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Using new substrate materials in Germany

Dr. Annette Bucher
University of Applied Sciences Weihenstephan-Triesdorf, Germany

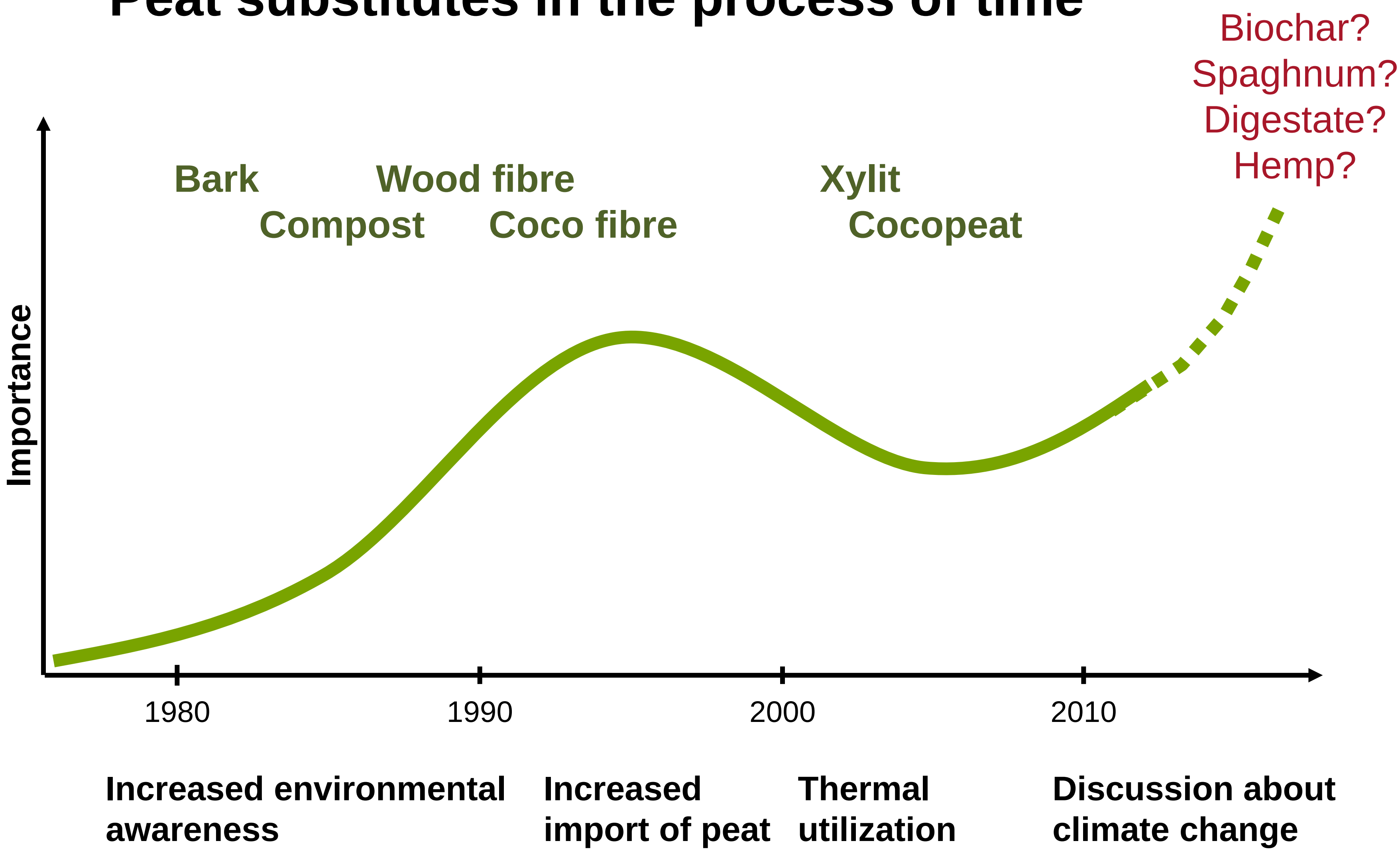
Background

- Germany: 9.5 mio m³ of peat p.a. for horticultural purposes

- **Advantages of peat**
  - High water capacity
  - High air capacity
  - Good structural stability
  - Free of pathogens, toxic substances and weeds
  - Low microbial activity
  - Low pH and nutrient level
  - Reliable high quality
  - Many years of experience

