From waste to fertilizer

Biotic strategies to increase the P fertilizer value of ashes and biochars?

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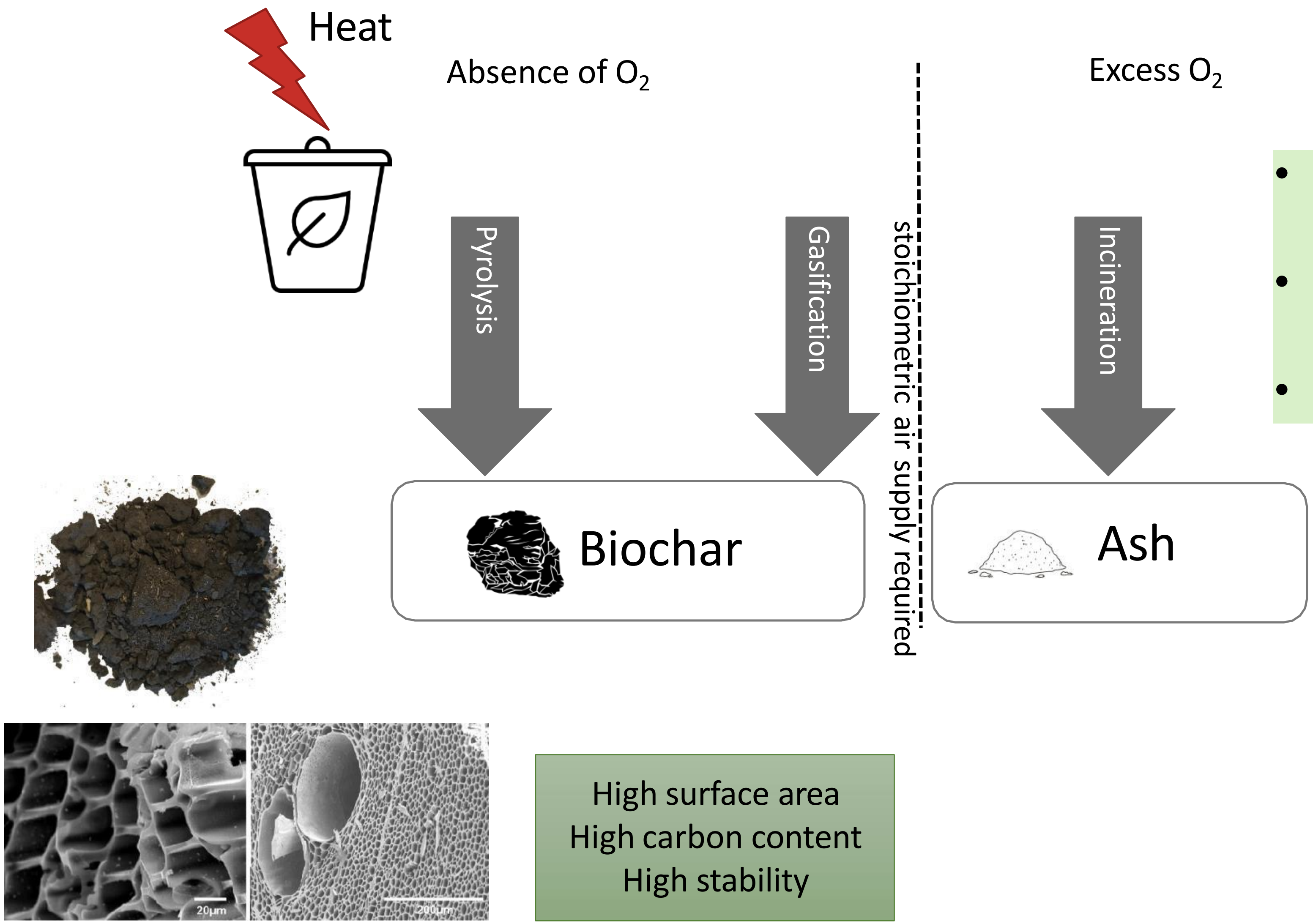
Thermal treatment of phosphorus-rich organic wastes



- Volume reduction
- Destruction of contaminants
- Stable C for sequestration

P availability after thermal treatment

- Crystalline, insoluble P compounds formed during thermal treatment
- Mainly Ca-phosphates or Al/Fe phosphates depending on elemental composition of feedstock

