# Phosphorus release from biochars prepared from rice husks, grape pomace and olive tree prunings

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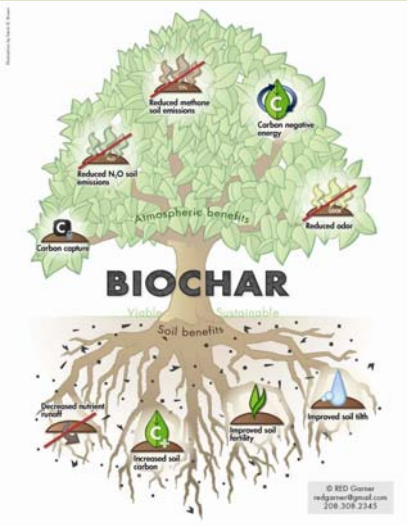
# WHAT IS BIOCHAR?

**Biochar (BC) is a high-carbon solid produced by pyrolysis of biomass and intended for soil applications**




## AGRONOMIC APPLICATIONS

- Biochar increases the capacity of the soil holding water and nutrients reducing the need for fertilizers
- Macro- and micronutrients retained in biochar could be released and made available to the plants
- BC is a potential P soil amendment as reserves of phosphorus-rich ores will become depleted in 30-100 years

## ENVIRONMENTAL APPLICATIONS

- Atmospheric carbon sink mitigating climate change
  - Estimated residence time of carbon in soil: 200-1000 years
- Reduction of $N_2O$ emissions from soil (strong greenhouse gas)
- Adsorbent in water phase (low-grade activated carbon)

# OBJECTIVES

- **Production of biochar via pyrolysis from**
  - Rice husks (RH)
  - Grape pomace (GP)
  - Olive tree prunings (OP)

- **Release of P already present in biochar and raw biomass in water**
  - Batch desorption and successive leaching experiments

- **Do P-leached biochars have the potential to become sorbents of fertilizer P?**

- **Agronomic application of biochar for cultivation of ryegrass**

# EXPERIMENTAL PART

- **Biomass pyrolysis temperature: 300°C and 500°C**

- **Phosphate desorption/leaching tests**
  - **Batch desorption kinetics (Biomass/Biochar : Water = 1:100)**
  - **Successive leaching experiments (4 successive extractions; Contact time: 24 h)**

- **Phosphate sorption experiments**
  - **Completely leached GP-300 and RH-300 biochar samples**

- **Cultivation of ryegrass (*Lolium perenne* L.)**
  - **Two types of soil: Sandy loam, Loam**
  - **Presence (2%) and absence of biochar**
  - **Presence (2%) and absence of compost**
  - **Additional fertilization (N and micro-nutrients) or not**

# RESULTS

## Properties of raw biomass and biochars

| BIOCHARS | Units | Rice husk | | Grape pomace | | Olive tree prunings | |
|---|---|---|---|---|---|---|---|
| | | 300$^0$C | 500$^0$C | 300$^0$C | 500$^0$C | 300$^0$C | 500$^0$C |
| C[a] | % | 44.00 | 35.70 | 46.60 | 19.90 | 50.2 | 31.6 |
| N[a] | % | 2.00 | 0.88 | 1.60 | 0.74 | 1.45 | 0.95 |
| Ash[c] | % | 63.54 | 91.25 | 25.67 | 48.39 | 31.3 | 43.8 |
| pH | | 7.50 | 7.60 | 10.80 | 11.00 | 10.00 | 11.00 |
| EC | µS/cm | 265 | 252 | 1058 | 528 | 204 | 204 |

| RAW BIOMASS | Units | Rice husk | Grape pomace | Olive tree prunings |
|---|---|---|---|---|
| C[a] | % | 37.00 | 49.60 | 55.50 |
| N[a] | % | 0.43 | 2.00 | 0.65 |
| Ash[c] | % | 4.73 | 1.82 | 2.22 |
| pH | | 6.10 | 5.00 | 5.80 |
| EC | µS/cm | 118.6 | 207 | 153.5 |