- **Why not use peat**
  - Peat mining destroys the ecosystem bog
  - Peat is renewable, but very slowly: 1 m in 1000 years
  - Drainage of bogs sets free high amounts of CO_2 (increases climate change)

Peat substitutes in the process of time



Demands on substrate materials

Chemical
- » Low pH
- » Low salt content
- » Beneficial contents of nutrients
- » Clear nutrient dynamics
- » High buffer capacity

Physical
- » Stable structure
- » Lightweight
- » High water and air capacity
- » Rewetable
- » Good capillarity

Biological
- » Free of weeds, pests and pathogens
- » Free of inhibitory and harmful substances

Other
- » Storable
- » Constant quality
- » Constant available
- » Low-priced

Possible substrate raw materials

- Bark compost
- Green compost
- Compost of digestate
- Wood fibre
- Coconut materials
- Xylit
- Biochar / Hydrochar
- Sphagnum
- Miscanthus straw
- Rice husks
- Hemp fibre

Bark compost – Production

Shredding

Adding 2 kg urea/m³

Controlled composting
(aerob; ~ 70 °C)

Sieving

Spruce/conifer raw bark

Bark compost

» Strong nitrogen immobilization

» Growth-inhibiting substances (resins, phenols, tannins)

» Well-balanced nitrogen dynamics

» Free of growth-inhibiting substances

Bark compost – Positive characteristics

- High air capacity → increases aeration and drainage
- Good structural stability → counteracts volume loss
- Good rewetting → fast water uptake after drying out
- Good pH-buffering capacity → stabilizes pH level
- High levels of potassium → consider for fertilization
- High cation exchange capacity
  → reduced risk of salt damage
  → prevents leaching of nutrients

Bark compost – Results

Calibrachoa cultivars grown in peat and peat + bark compost mixture, respectively (Lohr, 2012)

Bark compost – Possible Problems

- Low water capacity
  - → shorter irrigation intervals
- Possibility of nitrogen immobilization
  - → stored growing media needs to be analyzed prior to use
  - → nitrogen accented feeding
- Occasionally high levels of manganese
  - → add iron chelates
  - → pH > 6
- Growth-inhibiting substances
  - → use quality assured products (germination test)

Green (waste) compost – Production

Organic waste from private gardens and public green spaces

Removing impurities

Shredding/mixing/moistening

Controlled composting
(aerob; ~ 60 °C)

Sieving

→

Green compost

- Weed seeds and pathogens
- High degradability

- Disinfected material
- Stable humic compounds

Green compost – Positive characteristics

- Good structural stability
  → counteracts volume loss
- Good rewetting
  → fast water uptake after drying out
- Good pH-buffering against decrease
  → stabilizes pH level under acidifying conditions
- Suppression of soil-borne pathogens
  → reduces need of soil applied fungicides
- High cation exchange capacity
  → reduced risk of salt damage
  → prevents leaching of nutrients

Green compost – Possible Problems

- High and varying nutrient and salt levels
  - → limits ratio of compost in the growing medium
  - → must be analyzed prior to use
  - → use quality assured green composts (substrate-compost)
- Unwanted ingredients and foreign matters
  - → use quality assured green composts
- Iron deficiency due to high pH-values
  - → mix with components with low pH
  - → use water with low HCO_3^- level
  - → ammonium accented feeding
  - → add elemental sulphur
  - → use stable Fe-chelates (Fe-EDDHA)
- Excessive shore flies or soil fungi
  - → use completely matured composts

Green compost – Results

Fe deficiency chlorosis due to high pH - Calobrachoa cultivars grown in different compost containing substrates (Lohr, 2012)

Compost of digestate– Production

Solid residues from anaerobic digestion of renewable resources (biogas plant, filled with plant and animal material)

Controlled composting
(aerob; 8 weeks)

Addition of coarse material

Compost of digestate

- Growth inhibiting substances
- Not useful as substrate

- Free of growth inhibiting substances
- Addition of coarse material does not enhance rotting process but decreases nutrient contents

(Meinken et al. 2009)

Compost of digestate – Positive characteristics

- Release of nutrients (N, K, P) → consider for fertilization
- Free of growth inhibiting substances
- Well balanced nitrogen dynamics

