structure
  - Soil porosity
  - Soil aeration
  - Water capacity
  - Erosion
  - Microflora

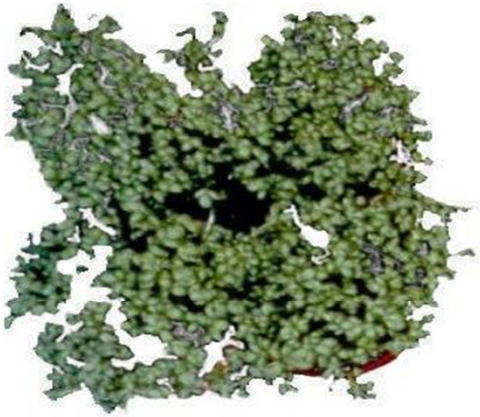
Disease control with quality compost

Disease control with quality compost

- **Influence of compost on plant health and vitality**
  - **Indirect:**
    - supply of macro- and micro-nutrients
    - soil structure
    - humus quantity and quality
    - water regulation
  - **Direct:**
    - influence of soil microflora through compost and compost microflora

Disease control with quality compost

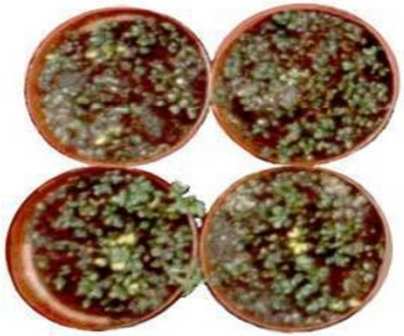
› **Not all composts are equal**



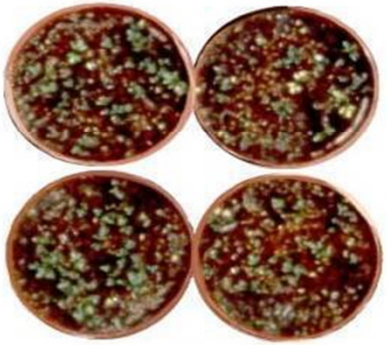
control

P. ultimum
+ 30% compost A

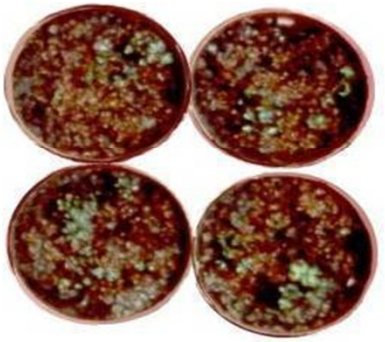
P. ultimum
+ 30% compost B



Pythium ultimum



P. ultimum
+ 30% compost A
heat treated



P. ultimum
+30% compost B
heat treated

Disease control with quality compost

- **Quality compost as plant protection agent in practice**
  - **Example 1: Compost in culture substrate**

Disease control with quality compost

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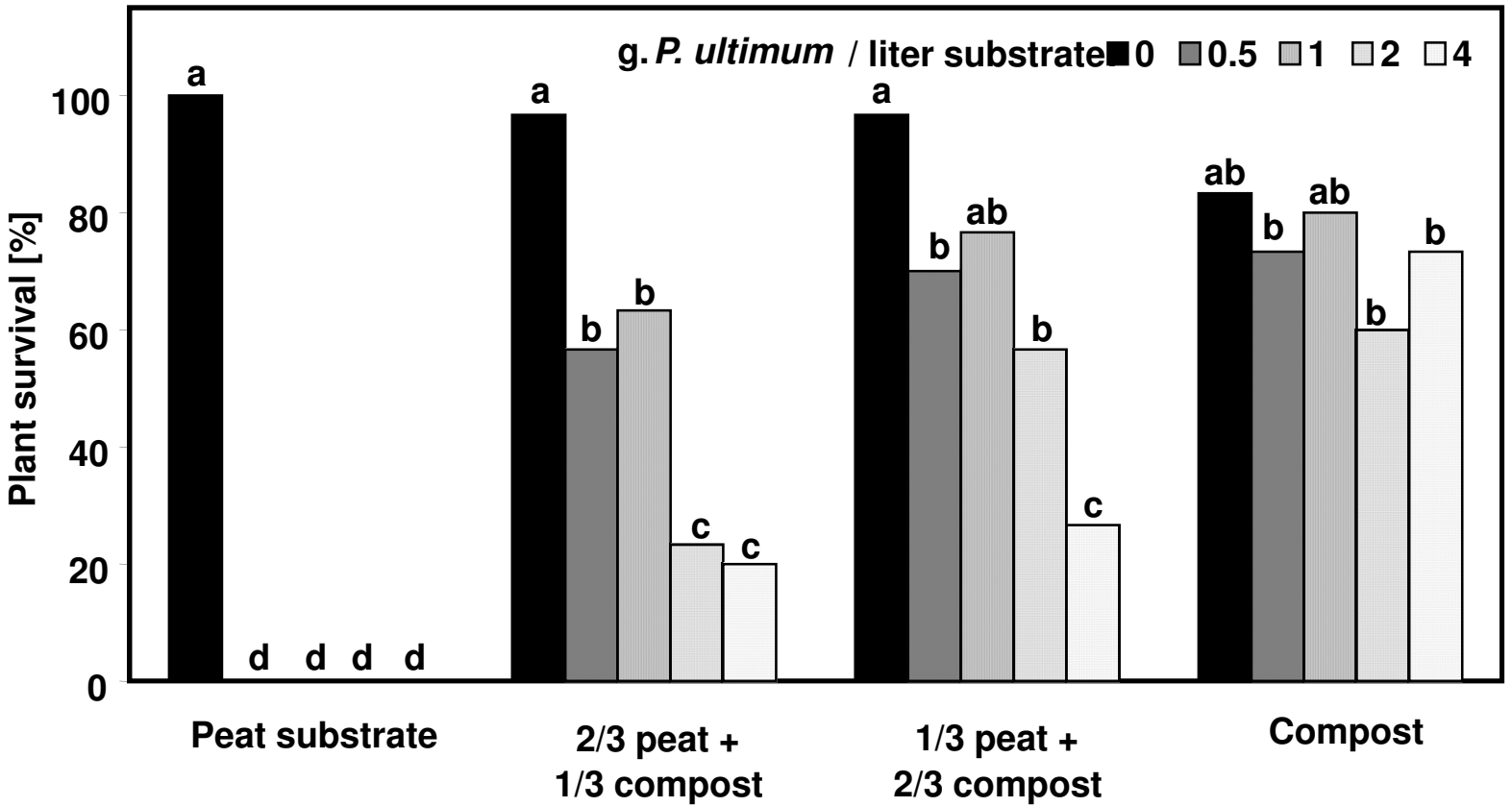

