Nano-hydroxyapatite from Wastes: Synthesis and P Release Evaluation Through A Soil Column Compared to Triple Super Phosphate

Società Italiana di Agronomia
52° Convegno Nazionale

La ricerca agronomica per la transizione verde

Portici, 25-27 settembre 2023

Nano-hydroxyapatite from Wastes: Synthesis and P Release Evaluation Through A Soil Column Compared to TSP

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Introduction

Recently, nanomaterials have become a tool to improve agrochemicals performance and nutrient use efficiency (Fellet et al. 2022). Nanohydroxyapatite (nHAP) belongs to the calcium phosphate compounds. nHAP can be synthesized from reagents or from biological wastes such as animal and fish bones and potentially used as a P-source for crops (Maschmeyer et al., 2020), but is poorly soluble in soil. *Pseudomonas alloputida* belonging to the group of P-solubilizing bacteria (PSB) is able to solubilize different forms of P-compounds, including hydroxyapatite (Srivastava et al., 2023). This work aims to test the behaviour of nHAPs from animal waste (chicken bones) compared to the traditional fertilizer triple super phosphate (TSP) in a soil columns-leaching experiment with and without *P. alloputida*.

Materials and Methods

<u>nHAP synthesis</u>: chicken bones were heated for 1 h in a muffle respectively at 300°C (nHAP300) and 700°C (nHAP700). The resulting products were then ground for 3 h. nHAPs were characterized by SEM, XRD analysis and FTIR spectroscopy. Elemental content was determined by an ICP-OES and a CHN analyser.

<u>Leaching test</u>: 32 PVC tubes (Ø = 4.30 cm, length = 30 cm) filled with sterilized agricultural soil (pH = 7.6, CE = 434±11.5 µS·cm^{-1}, sand =54%, silt=24%, clay=22%.) sieved at 2 mm (Fig. 1) and mixed with 10% of sand to facilitate drainage were used. The equivalent of 200 mg of P for each treatment was mixed with the soil. A *P. alloputida* suspension (expected final concentration: 10^9 cells g_{soil}^{-1}) was applied to a subset of columns (Fig. 1). Column irrigation occurred every week with 50 mL of sterile ultrapure water. The leachates were collected and characterized for their P content with an ICP-OES.