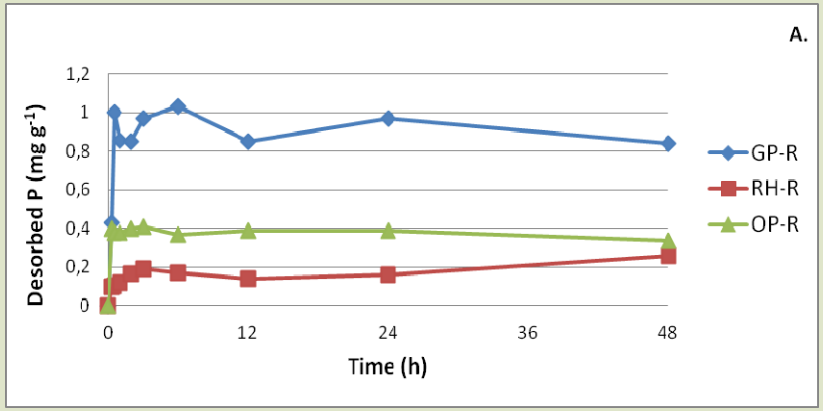
[a] As received basis
[c] Dry basis

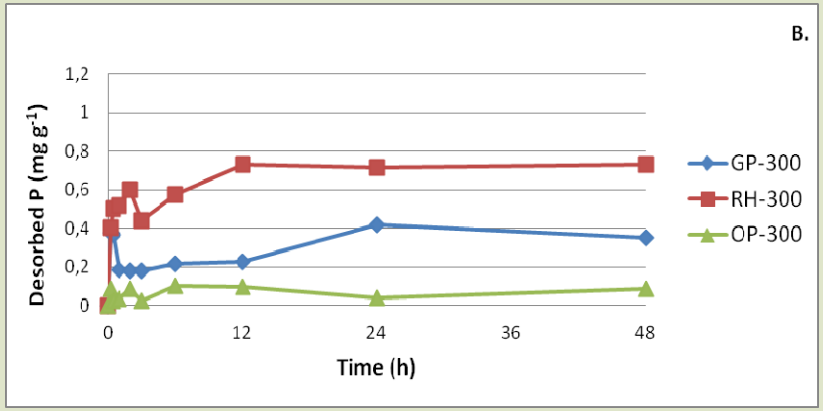
# Nutrient content of raw biomass and biochar samples by ICP-MS

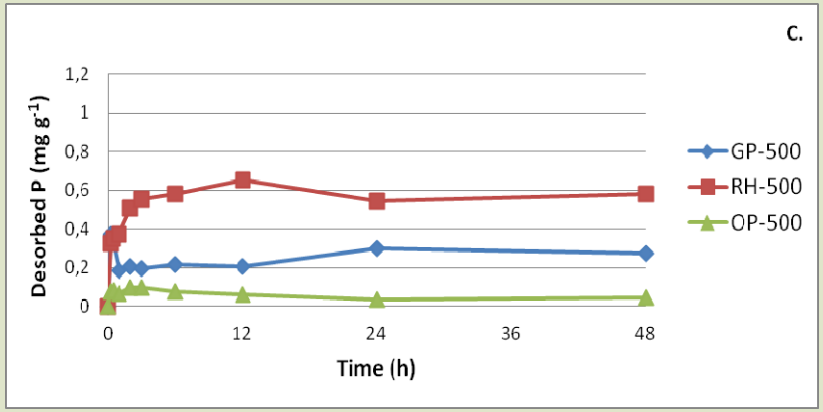
| Nutrient | Units | Raw biomass/Biochars | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | OP-R | OP-300 | OP-500 | RH-R | RH-300 | RH-500 | GP-R | GP-300 | GP-500 |
| P | mg $g^{-1}$ | 0.65 | 4.36 | 5.34 | 0.21 | 1.80 | 3.48 | 0.99 | 3.63 | 5.99 |
| Mg | mg $g^{-1}$ | 0.47 | 5.99 | 6.09 | 0.18 | 0.65 | 1.09 | 0.77 | 4.86 | 6.93 |
| K | mg $g^{-1}$ | 4.95 | 65.9 | 64.2 | 4.5 | 14.5 | 20.5 | 29.1 | 164.7 | 219.2 |
| Ca | mg $g^{-1}$ | 0.11 | 3.18 | 3.18 | 0.01 | 0.04 | 0.07 | 0.10 | 1.13 | 1.72 |
| Mn | mg $g^{-1}$ | 0.01 | 0.17 | 0.16 | 0.09 | 0.34 | 0.35 | 0.01 | 0.12 | 0.17 |
| Fe | mg $g^{-1}$ | 0.03 | 0.53 | 0.62 | 0.01 | 0.08 | 0.18 | 0.06 | 1.75 | 2.64 |
| Cu | mg $g^{-1}$ | 0.00 | 0.05 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 1.02 | 1.37 |
| Zn | mg $g^{-1}$ | 0.01 | 0.15 | 0.13 | 0.01 | 0.02 | 0.00 | 0.01 | 0.09 | 0.15 |