Compost of digestate – Possible problems

- pH 6.8 – 8 → mix with components with low pH
- High P contents
  - → especially with animal resources (slurry, manure) → not advisable
  - → plant damage (Fe deficiency chlorosis and necrosis) with P_2O_5 (CAL) > 500 mg/l
  - → addition of Fe-sulphate or COMPALOX (P-buffer) decreases P-induced damages
  - → maximum application of 10 Vol.-% in substrates
- High salt (4 – 6.2 g/l), sodium and chloride contents
  - → adjust content of compost in the substrate
  - → use other low-salt components for mixtures
- High contents of Zn, Cu depending on the raw material
  - → adjust content of compost in the substrate

Compost of digestate – Results

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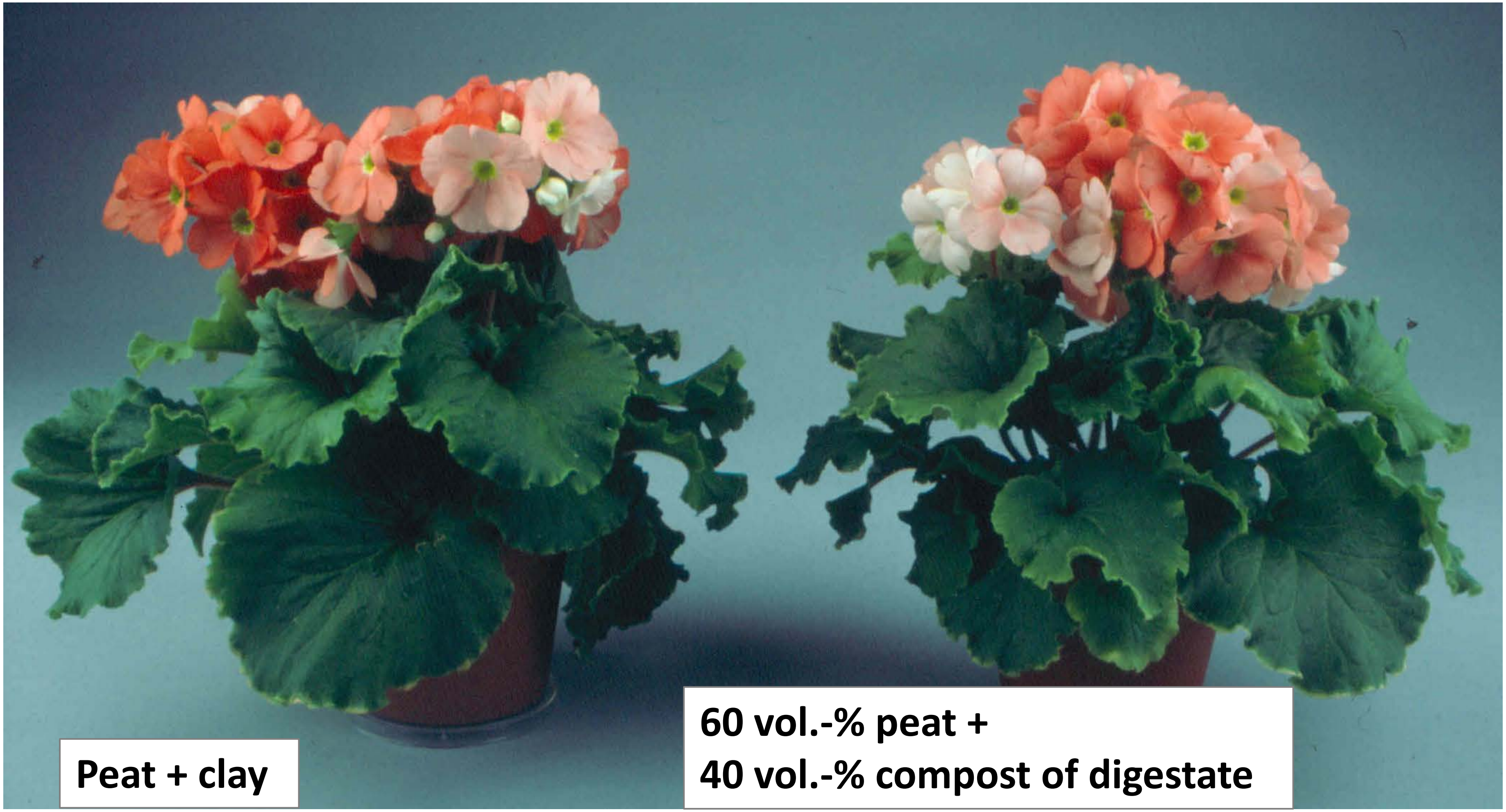