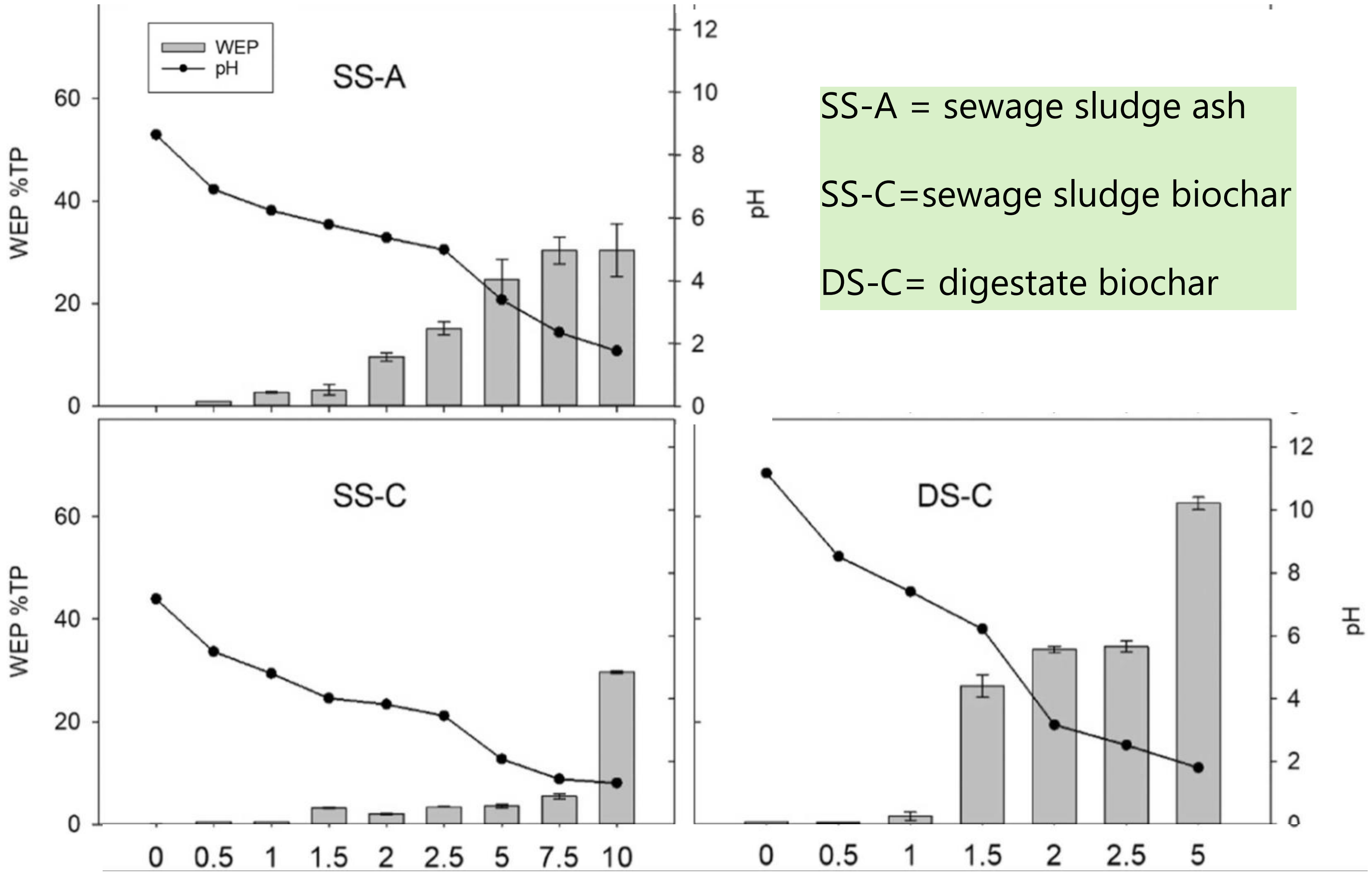
→ Often **low P availability from biochars and ashes** depending on feedstock, temperature during thermal treatment and soil properties like soil pH

How to increase P availability?

- P species are soluble at low pH (especially Ca species) or high pH (Fe and Al species)