OP-R: Olive tree prunings-Raw biomass; OP-300: Olive tree prunings-Biochar 300; OP-500: Olive tree prunings-Biochar 500; RH-R: Rice husk-Raw biomass ; RH-300: Rice husk-Biochar 300; RH-500: Rice husk-Biochar 500; GP-R: Grape pomace-Raw biomass; GP-300: Grape pomace-Biochar 300; GP-500: Grape pomace-Biochar 500

# Kinetics of P desorption

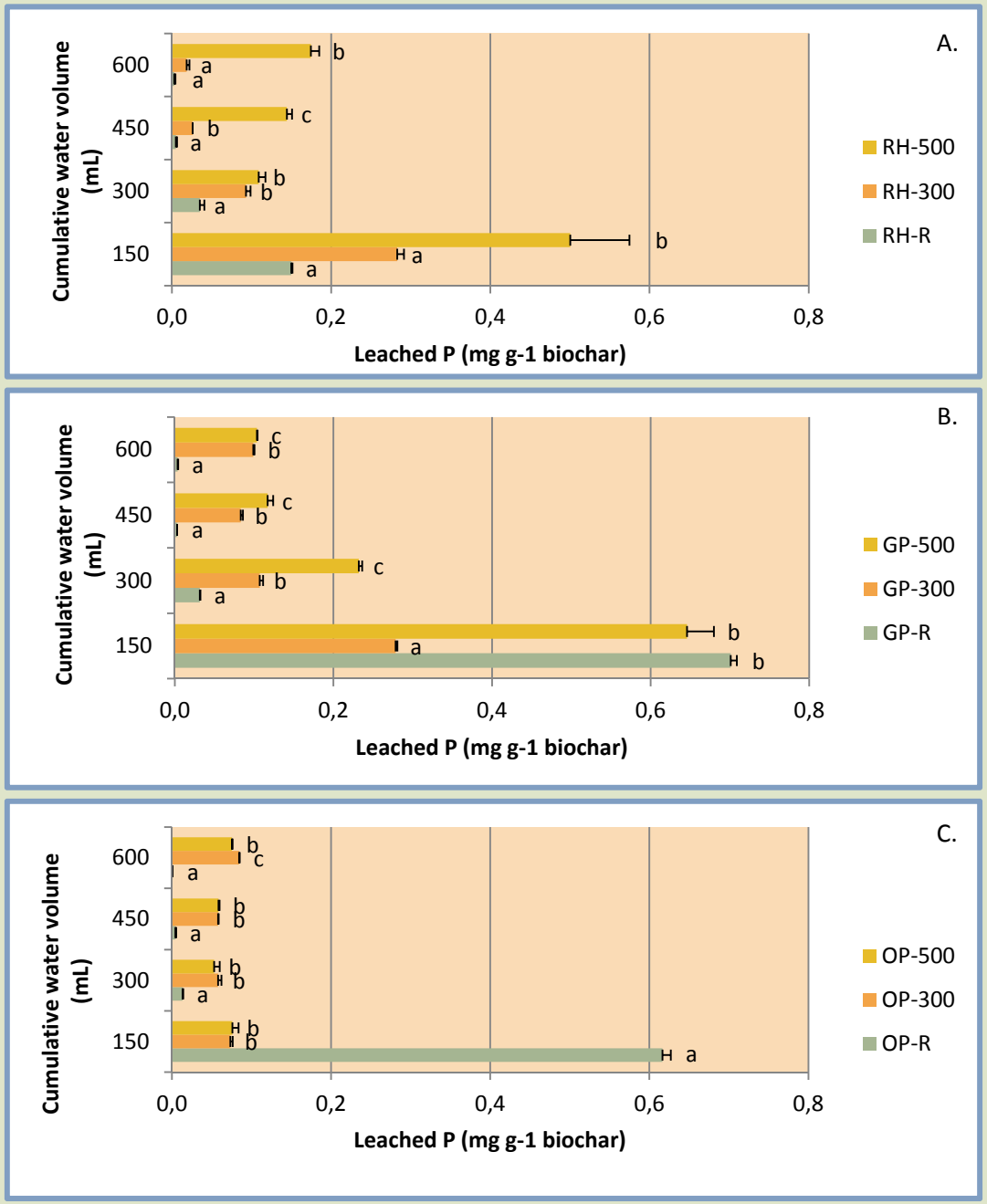



**Unpyrolyzed grape pomace** and **rice husk biochars at 300$^0$C** and **500$^0$C** showed the highest P desorption level in batch experiments

