Application of biochar and green compost in cascade

Bart Vandecasteele (ILVO)

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EJP SOIL
European Joint Programme

Interreg
North Sea

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Outline

1. Introduction: circular horticulture
2. Cascade: Wood-based biochar in horticultural substrates
3. Cascade: Biochar from spent horticultural substrates
4. Cascade: Green compost in horticultural substrates
5. Conclusions

1. Introduction: circular horticulture


PLANTS

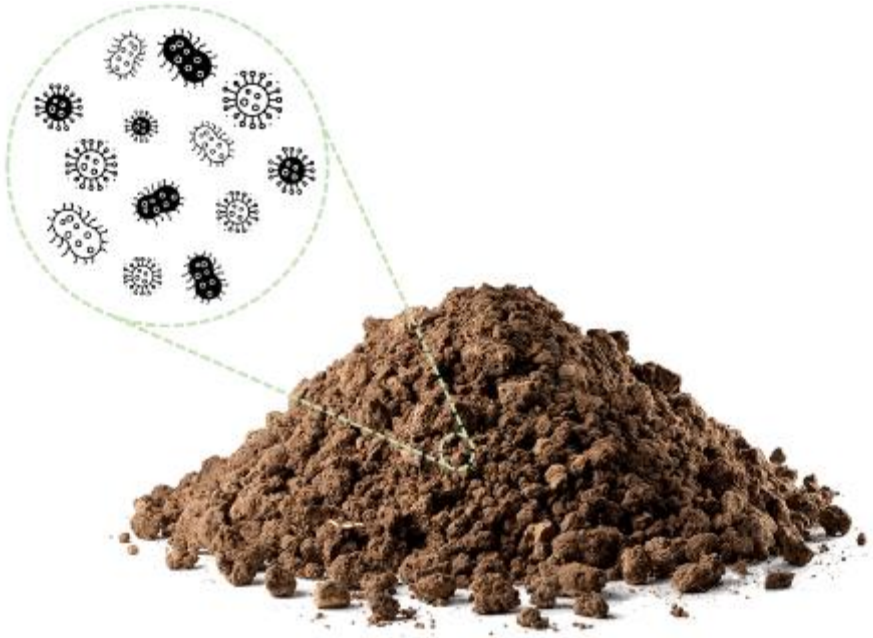
Renewable and stable C

Renewable and stable C

Circular horticulture: new challenges

New materials

- Wood and bark products
- Plant fibers
- Biochar



New isues

- Microbial: stability, N immobilization, …
- nutrients

New strategies

- Reuse of (processed) growing media
- Spent growing media => end-of-life: organic soil improver

Focus

Cascade

- Use of biomass in cascade to avoid competition for C
- ~~The Cascade Principle~~ (a structured hierarchy)

Chemical characteristics, C content and C stability

~~Pollutants~~

Peat-based => peat-reduced => peatfree horticultural substrates

Questions?

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2. Cascade: Wood-based biochar in horticultural substrates

Biochar in growing media

Different functions:

g/L	Disease suppression
	Carrier for biocontrol organisms or nutrients
	Liming agent
1 vol%	Fertilizer
5 vol%	Perlite replacement
10 vol%	Bulk material in horticultural substrate
100 vol%	Stand-alone horticultural substrate
	Biochar as an upcycling strategy
	Biochar as a cleanup method (pollutants & pathogens)

Or part of system:

Pyrolysis = heating and CO_2 for greenhouse + biochar for growing media

Direct wood-based biochar application in the soil

wood-based biochar

Application of spent horticultural substrates with wood-based biochar in the soil

Spent horticultural substrates with biochar

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Cas(cad)e study 1

Full scale trials

- Spent growing media from 2 full-scale greenhouse trials at PCFruit (2021 and 2022):
  - Peat-reduced (50% v/v peat) with 25% v/v green compost and 25% v/v wood fiber
  - Peat-reduced + 10% v/v wood-based biochar
  - Peat-free: 25% v/v green compost, 25% v/v wood fiber, 20% v/v plant fiber, 30% v/v bark compost
  - Peat-free + 10% v/v wood-based biochar

Added value of green compost in growing media

- High microbial biomass => improved nitrification
- Fertilizer replacement: P and K
- Lime replacement
- Peat replacement

Make biochar, not war

Wood-based biochars:

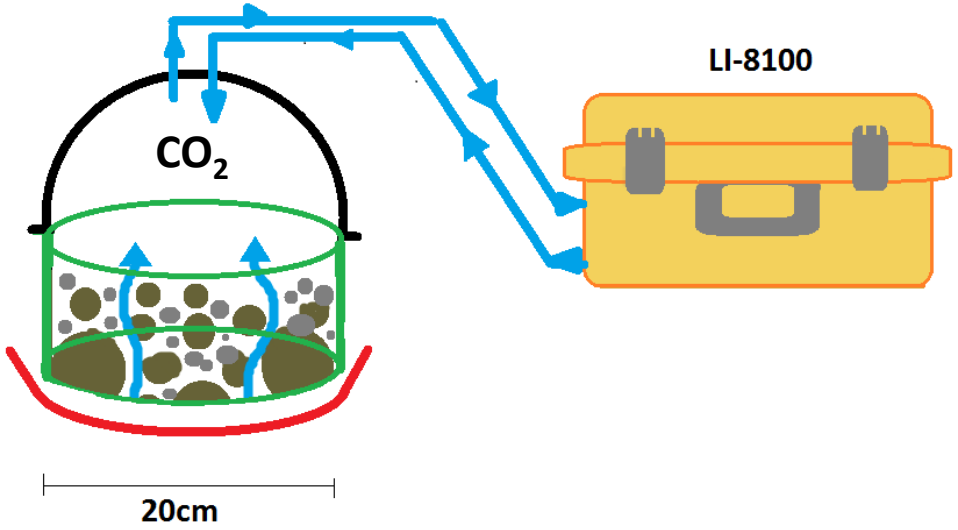
Very stable and ‘predictable’

Pellets or coarser material: can maintain the structure of the substrate

Method for “cleaning” biomass

Circular material + C-storage?