Plant growth of *Primula* in substrates with compost of digestate (right)

Compost of digestate – Results

P_2O_5 (CAL): 415 mg/l
P_2O_5 (CAT): 251 mg/l

P_2O_5 (CAL): 699 mg/l
P_2O_5 (CAT): 477 mg/l

P_2O_5 (CAL): 1851 mg/l
P_2O_5 (CAT): 758 mg/l

Problems due to high P_2O_5
Development of *Scaevola aemula* ‚Saphira‘ in substrates with composts of digestate (27 vol.-% = salt input 1 g/l)

(Meinken et al. 2009)

Wood fibre – Production

Untreated conifer wood waste from sawmills

Energy consuming thermal-mechanical processing (> 100 °C)

Adding slow release nitrogen fertilizer (impregnation)

Wood fibre

» Strong nitrogen immobilization

» Largely balanced nitrogen dynamics

Wood fibre – Positive characteristics

- » High air capacity → increases aeration and drainage
- » Good rewetting → fast water uptake after drying out
- » Quick drying of the substrate surface → less weeds/liverwort
- » Low bulk density → advantageous for logistics
- » High pH-buffering against decrease
  → stabilizes pH-level under acidifying conditions
- » Low in soluble salts and nutrients
  → required nutrient levels can be adjusted easily

Wood fibre – Possible Problems

- Low water capacity
  → short irrigation intervals
- Possibility of nitrogen immobilization
  → material needs to be analyzed prior to use
  → nitrogen accented feeding
  → use quality assured wood fibre
- Relatively quick decomposition
  → volume loss
- Low pH-buffering against increase
  → ammonium accented feeding
  → use water with low HCO_3^- level

Wood fibre – Results

100 vol.-% Peat

70 vol.-% wood fibre +
30 vol.-% green compost

Volume loss after 6 months

Coconut materials – Production

Mesocarp of coconut fruits

Extracted and cutted fibres

Sieved material between fibres

Mesocarp material cutted into cubes

Cocofibre

Cocopeat

Cocochips

Coconut materials – Positive characteristics

- High air capacity → low risk of water logging
- Good rewetting → fast water uptake after drying out
- Low bulk density → advantageous for logistics
- Low rate of decomposition
  - → reduced risk of nitrogen immobilization
  - → high structural stability
- Cocofibre: high capillarity
  - → supports water absorption
- Cocopeat: high level of plant-available water
  - → good water supply

Coconut materials – Results

(Lohr 2012)

Substrates made of 100 vol.-% cocopeat are possible

- air and water capacity of cocopeat is comparable to peat

Coconut materials – Possible Problems

- High levels of Na^+, K^+ and Cl^- from soaking in salt water
  - → use only products soaked in fresh water or mechanically produced material
  - → use buffered material
  - → consider potassium for fertilization
  - → use quality assured coconut materials
- Transport
  - → costs
  - → CO_2 footprint
- Cultivation of palms in plantations
  - → cut down of rain forrests

Coconut materials – Results

Control Peat | Cocopeat, untreated | Cocopeat, washed | Cocopeat, buffered with $Ca(NO_3)_2$

Euphorbia pulcherrima **at the end of the trial in 100 % cocopeat with different pretreatment**

(Emmel, 2014)

Xylit – Production

mechanical defibration

sieving

raw Xylit

Xylit

- Minor component at brown coal mining
- Not completely carbonized, woody material

Xylit – Positive characteristics

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» Low pH (4,5)
  → suitable for horitculture (pH adjustment by liming)

» Low salt contents

» Low nutrient contents
  → addition of fertilizer recommended

» Stable N dynamics
  → no/ very low N-immobilization

» Stable structure / low decomposition
  → no volume loss

» Hight exchange capacity
  → less risk of salt induced damages with over-fertilization
  → less risk of nutrient loss by leaching

Xylit – Results

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(Lohr, 2012)

Xylit as main component of a peat free potting soil

Xylit – Results

100 vol.-% peat

(Lohr, 2012)

80 vol.-% peat + 20 vol.-% xylit

Development of *Impatiens* with excessive basic fertilization

Xylit – Possible problems

- Adherence of brown coal dust
  → pollution by black colored drainage water
- Water holding capacity is lower than of peat
  → consider for irrigation strategies
  → use surfactant for substrate production
- Question of further availability and sustainability
  → end of brown coal mining

Biochar – Production

Pyrolysis

normal pressure

Temperature up to 800° C (energy!)