→pH modifications to increase P availability

Acid solubilization



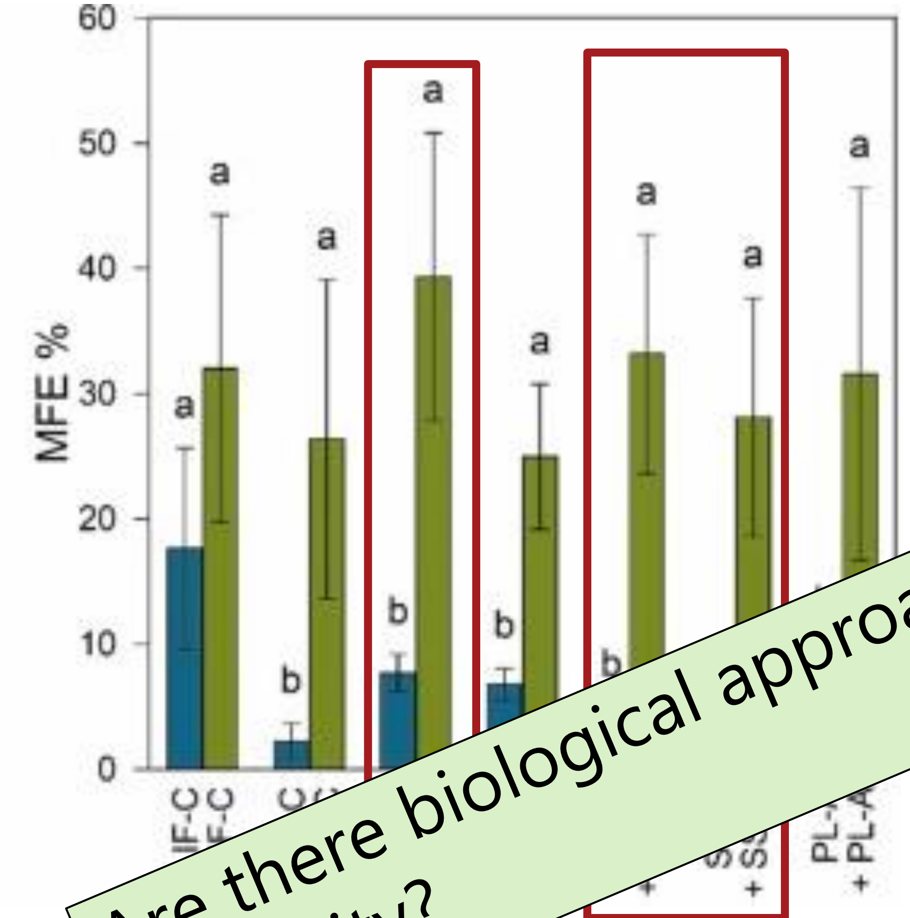
Sulfuric acid molarity

SS-A = sewage sludge ash

SS-C=sewage sludge biochar

DS-C= digestate biochar

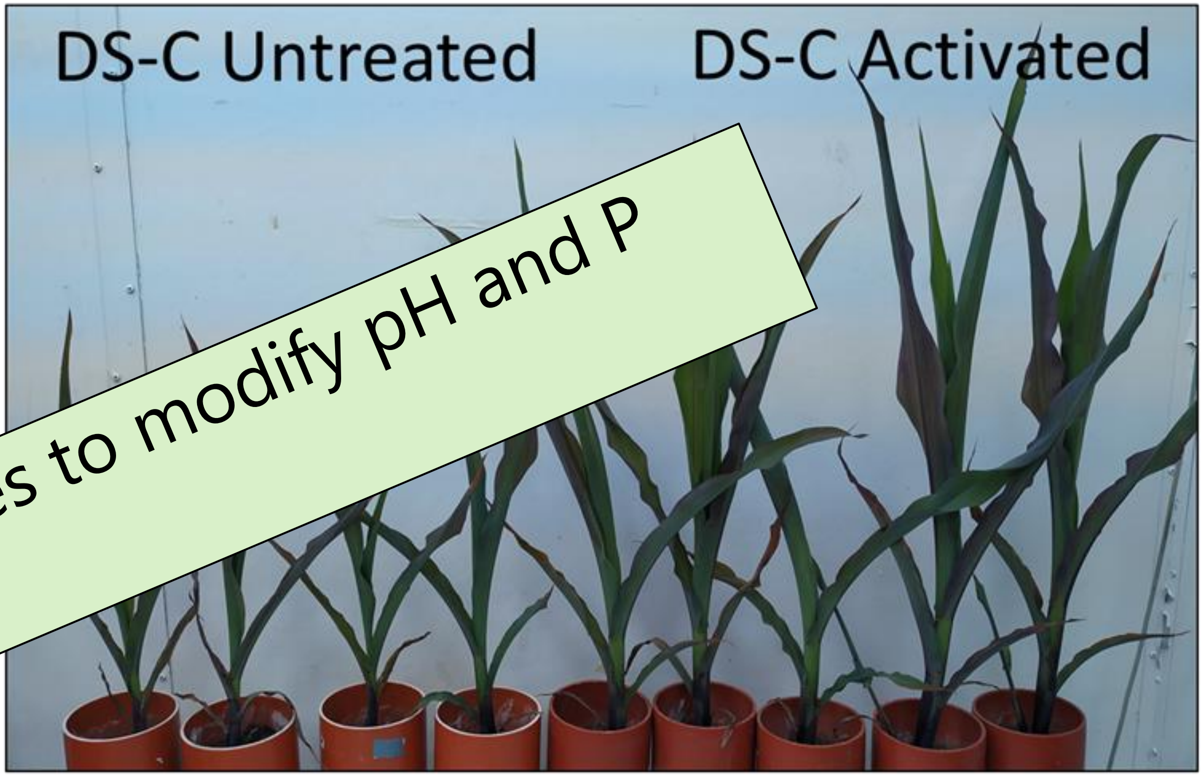
Kopp et al. 2023



Are there biological approaches to modify pH and P solubility?