CO_2 emission or 0_2 consumption for screening biological stability



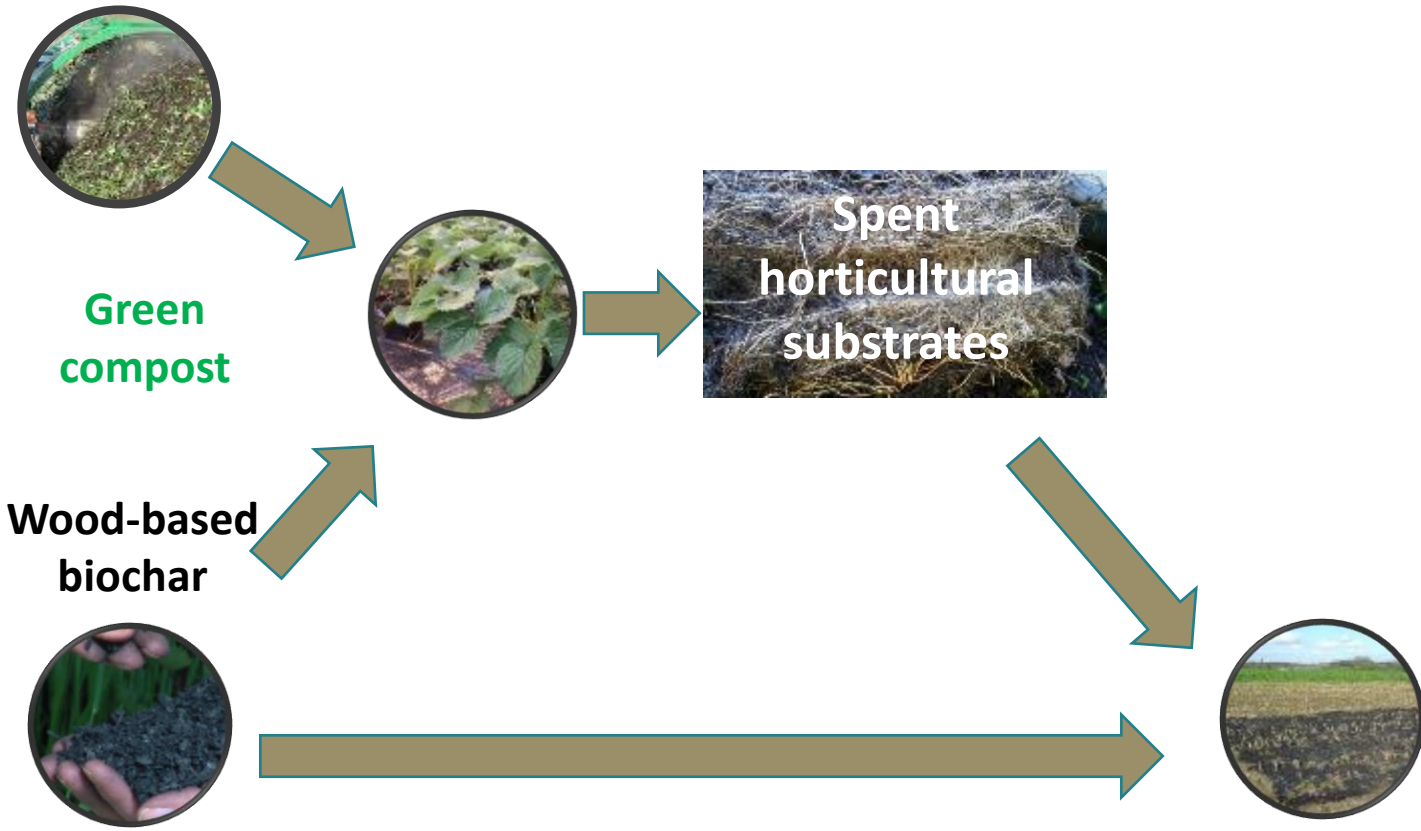
Unstable

Stable

- High CO_2 release
- Low CO_2 release

- High O_2 uptake
- Low O_2 uptake

		Spent horticultural substrates	Composted spent horticultural substrates	Biochar from spent horticultural substrates
Number		8	8	8
Organic C	g /kg dry matter			
InorganiC C	g /kg dry matter			
CO_2 release	mmol CO_2/kg C/h			
C/P ratio	-			
total CEC	cmolc/kg dry matter			



		Spent horticultural substrates without biochar	Spent horticultural substrates with biochar
Number		4+4+4	4+4+4
Organic C	g /kg dry matter	282	**349**
InorganiC C	g /kg dry matter	1.1 a	0.9 a
CO_2 release	mmol CO_2/kg C/h	3.0	**2.1**
C/P ratio	-	95	115
total CEC	cmolc/kg dry matter	56	51