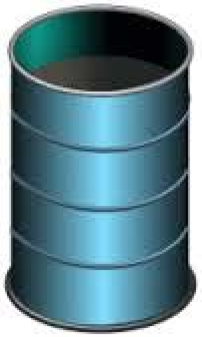
Combustion under low oxygen athmosphere

Dry biomass → **Biochar**

Hydrochar – Production

Dry and wet biomass
+ H_2O
+ catalytic converter

Hydrothermal carbonization
10 - 40 bar
Temperature up to 250° C (energy!)
anaerob



Hydrochar sludge

drying

Hydrochar

Biochar / Hydrochar – Positive characteristics

- High content of stable C → does not escape as CO_2
  → mitigate climate change
- Carbonized biomass is considered to be responsible for the high fertility of the „Terra-Preta soils“ found in the Amazonian basin
- Absorption of nutrients is expected
  → might improve soil fertility
- Use of up to 20 vol.-% Biochar / Hydrochar in substrates resulted in acceptable growth

Biochar / Hydrochar – Results

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80 % Peat
20 % Biochar 1

100 % Peat

80 % Peat
20 % Biochar 5

Growth of *Impatiens-Neuguinea hybrids* in substrates with biochar

Biochar / Hydrochar – Results

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40 % green compost
30 % cocopeat
30 % biochar 5

(Meinken, 2014)

40 % green compost
60 % cocopeat

40 % green compost
30 % cocopeat
30 % biochar 6

Growth of balcony plants in substrates with different biochars

Biochar / Hydrochar – Possible Problems

» Quality depends on raw material and production process
→ Biochar is often more suitable than Hydrochar

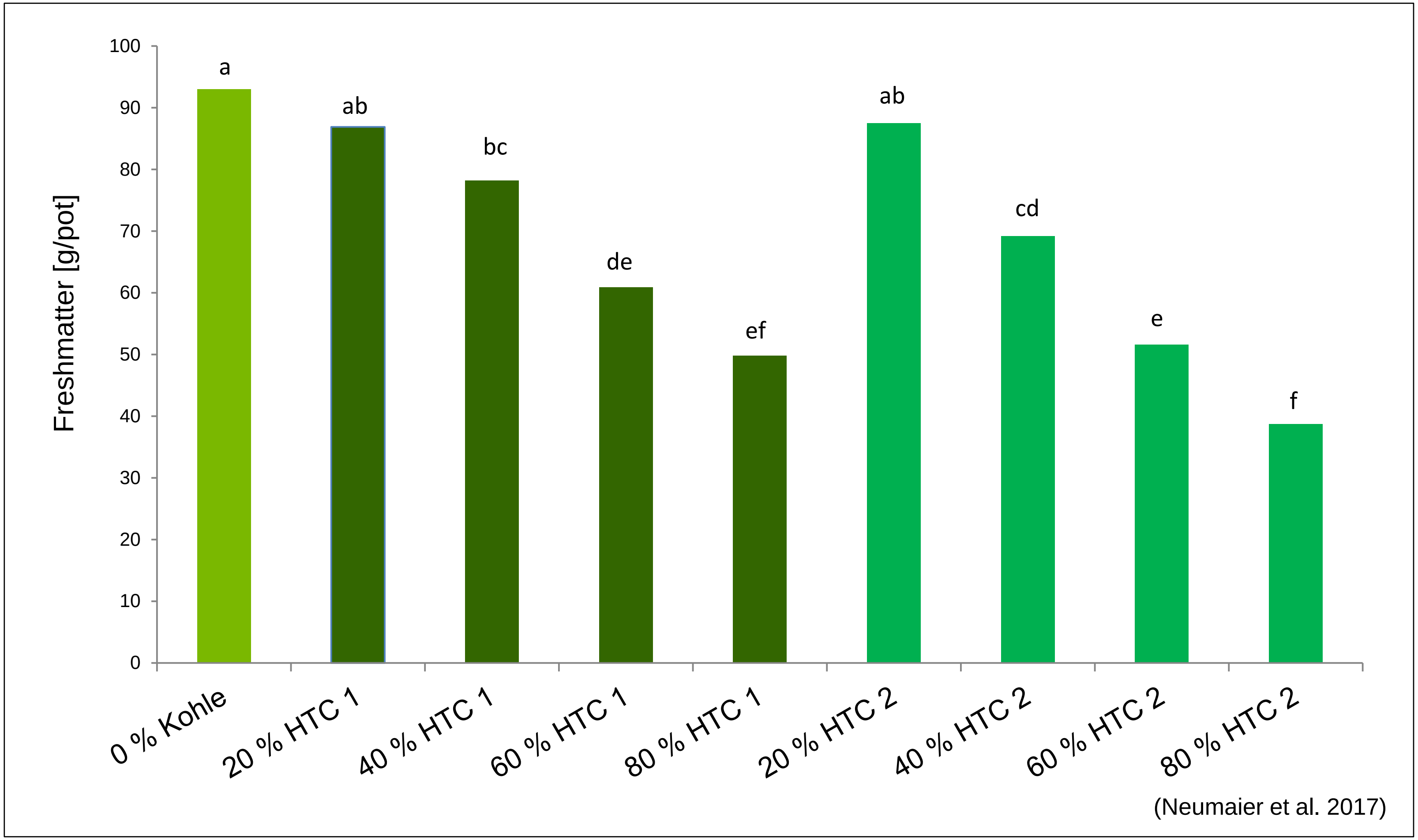
» Too high N-immobilization (Hydrochar > Biochar)
→ not reduced by co-composting in all cases