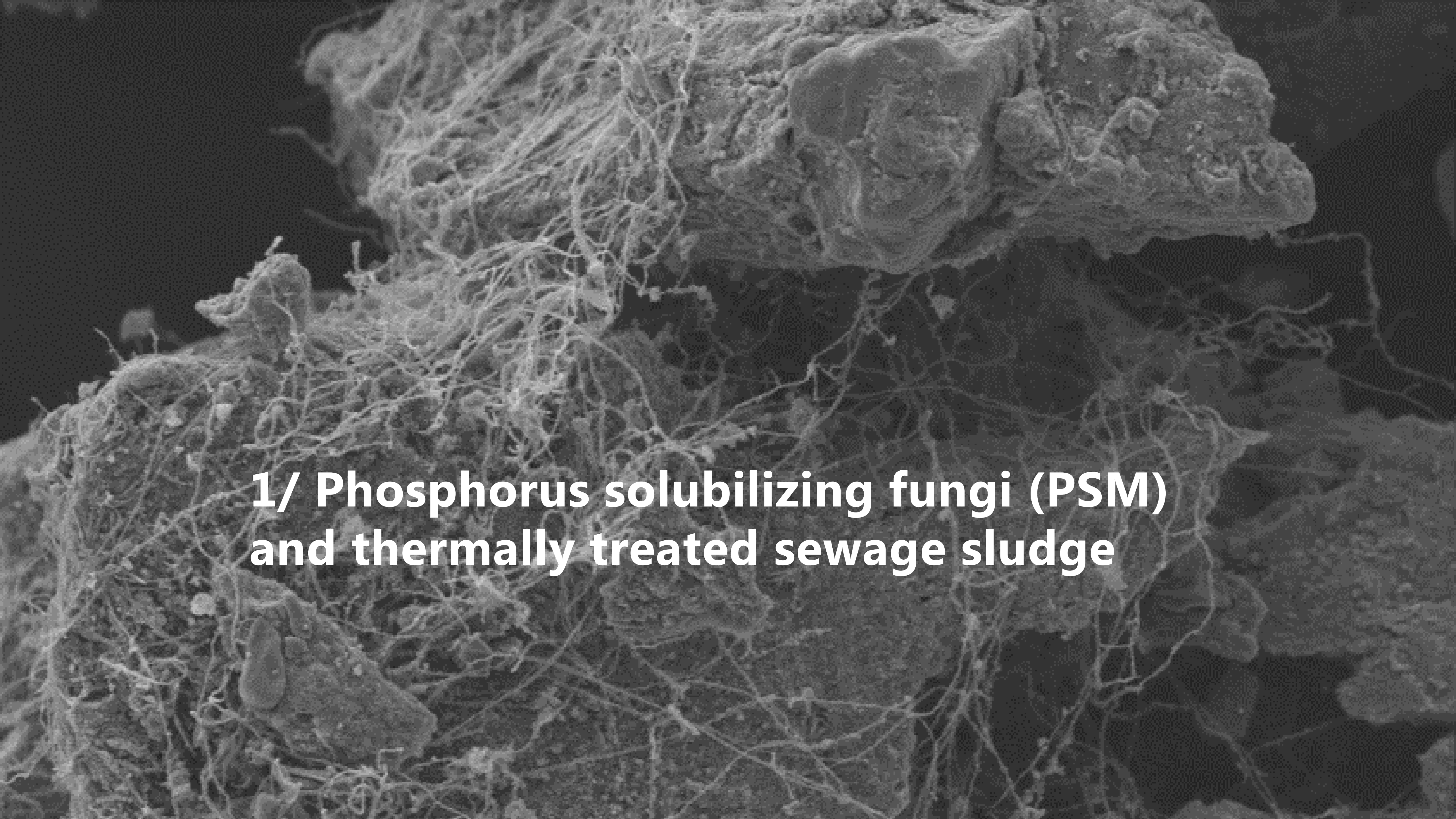
5 M 7.5 M 10 M

+=acidified



Kopp et al. 2023

- Problematic to handle
- Corrosive
- Not allowed in organic farming

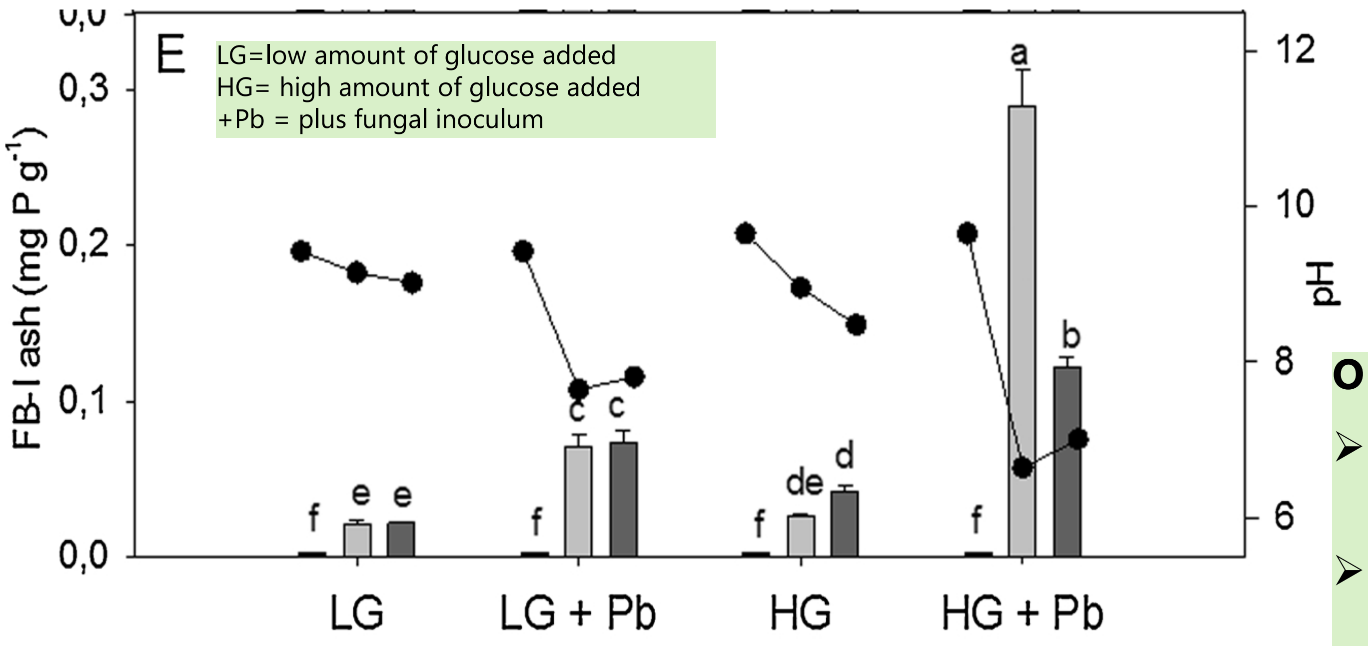


1/ Phosphorus solubilizing fungi (PSM) and thermally treated sewage sludge

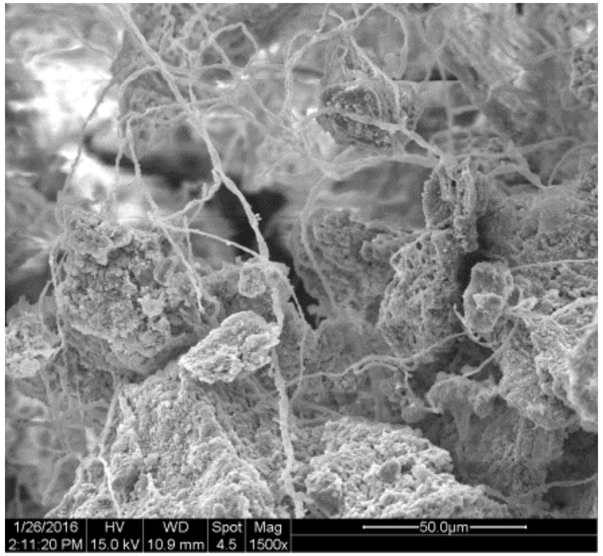
1/ Can thermally treated sewage sludge be colonised by PSM? Is any P-solubilisation occurring?