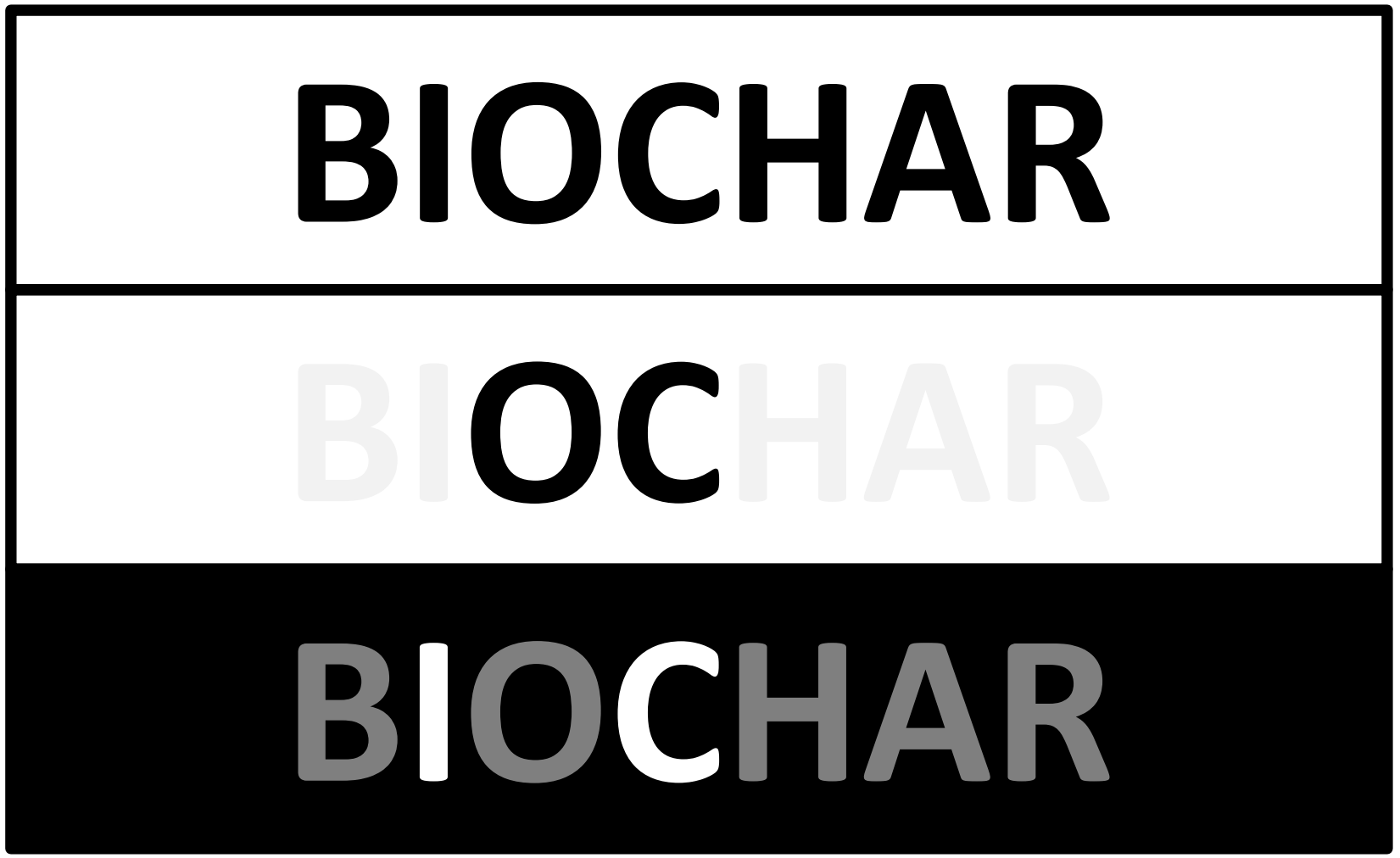
Cas(cad)e study 1: conclusions

Processing spent horticultural substrates

- Spent organic growing media: rich in stable C
- Added value of composting: only for sanitation goals
- Added value of conversion to biochar?
  - Renewable energy
  - Sanitation, cleaning method
  - Higher inorganic C contents?
  - no higher C stability?
  - No increase in organic C, C/P or CEC

Added value of biochar in spent growing media

- Already effect at 10% v/v biochar => higher C content + higher C stability
- Extra C of biochar is still present in (processed) spent growing media
- Confirmation of previous research on biochar in spent peat-reduced and peat-free substrates: https://doi.org/10.1007/s10705-023-10315-8


BIOCHAR
BIOCHAR
BIOCHAR

Questions?

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3. Cascade: Biochar from spent horticultural substrates