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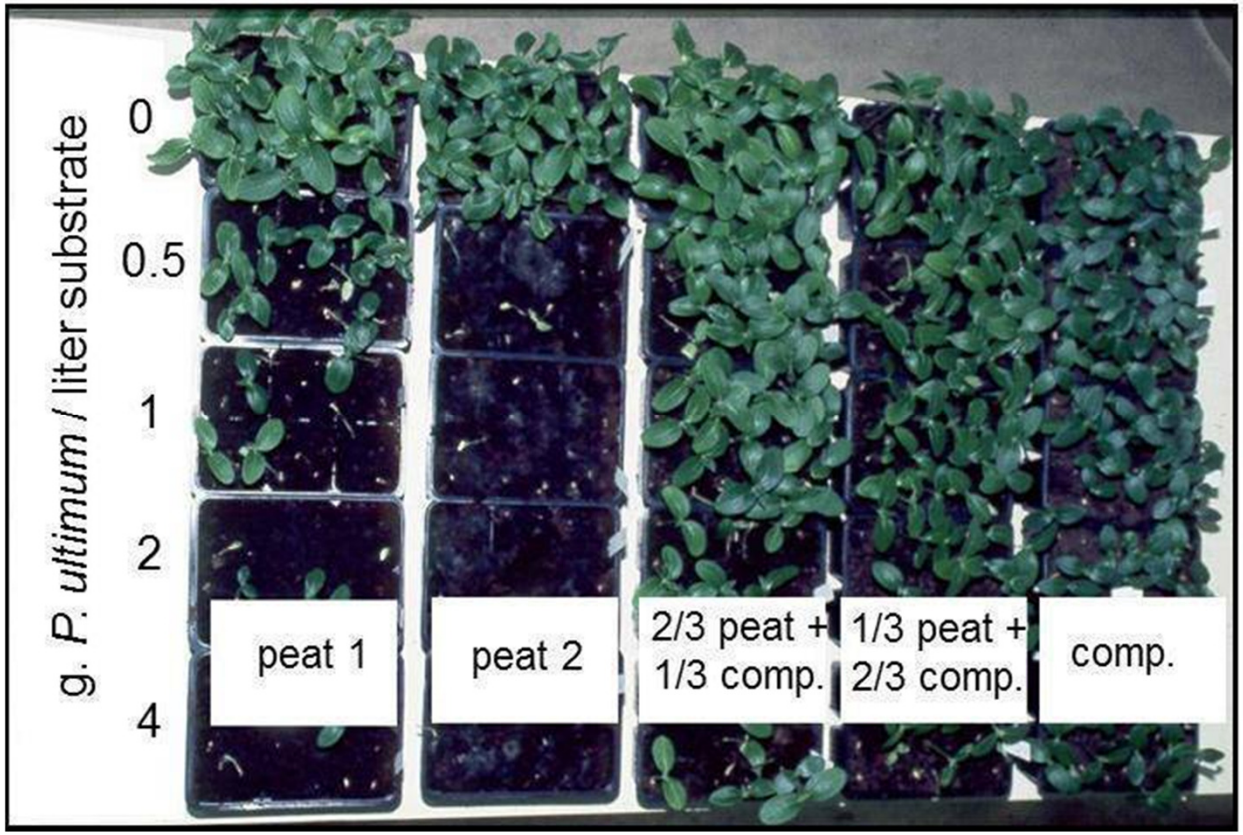

Disease control with quality compost

- **Quality compost as plant protection agent in practice**
  - **Example 1: Compost in culture substrate**

Disease control with quality compost

- **Quality compost as plant protection agent in practice**
  - **Example 1: Compost in culture substrate**
    - Buffers the system microbiologically
    - Prevents pathogen invasion
    - Reduces disease incidence drastically
    - Secures plant production

Disease control with quality compost

- **Quality compost as plant protection agent in practice**
  - **Example 2: Compost after soil steaming**

Disease control with quality compost

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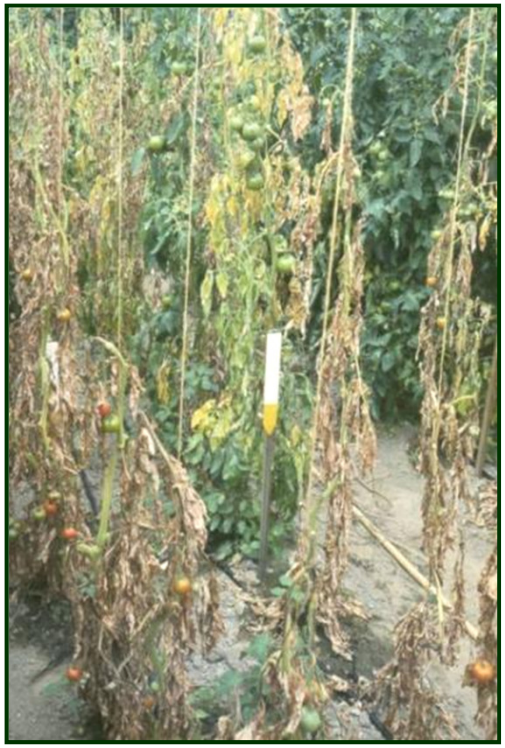