» Growth depression with Hydrochar
→ due to N-immobilization and phytotoxic substances
→ should be used only with caution

» Adsorption of nutrients
→ only phosphate in relevant dimensions

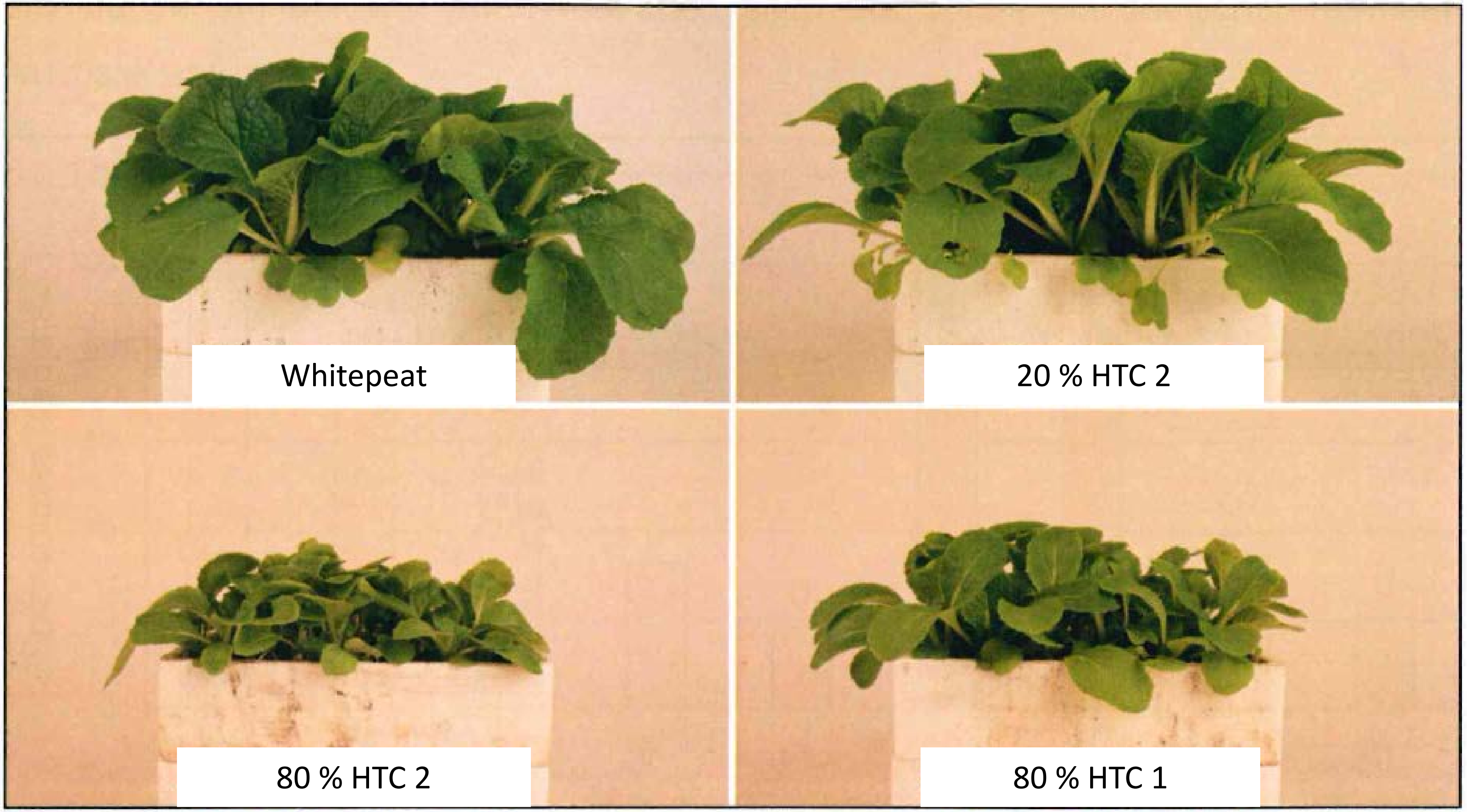
» At present not recommended as component in substrates
→ too little positive experience
→ no prediction about further significance at present