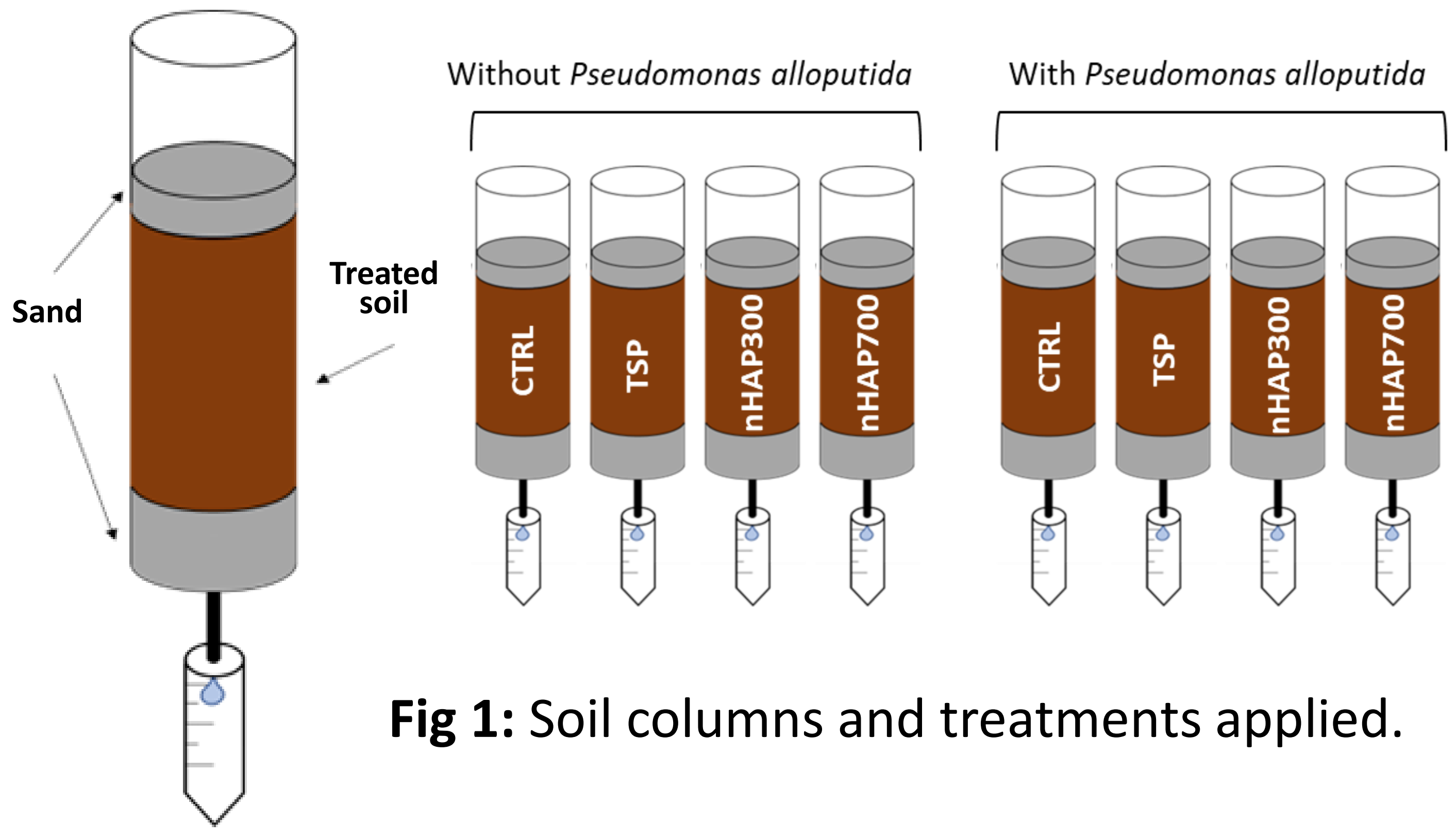

Fig 1: Soil columns and treatments applied.

Results

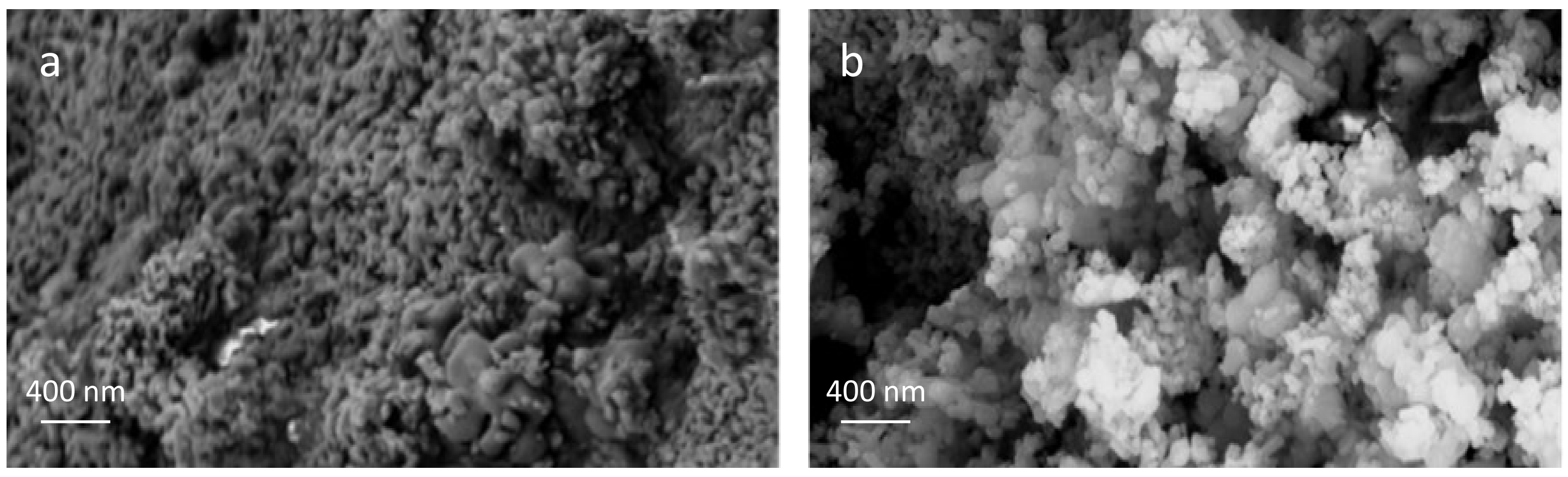

Fig 2: SEM images of a) nHAP300 and b) nHAP700.

Tab 1: Main characteristics of nHAP 300 and nHAP700.