Methods:

- solid state incubation
- Material characterisation



Raymond et al. 2018



Outcomes:

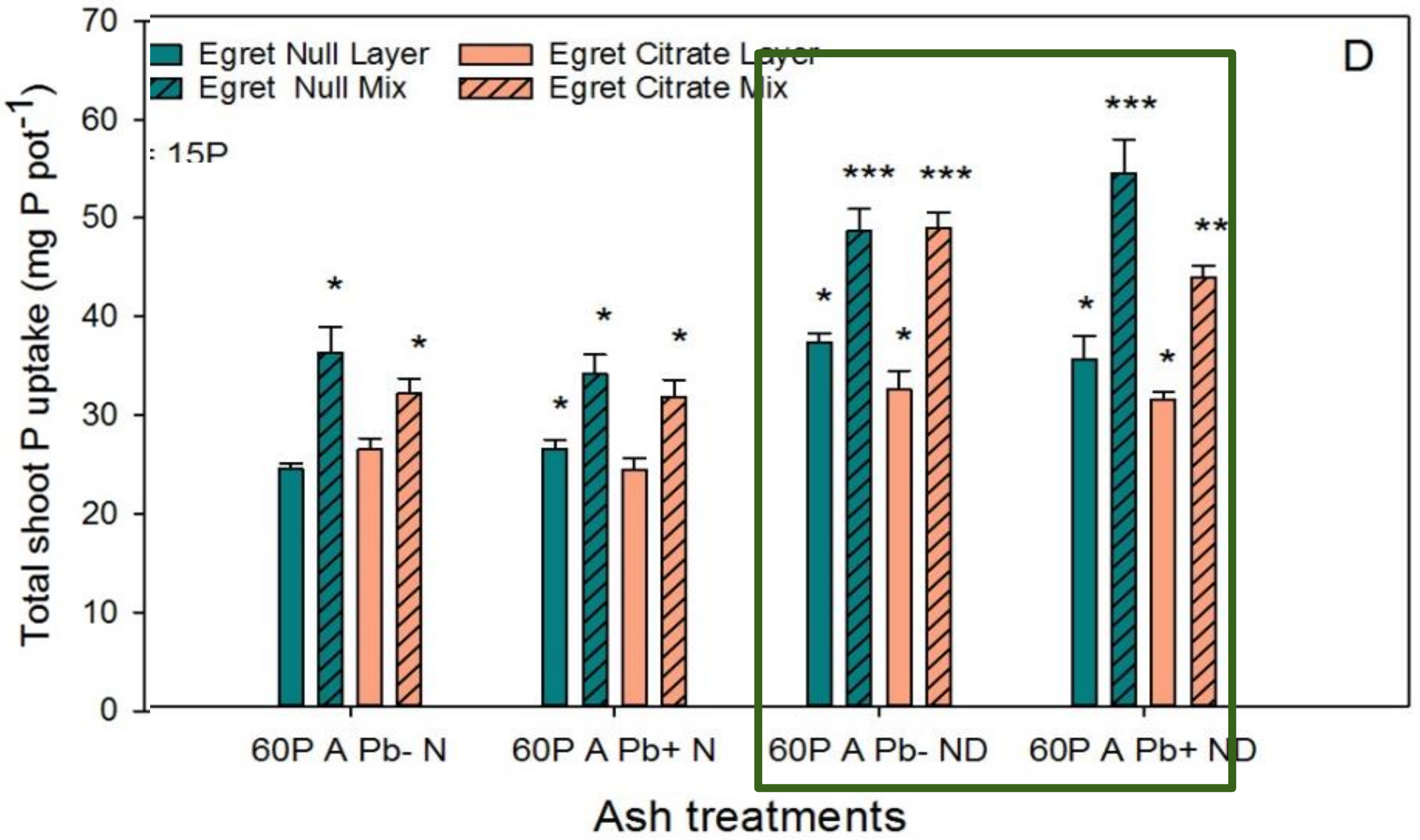
- Glucose, biochar/ash pH and total N affected *P.bilaiae* colonisation.
- On three of the tested ashes and biochars, *P.bilaiae* increased P-availability by acidification
- Greatest P-solubilisation on sewage sludge ash