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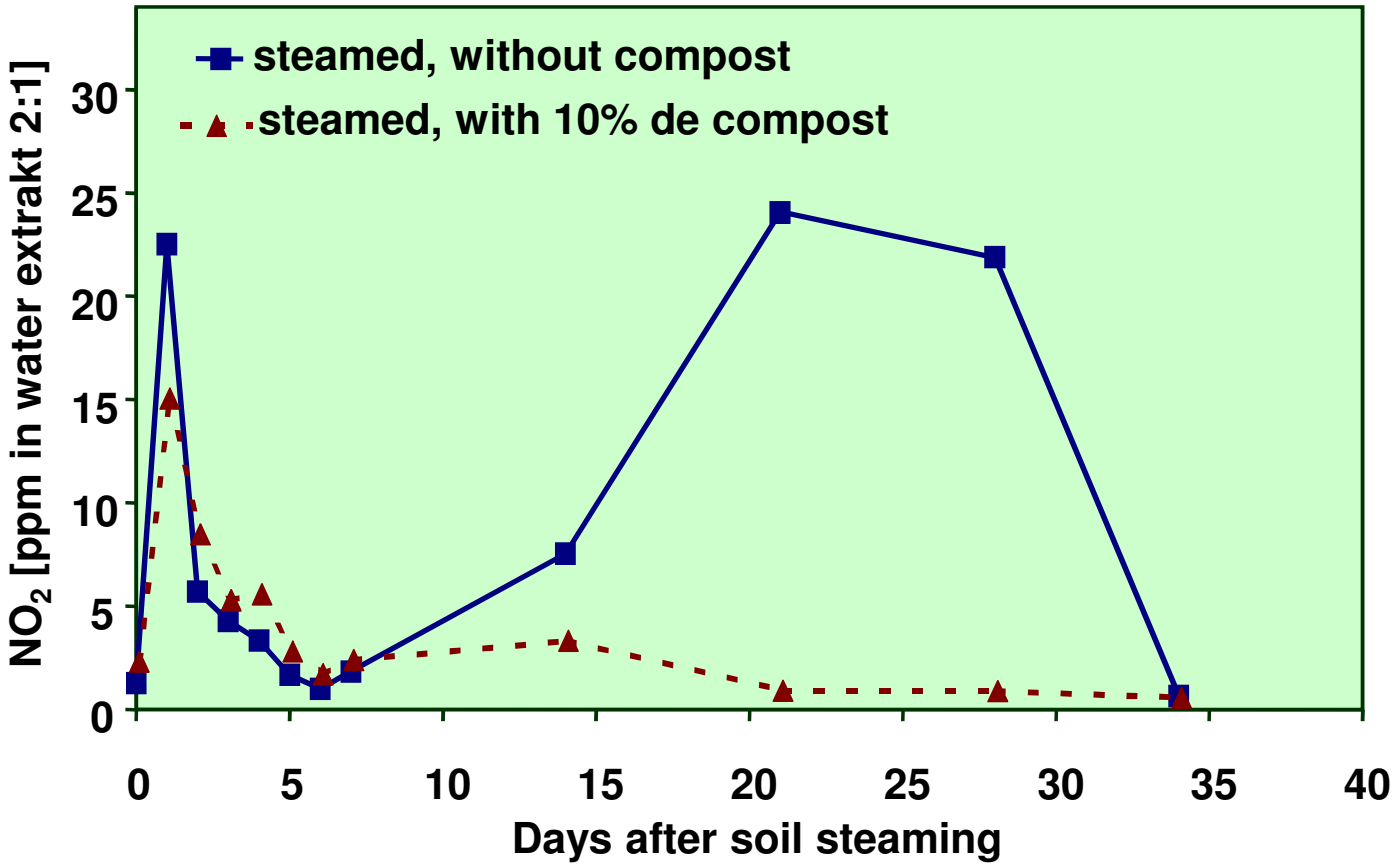

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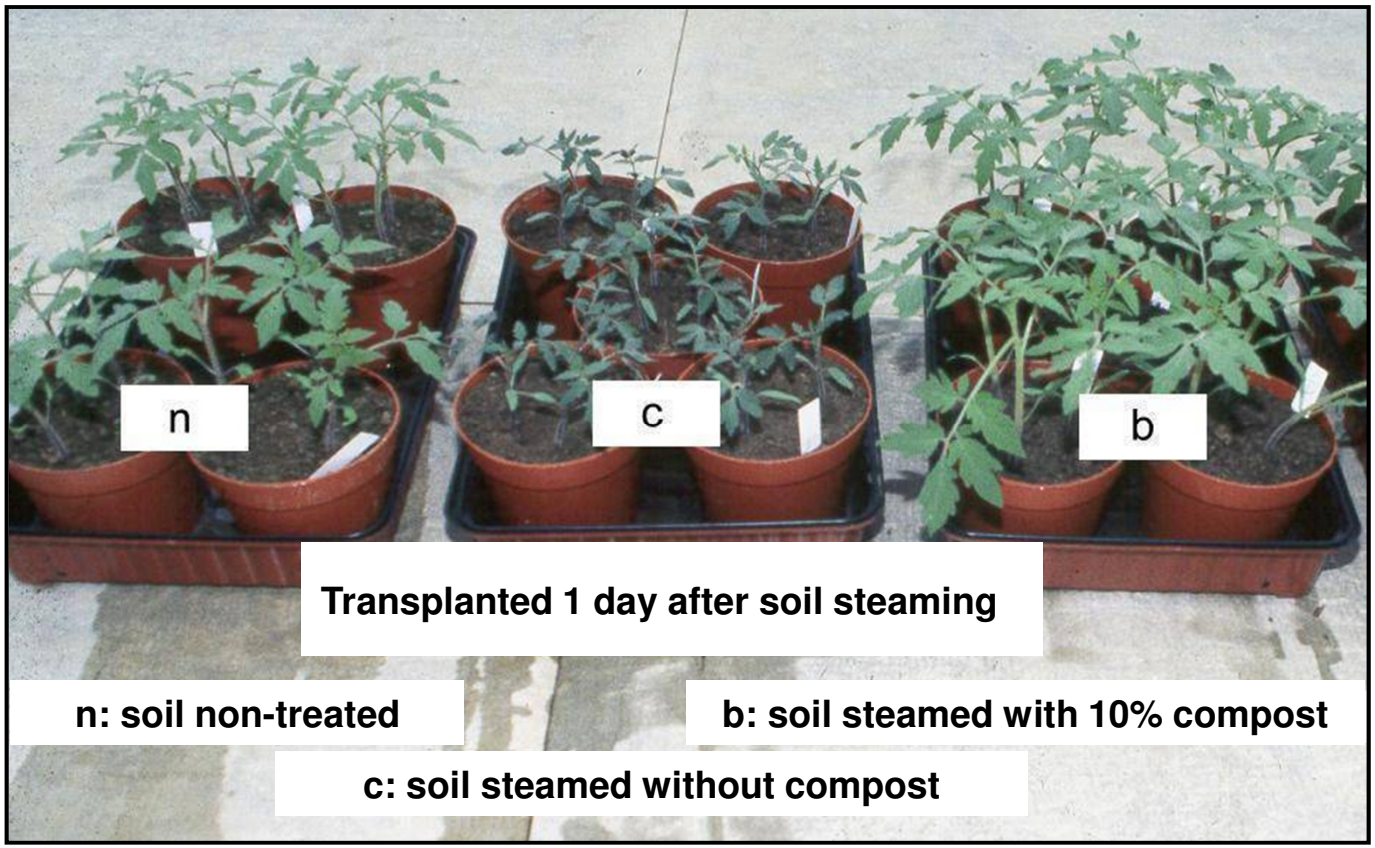