Direct wood-based biochar application in the soil

wood-based biochar

Application of biochar from spent horticultural substrates in the soil

Biochar from spent horticultural substrates

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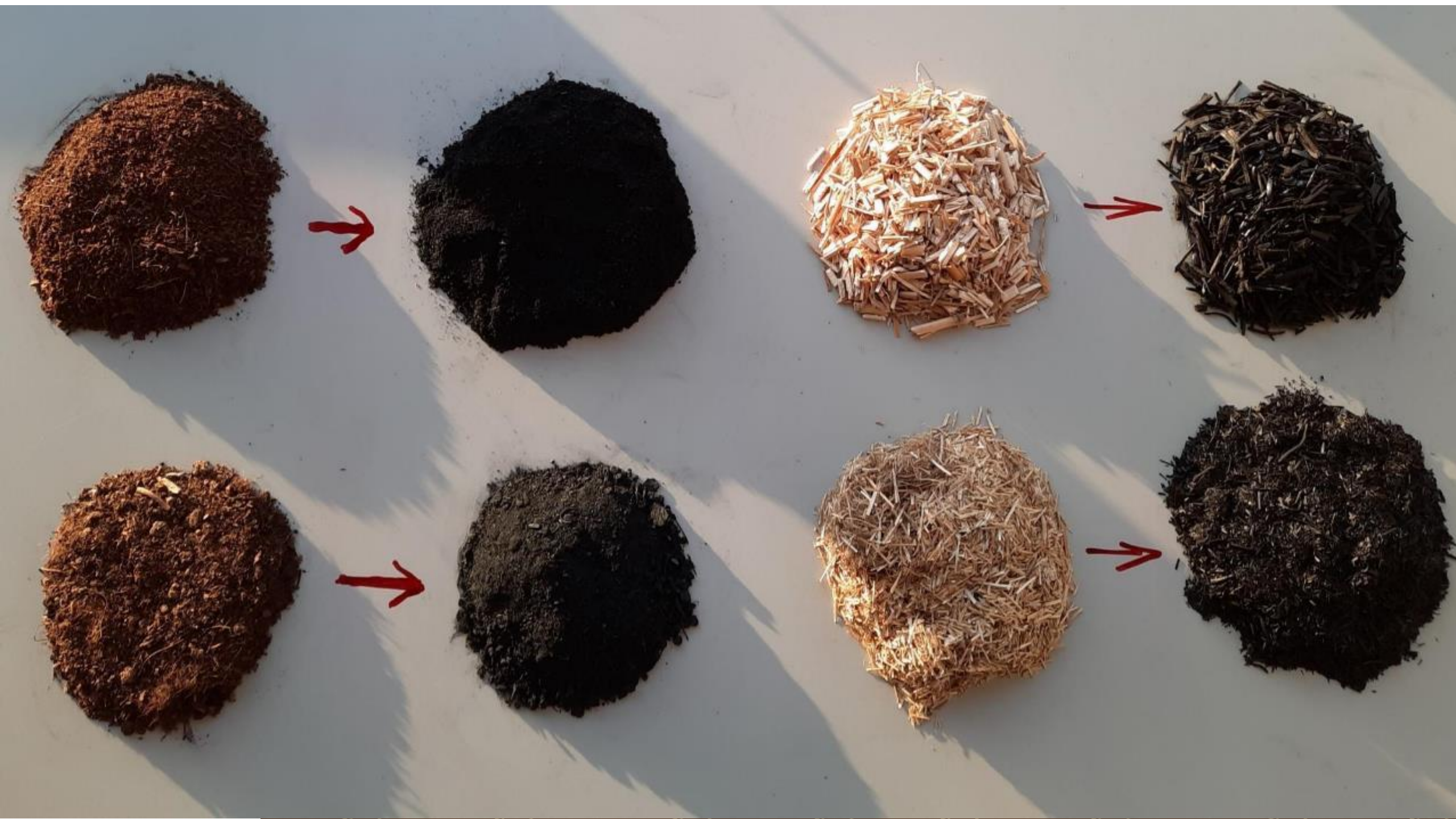
Cas(cad)e study 2

Scenario: wood-based biochar vs. biochar from spent growing media

- 12 wood-based vs.
- 4 bark-based vs.
- 6 fiber-based biochar vs.
- Biochar from spent growing media:
  - 7 Peat-based
  - 8 Peat-reduced or Peat-free