Pot experiment with inoculated SS ash

Methods:

- Different biotic strategies to improve ash-P plant availability in soil:
    - Pre-treatment of the ash with *P.bilaiae*
    - Ash placement in soil
    - N-fertilisation: use of ammonium (plus nitrification inhibitor) to stimulate rhizosphere acidification
    - (Two different wheat lines)

Results: Total shoot P-uptake



- No effect of ash pre-treated with *P. bilaiae*
- Major effects: Ash placement:N-fertilisation → Mix:NH_4 > Layer:NH_4 > Layer/Mix:NH_4NO_3

Raymond et al. 2019

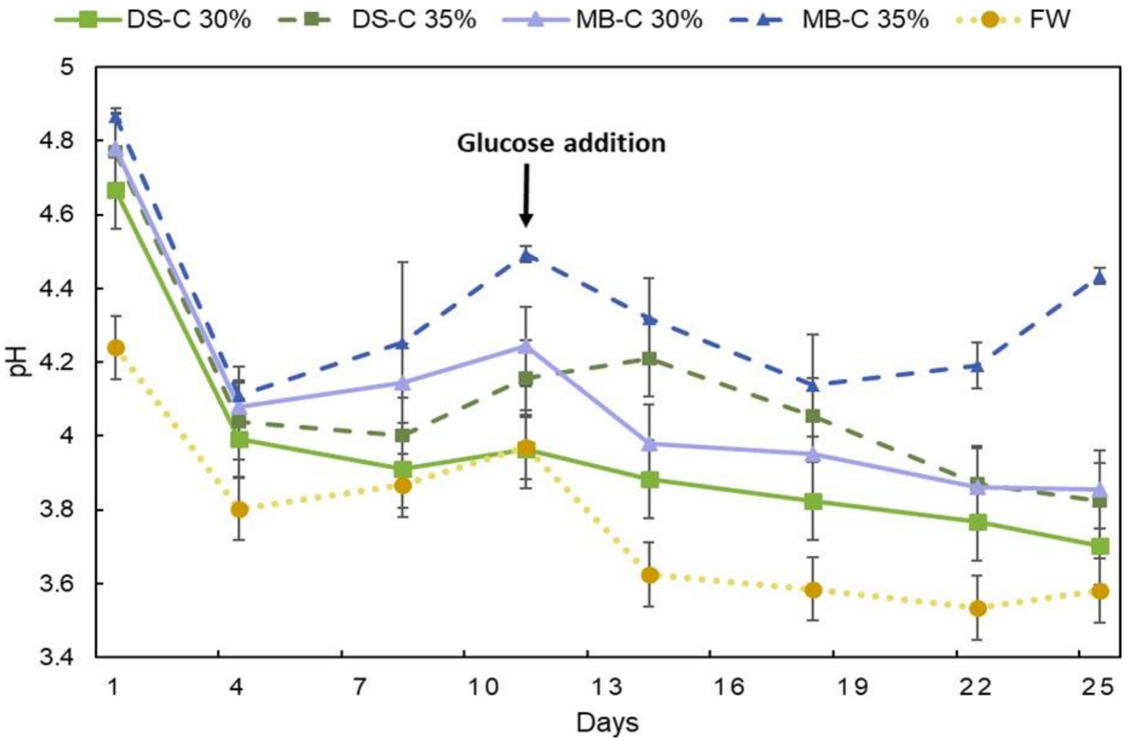
Preliminary conclusions

Positive effect of P-solubilising fungi on sewage sludge ash on P-availability *in vitro*

We could not conclude on any additional beneficial effect of the inoculation of P-solubilising fungi on the sewage sludge ash on plant growth and P-uptake

Too little initial P solubilization – which processes occurred in soil?
Sewage sludge products not suitable?