	Structure *	Size (nm)**	P (%)	N (%)	C (%)
nHAP300	Amorphous	50-250	8.83	5.58	31.3
nHAP700	Crystalline	50-400	19.4	0.06	0.38

*determined by XRD analysis; **determined by SEM.

<u>Leaching test</u>: P from nHAP is less mobile in soil than P from TSP. Furthermore, the presence of *P. alloputida* neither affects the quantity of P lost nor P-bioavailable* (P-Olsen).

*referred to the significant difference between each treatment. Two-way ANOVA, Tuckey post-hoc test, p<0.05, n=4.

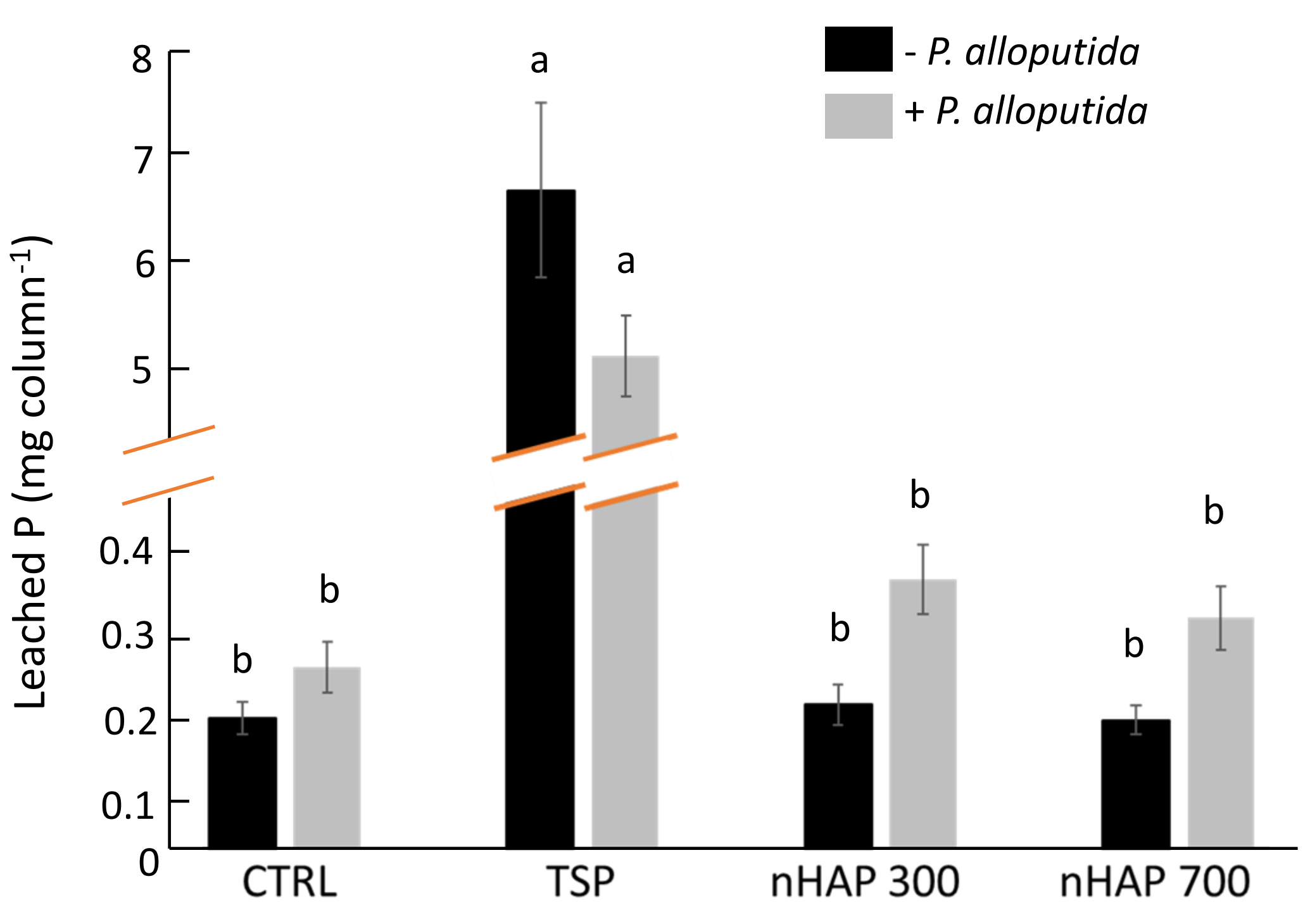

Fig 3: Total P losses at the end of the experiment.