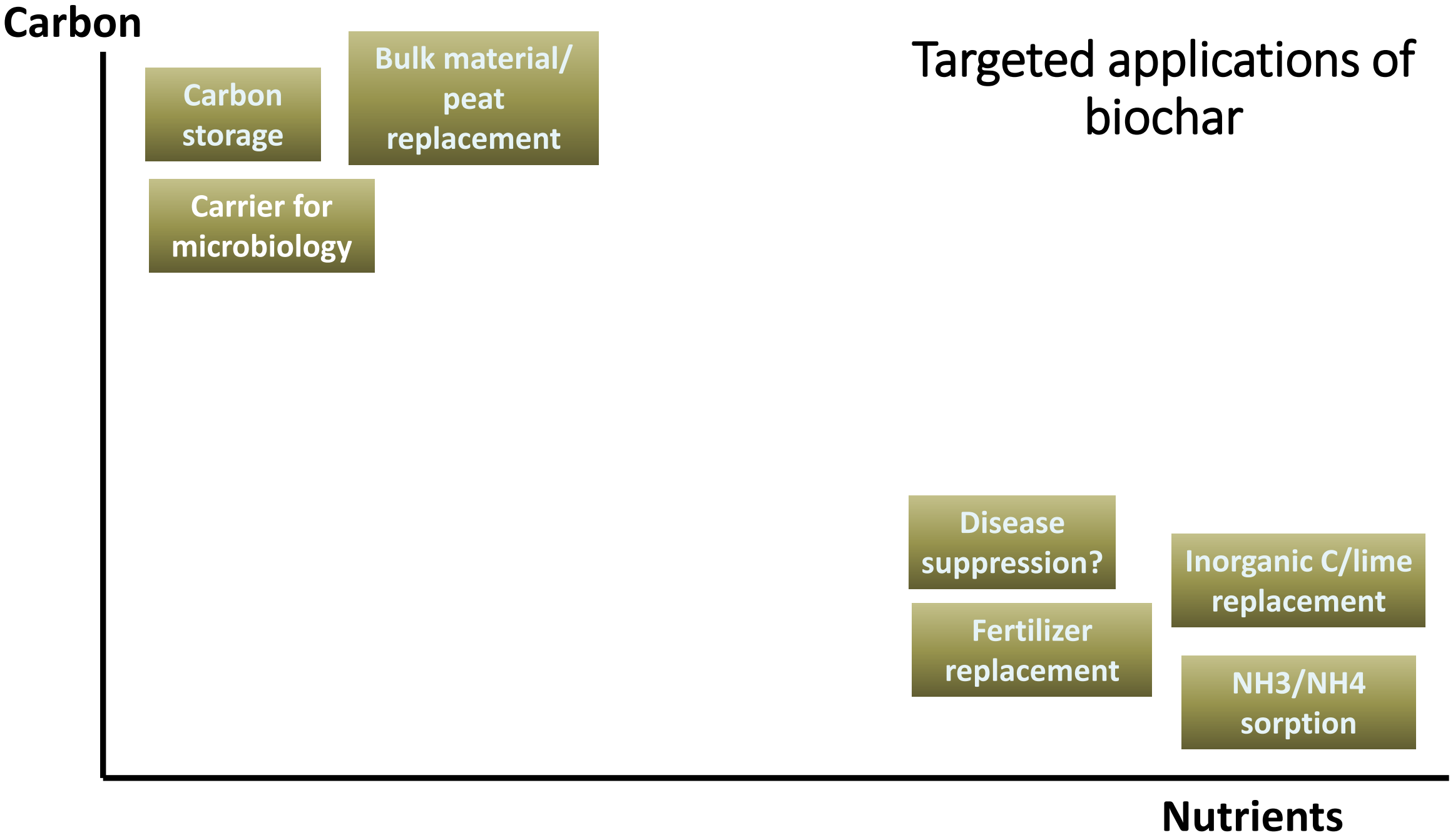
		wood-based biochar	Bark biochar	Biochar from plant fibers	Biochar from peat-based substrates	Biochar from substrates with green compost
Number		11	4	6	7	8
Organic C	g /kg dry matter	**803 b**	**790 b**	**793 b**	**686 b**	284 a
InorganiC C	g /kg dry matter	1.0 ab	0.5 a	1.2 ab	3.3 b	3.3 b
Oxygen Uptake Rate	mmol O_2/kg OM/h	1 a	1 a	1 a	2 a	**8 b**
C/P ratio	-	**616 cd**	**715 d**	**392 bc**	279 b	81 a
total CEC	cmolc/kg dry matter	25	19	33	30	29

Cas(cad)e study 2: conclusions

Processing spent horticultural substrates into biochar

- Biochar from bark or plant fibers are good alternatives for wood-based biochar
- Stability of biochars from spent organic growing media:
  - Risk for lower biological stability when produced at 450°C or lower
  - higher biological stability when produced at 500°C or higher
- Inorganic C contents
  - spent organic growing media: high in Ca and Mg
  - inorganic C is formed during pyrolysis/gasification
  - Both for peat-based and peat-reduced spent growing media

Targeted applications of biochar



Debode *et al. Biochar* (2024) 6:91
https://doi.org/10.1007/s42773-024-00368-5

Biochar

RAPID REPORT Open Access

Wood-based biochars produced at low pyrolysis temperatures are good carriers for a *Trichoderma*-based biopesticide

Jane Debode[1*], Jarinda Viaene[1], Kristof Maenhout[1], Lisa Joos[1,2], Soraya C. França[3], Ann Cuypers[4] and Bart Vandecasteele[1]

Abstract

The goal was to investigate biochars' potential as carrier for commercial *Trichoderma*-based biopesticides, facilitating their application in soil or growing media. Thirty-five biochars produced from various feedstocks and pyrolysis temperatures were chemically characterized. Incubation and cold storage tests using a commercial *Trichoderma*-based

https://doi.org/10.1007/s42773-024-00368-5

Questions?