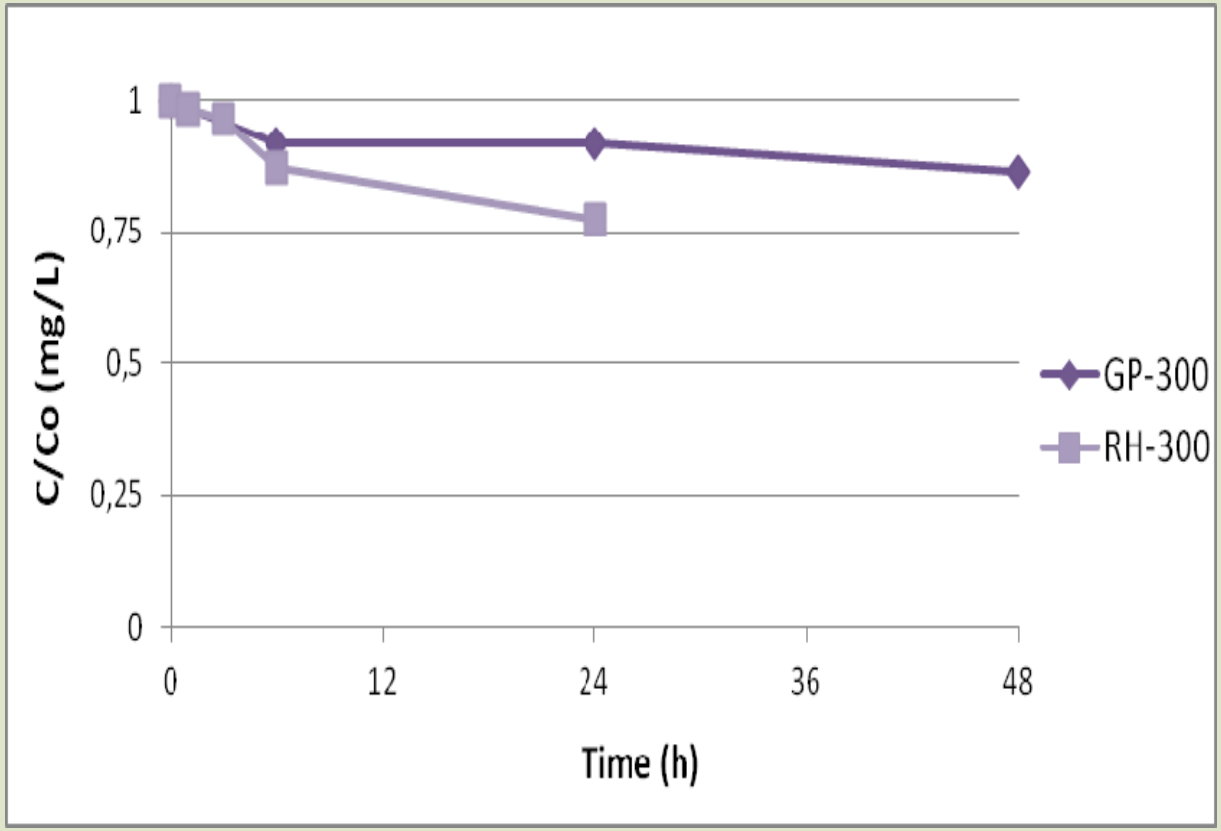
# Successive leaching of P




A continuous release of **P from all biochars** as compared to raw biomass samples, where the highest concentrations were detected during the first extraction.