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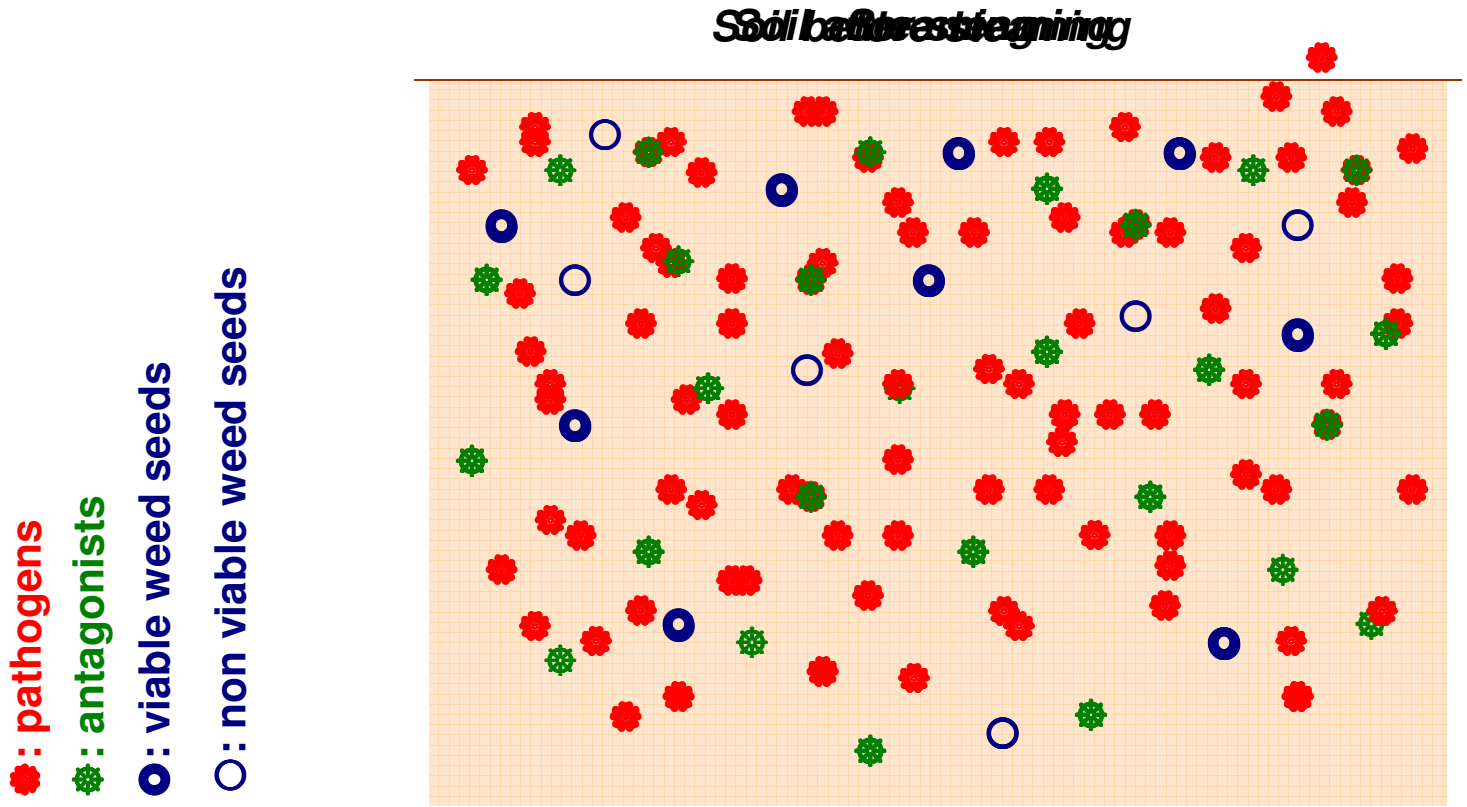

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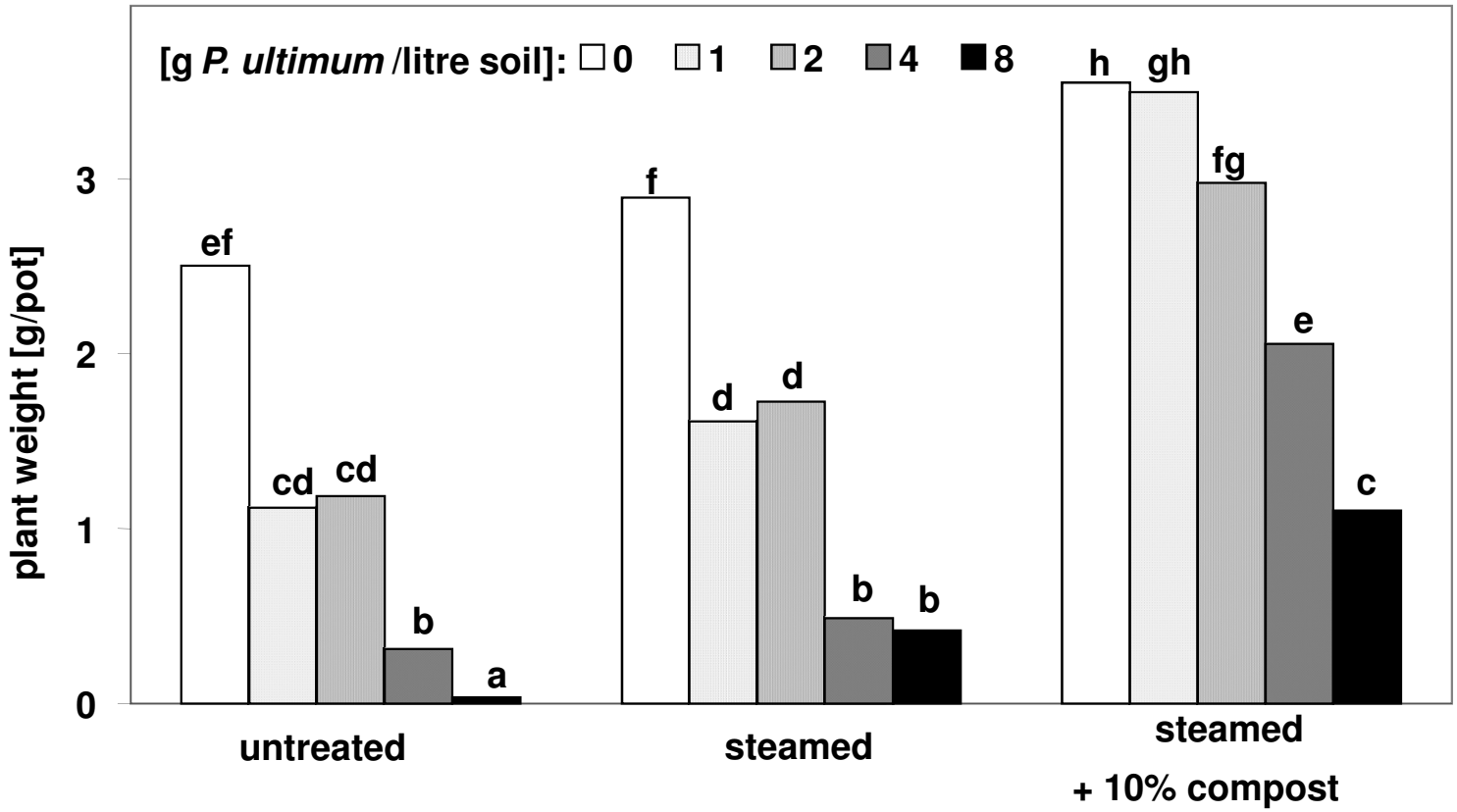