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4. Cascade: Green compost in horticultural substrates

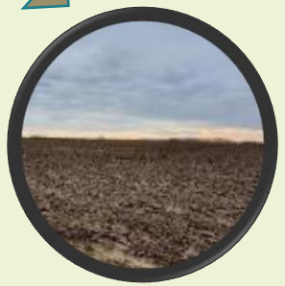

End-of-life of organic
horticultural substrates?

Direct green compost application in the soil

Green compost

Application of spent horticultural substrates with green compost in the soil

Green compost



Cas(cad)e study 3

Scenario 1: green compost vs. spent growing media

- 16 green compost and woody compost from commercial composting plants
- Spent growing media from 8 full-scale greenhouse trials or from growers:
  - 19 Peat-based
  - 15 Peat reduced:
    - 7 Peat-reduced with green compost (10-25% v/v), wood fiber, plant fiber, bark compost, coir
    - 8 Peat-free with green compost (10-25% v/v), wood fiber, plant fiber, bark compost, coir
- 12 composted spent growing media

		Green compost	Peat-based spent horticultural substrate	spent horticultural substrates with green compost	Composted spent horticultural substrates
Number		16	19	15	12
Organic C	g /kg dry matter	242 a	**445 c**	**354 b**	**354 b**
Inorganic C	g /kg dry matter	2.3 c	0.5 a	1.1 b	0.9 b
CO_2 release	mmol CO_2/kg C/h	7 b	**1 a**	**2 a**	**2 a**
Oxygen Uptake Rate	mmol O_2/kg OM/h	6 b	**2 a**	**2 a**	**2 a**
C/P ratio	-	126a	**542 b**	231 a	161 a
total CEC	cmolc/kg dry matter	41 a	**97 c**	**63 b**	**73 b**

Questions?

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5. Conclusions

Renewable biomass: use it wise thus use it twice?

Green compost

- green waste => composting => product
- Bulk material in horticultural substrates, can replace lime and fertilizers
- Then use spent horticultural substrates as C-rich soil improver

Biochar

- Feedstock => Pyrolysis/gasification => products
- Renewable energy + CO_2 + biochar
- Biochar: bulk material in horticultural substrates
- Then use spent horticultural substrates as C-rich soil improver
- C stability: direct vs indirect, and short- versus long-term (priming effects)

Cas(cad)e study: Circular horticulture + soil application

Renewable horticultural substrates vs. green compost

- Higher C content and higher C stability
- Lower inorganic C content: Lower lime replacement value
- More C per unit P
- No dead matter: both are a source of microbial biomass

Biochar from spent horticultural substrates vs. wood-based biochar

- Biochar from bark or strawlike fiber = wood-based biochar
- Peat based biochar > renewable substrate based biochar
- Higher inorganic C content: higher lime replacement value
- Biochars from horticultural substrates produced at 400-450°C: lower C stability
- C per unit P: variable but still high

Circular horticulture vs. Soil-friendly practices

There is a link!
Spent organic horticultural substrates =
C-rich soil improver

Using biochar and green compost in a cascade
Avoids competition for this biomass

More info?

Biochar in growing media

Webinar: https://www.youtube.com/watch?v=R9kB-F54Tow

Paper: Towards environmentally sustainable growing media for strawberry cultivation: Effect of biochar and fertigation on circular use of nutrients - ScienceDirect **(open access)**

Microbial activation of biochar

Webinar: https://www.youtube.com/watch?v=_qdJGDUvZ_4

Paper: S-enhanced microbial activation of biochars and processed grass fibers for circular horticulture - ScienceDirect **(open access)**

The repeatability of reusing horticultural substrates

Webinars:

https://youtu.be/McoTPzB-47Q?si=R1Qsp_S6udXyk9Dt

https://youtu.be/6Qdt0UU9bzQ?si=He4jNqQiUuFds_DN

https://youtu.be/EFb9Iid-2Mg?si=e0TWbg_v0vqN4TaH

https://youtu.be/Tl3SFJ2VUmY?si=yYcjLHxr4Q4RgNqq

Questions?

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