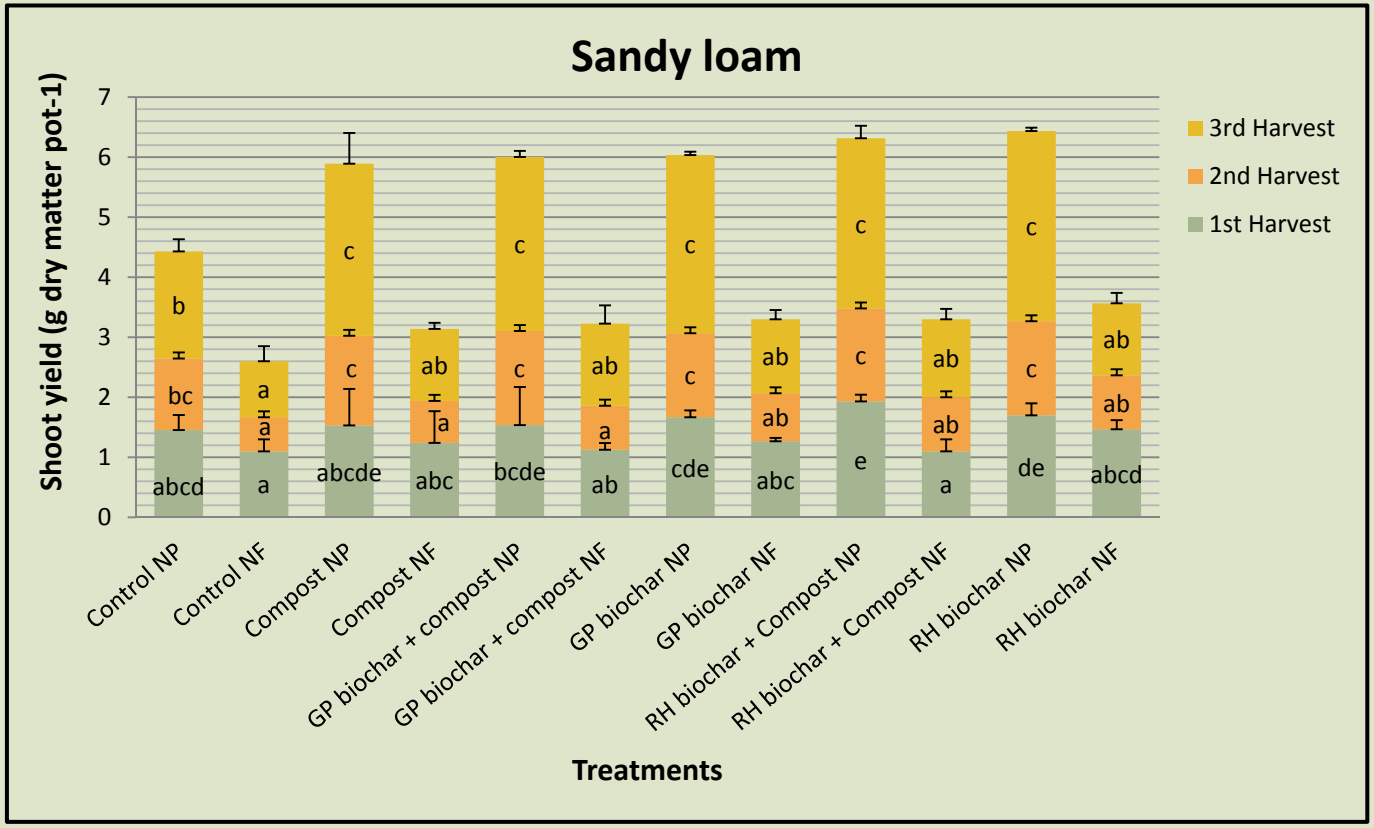
Biochars, at **500°C**, leached more P in all four extractions, compared to biochars at 300°C, apart from olive tree prunings biochars, where both pyrolysis temperatures presented a similar trend.

# Sorption of P on leached biochars




**Sorption** of P on leached biochars **was not observed.**

# Shoot yield according to treatment




- At the end of the 3rd harvest, application of compost/biochar provided fertilization in the absence of additional Phosphorus at statistically significance difference

- Yet, fertilization with N and micro-nutrients was still necessary

# CONCLUSIONS

- **Release of phosphates varies with biochar type.**

- **All six biochars showed a continuous phosphate release into the water phase.**

- **Both biochars tested (after previously being leached from their P content) showed small additional P sorption capacity, therefore they could not be characterized sorbents of fertilizer P.**

- **Agronomic application of compost/biochar provided phosphorus to a loam soil.**

**BUT**

- **The efficiency of biochar agronomic applications depends on**
  - **Type of soil**
    - **Type of biochar**
      - **Additional nutrients/soil conditioners**
        - **Environmental conditions**