Disease control with quality compost

- **Quality compost as plant protection agent in practice**
  - **Example 2: Compost after soil steaming**

Disease control with quality compost

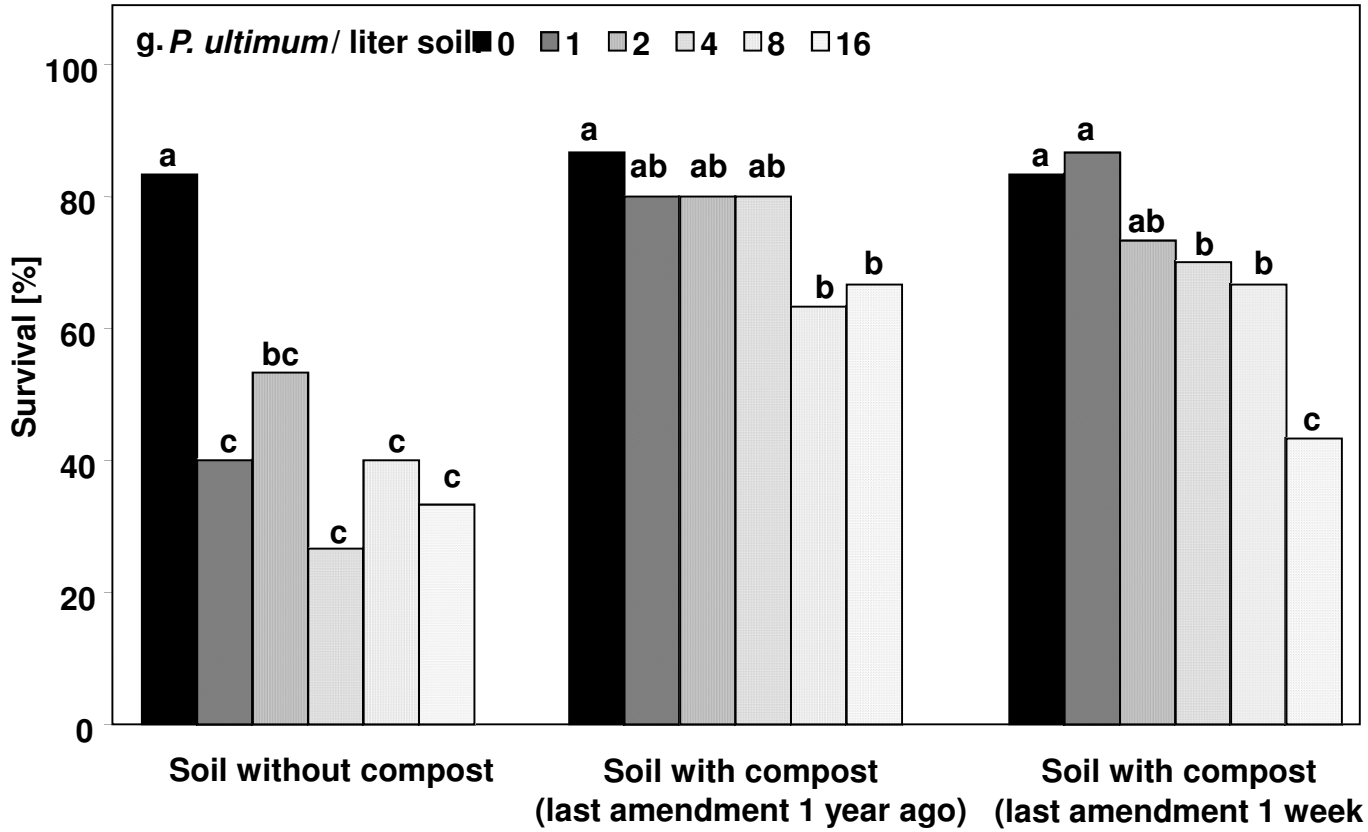
- **Quality compost as plant protection agent in practice**
  - **Example 2: Compost after soil steaming**
    - Detoxification of the soil
    - Allows earlier planting of seedlings
    - Prevents soil re-colonisation with pathogens
    - Allows sustainable soil steaming

Disease control with quality compost

- **Quality compost as plant protection agent in practice**
  - **Example 3: Compost in the field**

Disease control with quality compost

- Quality compost as plant protection agent in practice
  - Example 3: Compost in the field