Biochar / Hydrochar – Results



Growth of chinese cabbage in substrates with Hydrochar and adequate fertiliziation

Biochar / Hydrochar – Results



(Neumaier et al. 2017)

Growth of chinese cabbage in substrates with Hydrochar and adequate fertiliziation

Biochar / Hydrochar – Results

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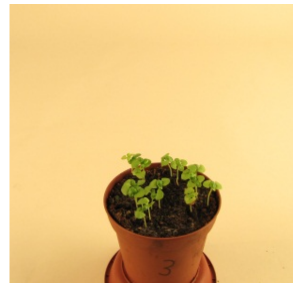
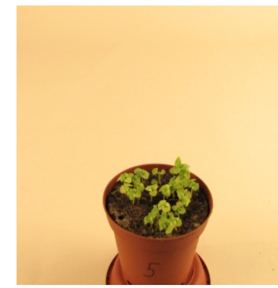
100 % Peat

50 % Peat
50 % Hydrochar 1



100 % Hydrochar 1

50 % Peat
50 % Hydrochar 2



100 % Hydrochar 2

Growth of basil in substrates with Hydrochar

(Neumaier et al. 2017)

Peat substitutes in practice

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100 vol.% peat

50 vol.% cocopeat
35 vol.% wood fibre
15 vol.% compost

35 vol.% wood fibre
15 vol.% compost
20 vol.% perlite
30 vol.% spahgnum

100 vol.% peat

50 vol.% cocopeat
35 vol.% wood fibre
15 vol.% compost

35 vol.% wood fibre
15 vol.% compost
20 vol.% perlite
30 vol.% spahgnum

30 vol.% cocopeat
20 vol.% wood fibre
50 vol.% perlite

50 vol.% cocopeat
50 vol.% perlite

50 vol.% wood fibre
50 vol.% perlite

30 vol.% cocopeat
20 vol.% wood fibre
50 vol.% perlite

50 vol.% cocopeat
50 vol.% perlite

50 vol.% wood fibre
50 vol.% perlite

Saintpaulia ionantha **and** ***Petunia-Cultivars*** **in different substrates**

(Emmel and Ahrens, 2019)