2/: "Bioacidification"- liquid state fermentation of biochar substrates with naturally occurring acidifying microorganisms



Kopp et al., accepted

Substrate: liquefied food waste (FW)

DS-C: digestate solid biochar

MB-C: meat- and bonemeal biochar

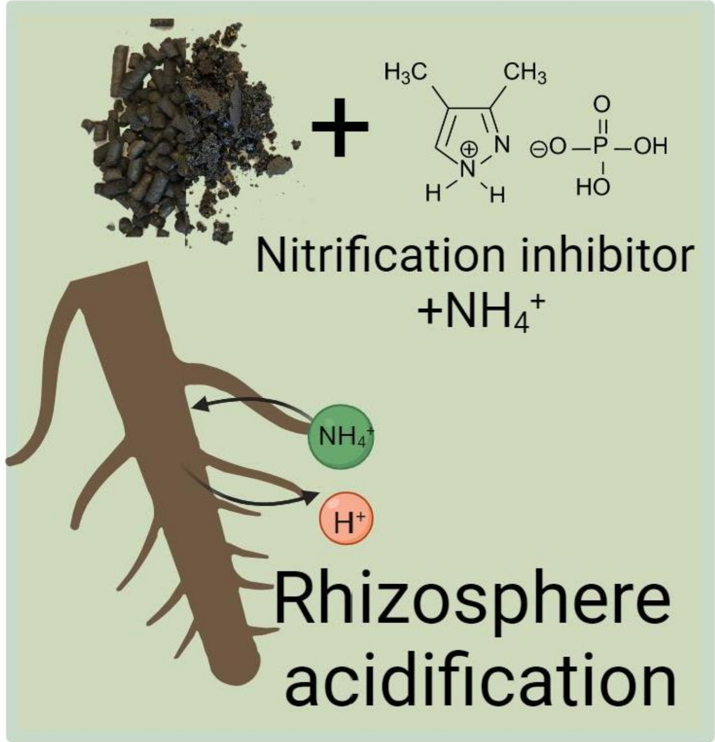
BA=bioacidified, SA= sulfuric-acid acidified

	Digestate biochar			Meat/bone biochar		
	-	BA	SA	-	BA	SA
Total P (mg /g)	26.6	8.8 ↓	20.5	106.9	28.1 ↓	85.2
WEP % TP	0.2	34.2 ↑	28.4	0.3	33.0 ↑	39.4