Disease control with quality compost

- **Quality compost as plant protection agent in practice**
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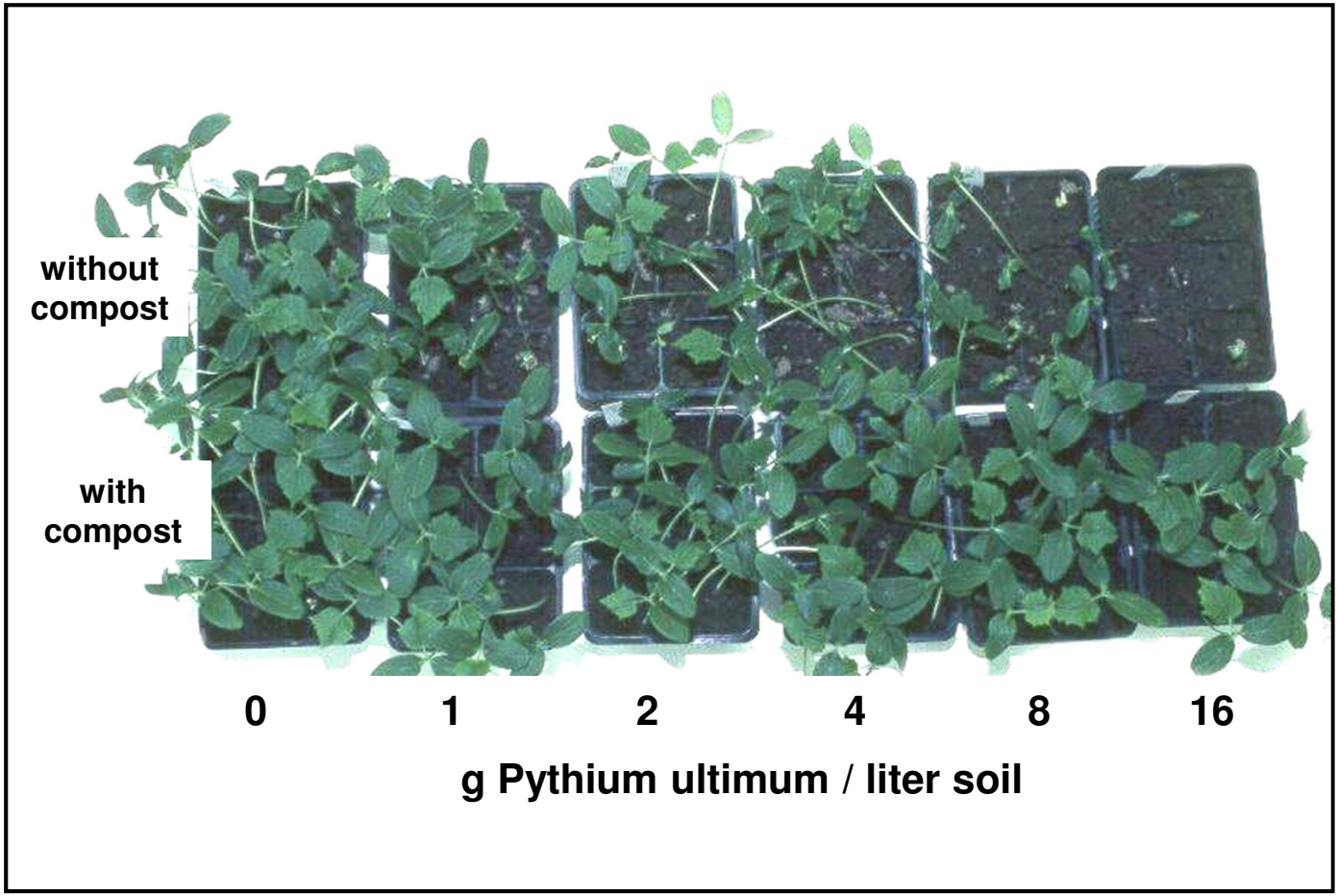
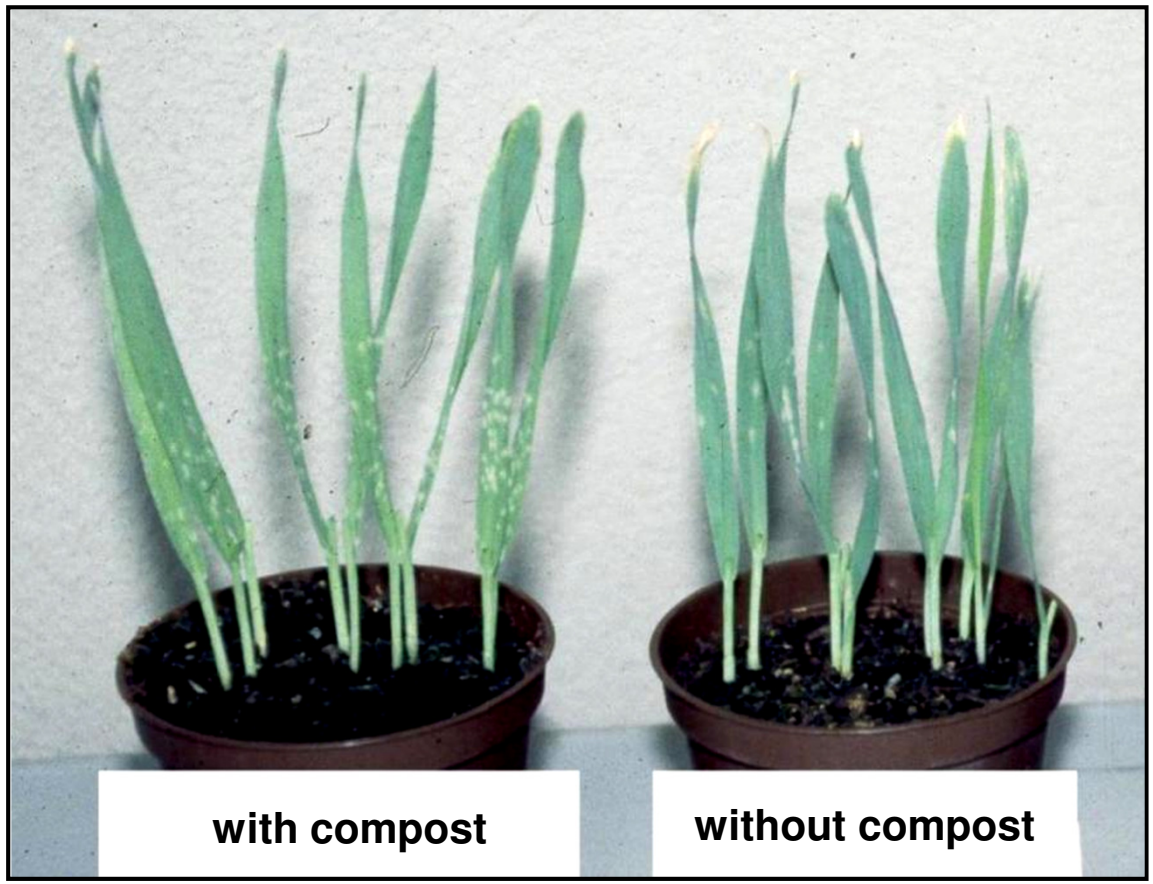


Disease control with quality compost

- **Quality compost as plant protection agent in practice**
  - **Example 3: Compost in the field**
    - Reduces disease incidence
    - The more intensively the field is cultivated, the more evident is the positive effect of compost on plant health