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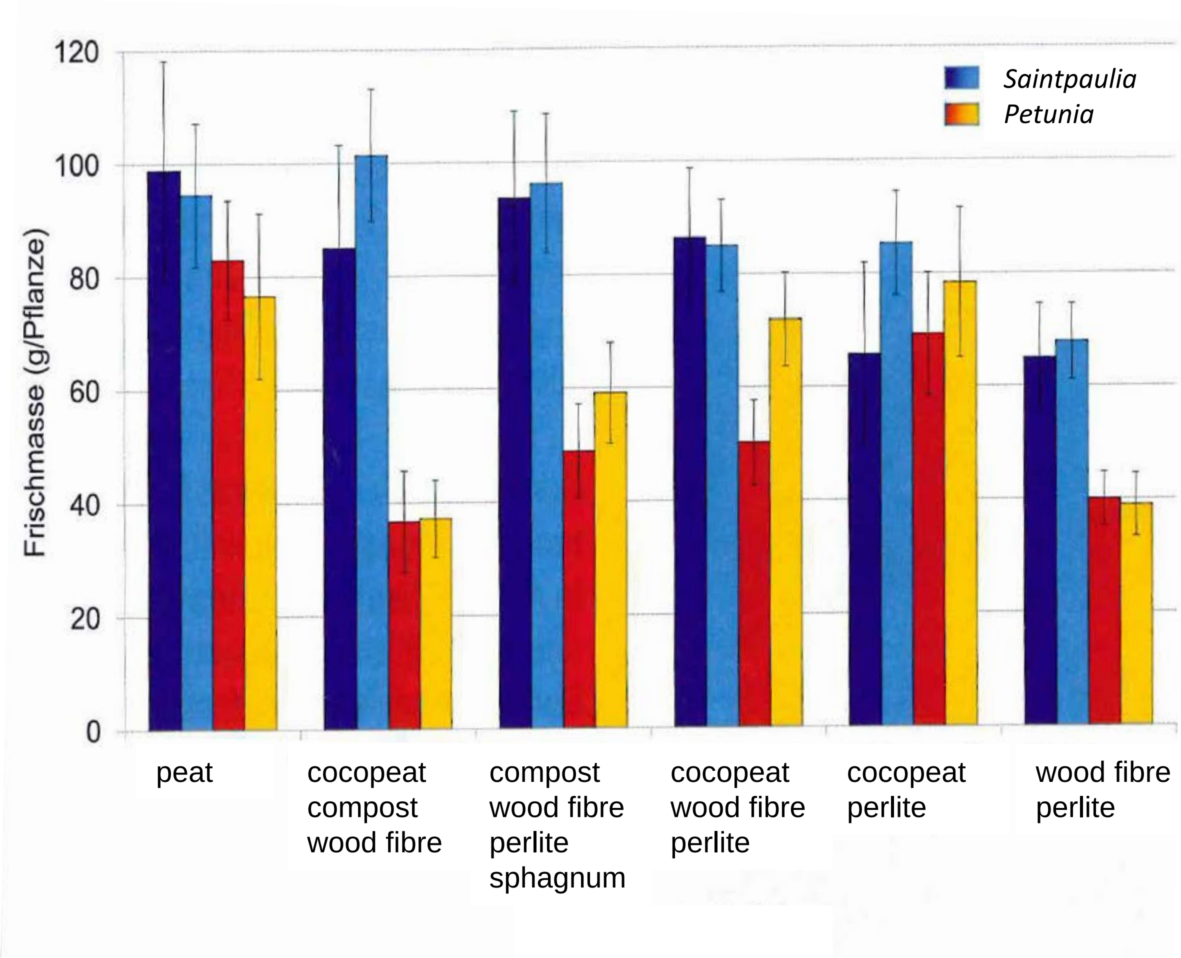
Peat substitutes in practice



Fresh matter of *Saintpaulia ionantha* and *Petunia-Cultivars* in different substrates at the end of trial (Emmel and Ahrens, 2019)

Peat substitutes in practice

Suggestions for use

Peat substitute	Ratio (vol.-%)	Ideal mixing partner
Bark compost	up to 50	Fine materials
Green compost	20 – 40	Nutrient-poor materials with low pH-value
Compost of digestate	up to 10 %	Materials with low salt and P content
Wood fibre	20 – 40	Materials with low biological activity and fine structure
Cocofibre	up to 20	Fine materials
Cocopeat	up to 100	–
Xylit	20 - 40	Green and bark compost, wood fibre

Peat substitutes in practice

100 vol. % Peat

50 vol. % Cocopeat
30 vol. % Green compost
20 vol. % Cocofibre

- 9.5 mio m³ peat p. a. ⟷ 1.0 mio m³ peat substitutes p.a.
- Germany, 2019, use of:
  500.000 m³ green compost
  300.000 m³ wood fibre
  235.000 m³ bark compost
  150.000 m³ coco products

(Gugenhan, 2019)

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Peat substitutes in practice

- Peat substitution for ornamental plants is possible
- Apart from cocopeat, all substances are only possible in mixtures with different proportions
- Culture management (irrigation, fertilization) must be adapted to the substrate properties
- Precise knowledge of the components used is a prerequisite
- High quality products are important (quality assured products)
- Substrates are not a waste bin
- Caution with "exotic" materials
- The availability of peat substitues in sufficient quantities and with a competitive price is not guaranteed in the future

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All pictures, except explicitly marked : HSWT (University of applied sciences Weihenstephan-Triesdorf, Institute for Horticulture, Group for Plant nutrition and soil science)