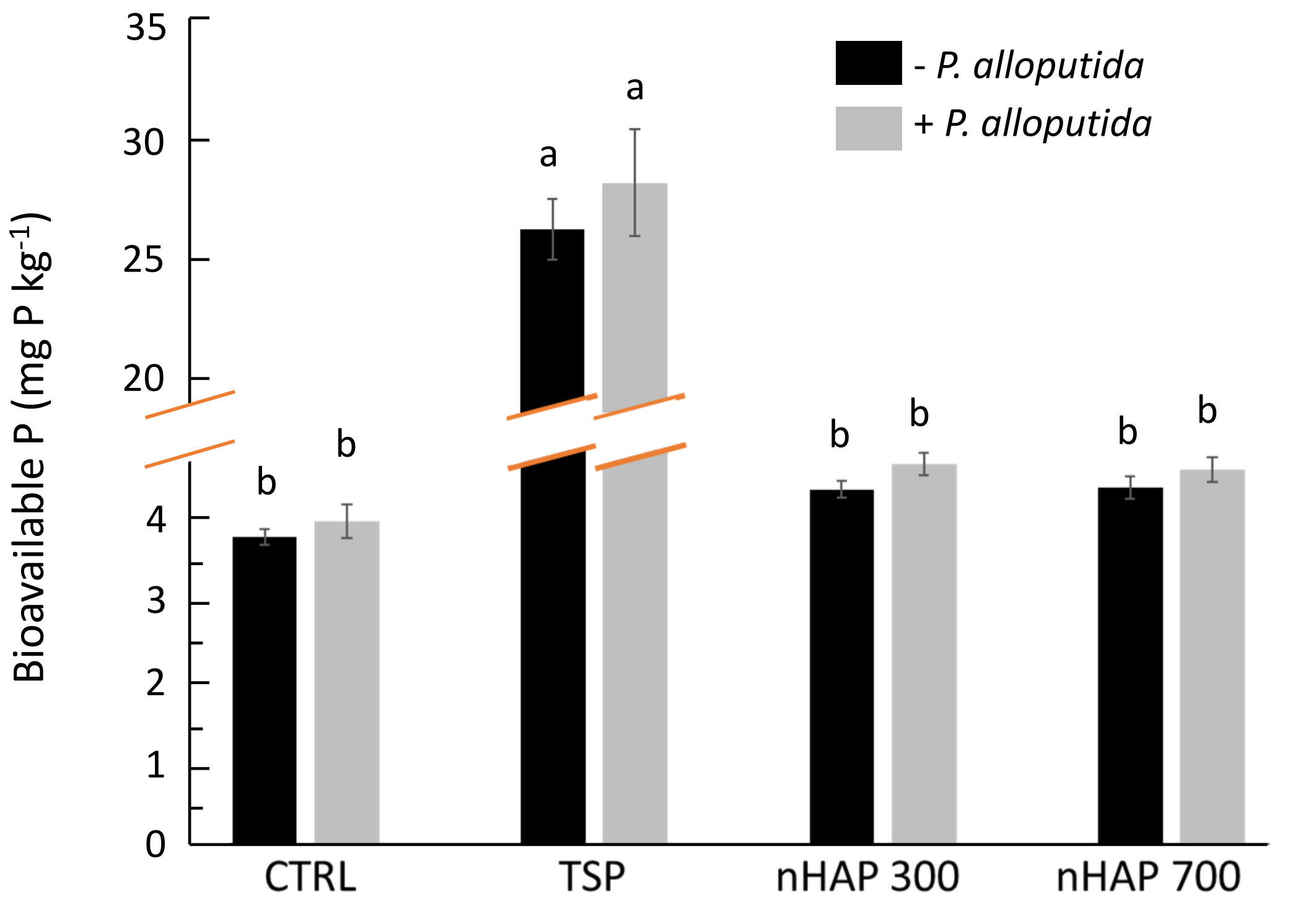

Fig 4: Bioavailable P at the of the experiment.

Conclusions

1. nHAP obtained from animal bones allows to recover P from wastes.
2. nHAP has proven to be a effective in reducing P leaching compared to TSP.
3. In our conditions the presence of the PSB *P. alloputida* did not enhance P release from nHAP.

References

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Maschmeyer et al., 2020. Chem. Soc. Rev., DOI:10.1039/C9CS00653B.
Srivastava S. et al. 2023. Sci. Rep. 13: 4918. DOI: s41598-023-31154-1.

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