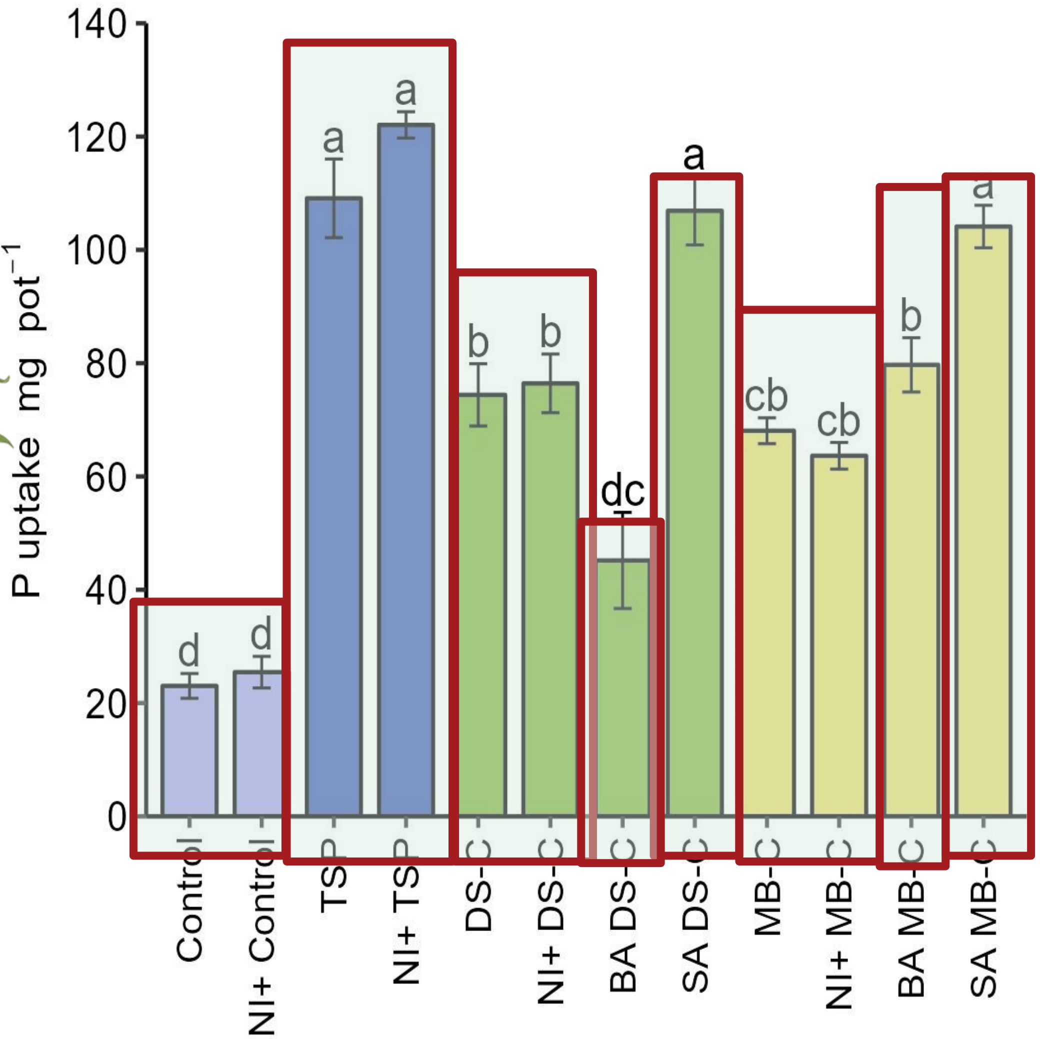
Pot experiment with maize

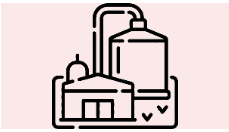
Digestate char (DS-C)

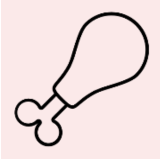
Meat and bone meal char (MB-C)



Pot study







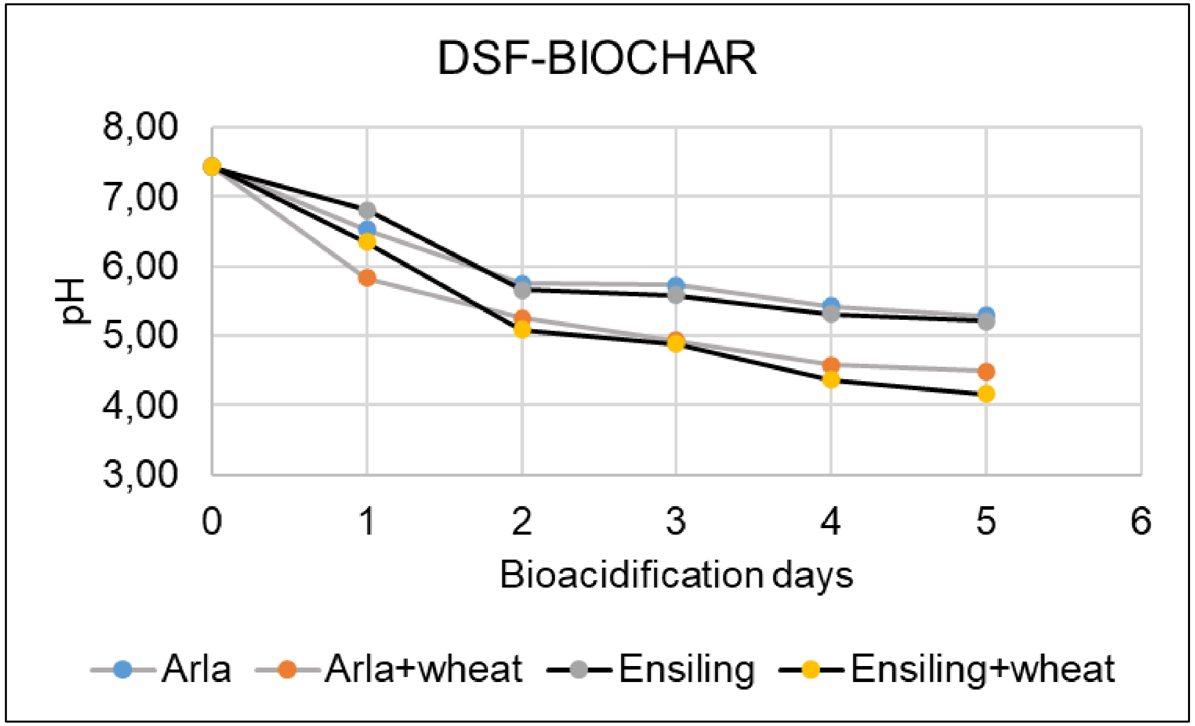
- **Nitrification** inhibitor did not increase P uptake, possibly due to generally low soil pH.
- **SA** increased P uptake to the same level as mineral P
- **Bioacidification** solubilized P, but application of the fermentation substrate with the biochar did induce pH changes and nutrient immobilization, especially for D-SC (low P content)

Kopp et al., accepted

Conclusions

- Tested biological approaches (single strain inoculation, rhizosphere acidification or bioacidification) not effective in soil

- But potential for further development of the approaches, especially fermentation – adding some specific strains, different C sources



Thanks for your attention!