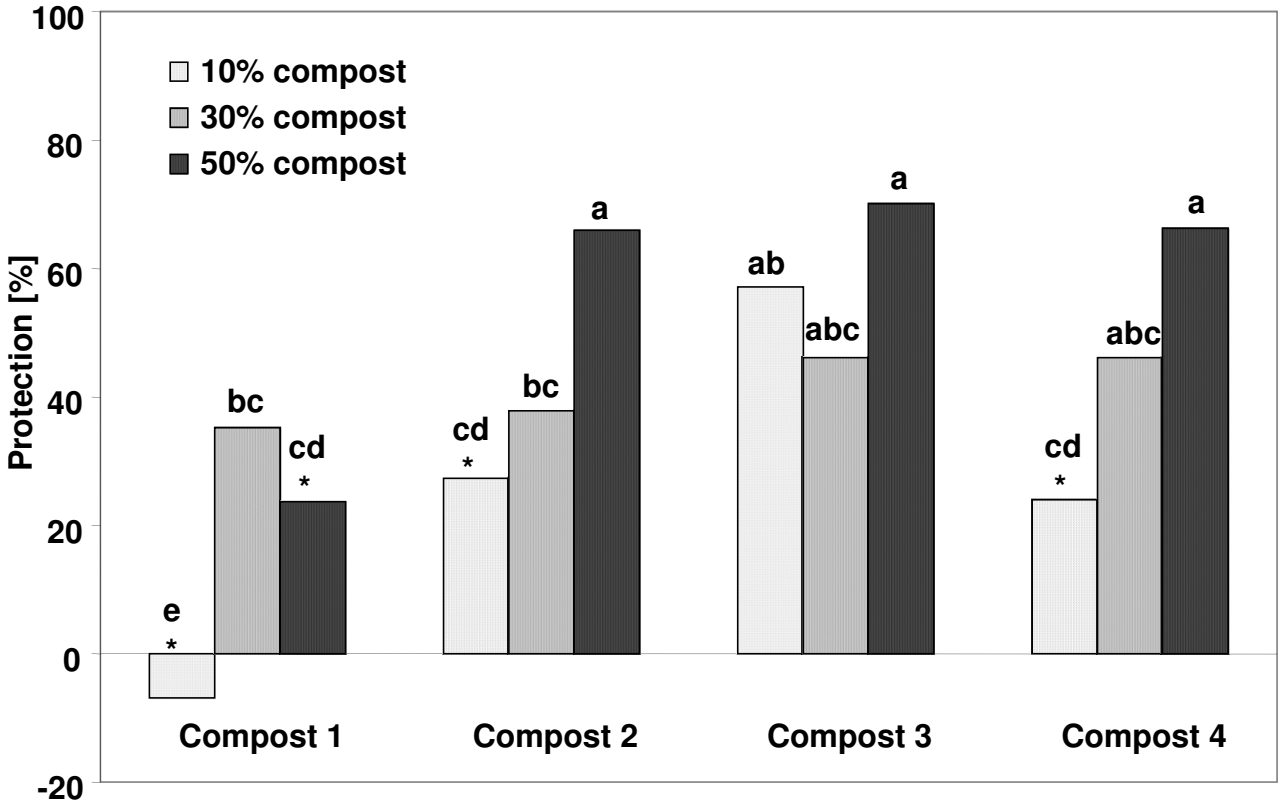
Disease control with quality compost

- **Quality compost as plant protection agent in practice**
  - **Example 4: Compost effect on the whole plant**



Disease control with quality compost

- **Quality compost as plant protection agent in practice**
  - **Example 4: Compost effect on the whole plant**



Disease control with quality compost

- **Quality compost as plant protection agent in practice**
  - **Example 4: Compost effect on the whole plant**
    - Reduces disease incidence without direct contact with the pathogen
    - Efficacy varies greatly from compost to compost

Compost quality management in practice

Compost quality management in practice

- **Quality management: from collecting the biowaste to compost use**
  - **Quality of the green waste**
  - **Composition of the starting mixture**
  - **Management of composting process**
  - **Compost storage**
  - **Choice of the adequate compost for each utilization**
  - **Compost application strategy**

Compost quality management in practice

- **Process management:**
  - Composition of the initial mixture

Compost quality management in practice

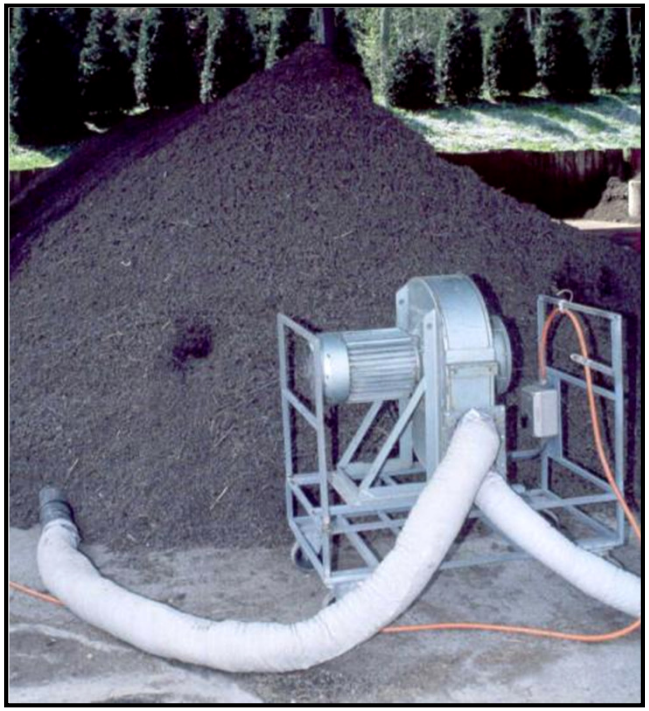
- **Process management:**
  - Regulation of water content

Compost quality management in practice

- **Process management:**
  - Regulation of aeration

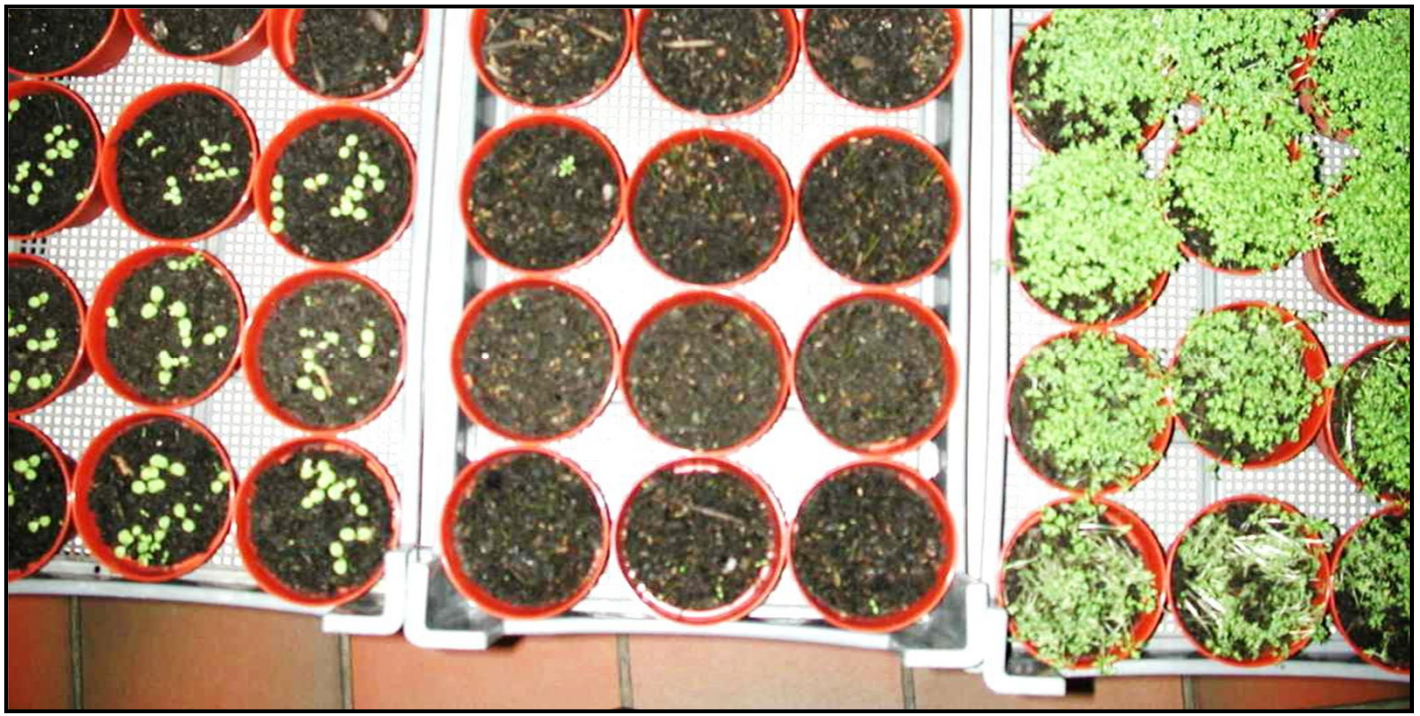
Compost quality management in practice

- **Process management:**
  - Storage management



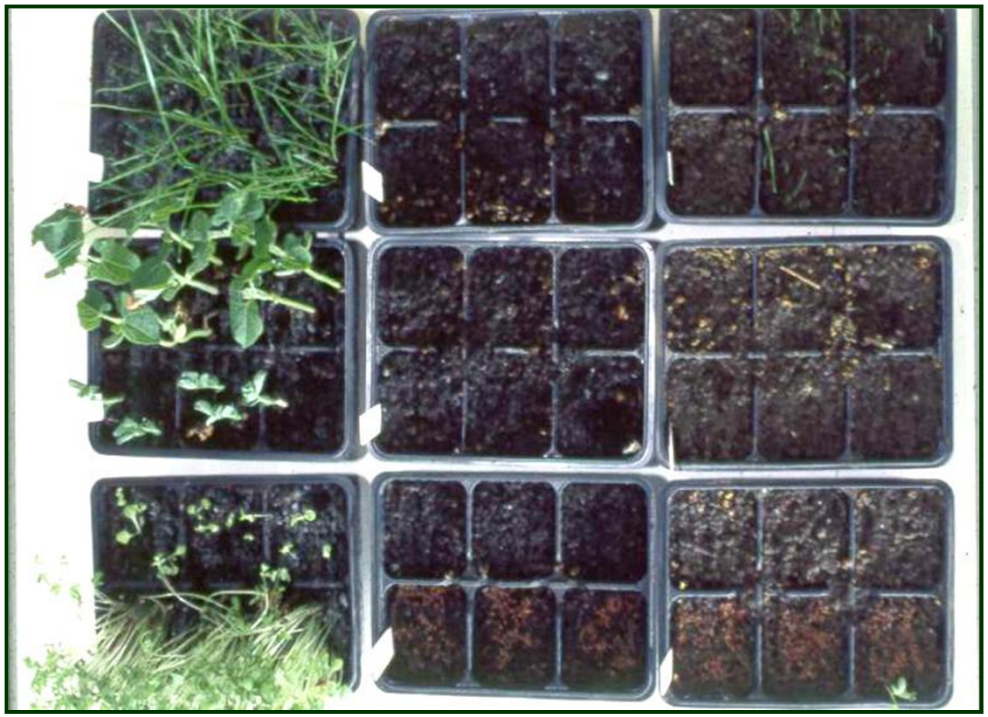
Compost quality management in practice

- **Inadequate process management:**
  - For example no hygienisation



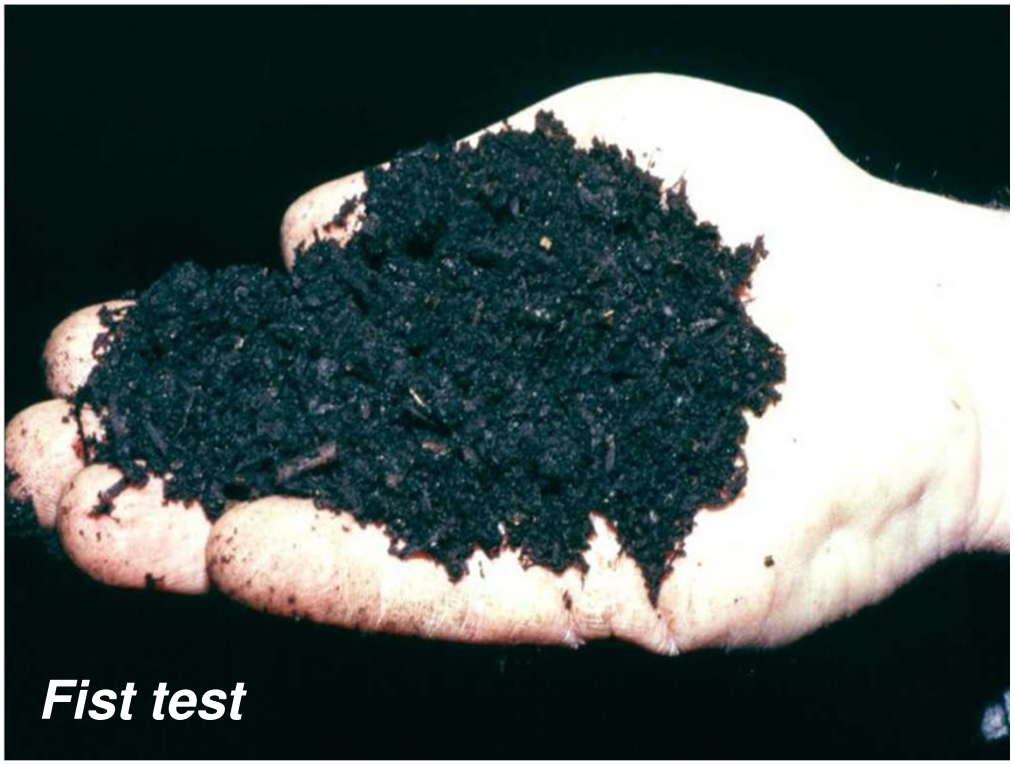
Compost quality management in practice

- **Inadequate storage:**
  - For example phytotoxicity



Compost quality management in practice

- **Evaluation of compost quality**
  - **With own senses**



Fist test

Compost quality management in practice

- **Evaluation of compost quality**
  - **With own senses**

Smelling test

Compost quality management in practice

- **Evaluation of compost quality**
  - **With own senses**

Compost quality management in practice

- **Evaluation of compost quality**
  - **With own senses**

Contaminants in compost

Compost quality management in practice

- **Evaluation of compost quality**
  - **With simple analysis**
    - Process parameters:
      - O_2
      - moisture
      - temperature
    - Chemical and physical analyses
      - pH
      - salinity
      - NH_4, NO_2, NO_3
    - Biotests
      - phytotoxicity tests
      - disease suppressivity tests

Conclusions

Conclusions

- Quality compost can improve soil fertility and plant growth and health
- Quality management is the key for a successful production and use of compost
- Training and experience are necessary to ensure production of quality compost and its correct use
- The choice of the right product and application strategy is decisive to obtain the desired impact
- The relation between compost producer and compost user has to be improved to assure the future of composts

Thank you very much for your attention …

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