

Phosphorus recycling of sewage sludge through the combination of low-temperature-conversion and thermochemical post-treatment

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Introduction and objectives

Over the last decades various processes for phosphorus (P) recycling have been developed (Mephrec, ASHDEC, RECOFOS, struvite precipitation, etc.). However, all processes exhibit failings such as bad economic feasibility, too high heavy metal contents or low plant-P-availability. The **objective** of this work was the improvement of P-recycling of sewage sludge by finding a way to enhance plant-P-availability and to lower heavy metal concentrations. We assumed that the combination of:

- low-temperature-conversion (LTC) and
 - thermochemical post-treatment (TPT) + HCl and Na₂SO₄
- provides high plant-P-availability and low content of heavy metals.

Material and methods

Two dried sewage sludges differing in P elimination (Chem-P and Bio-P) were treated in a batch reactor (Fig. 1) at 400 or 500 r C (LTC). These chars were post-treated in a rotary furnace at 950 r C (TPT) with HCl and/or Na₂SO₄ (Fig. 2).

All products were tested in pot experiments with maize (*Zea mays*) using a P-poor subsoil mixed with 50% sand (14 mg CAL-P/kg soil). As control for optimum P supply „Triple Superphosphate“ (TSP) was used. Phosphate was fertilised with 100 mg/kg.

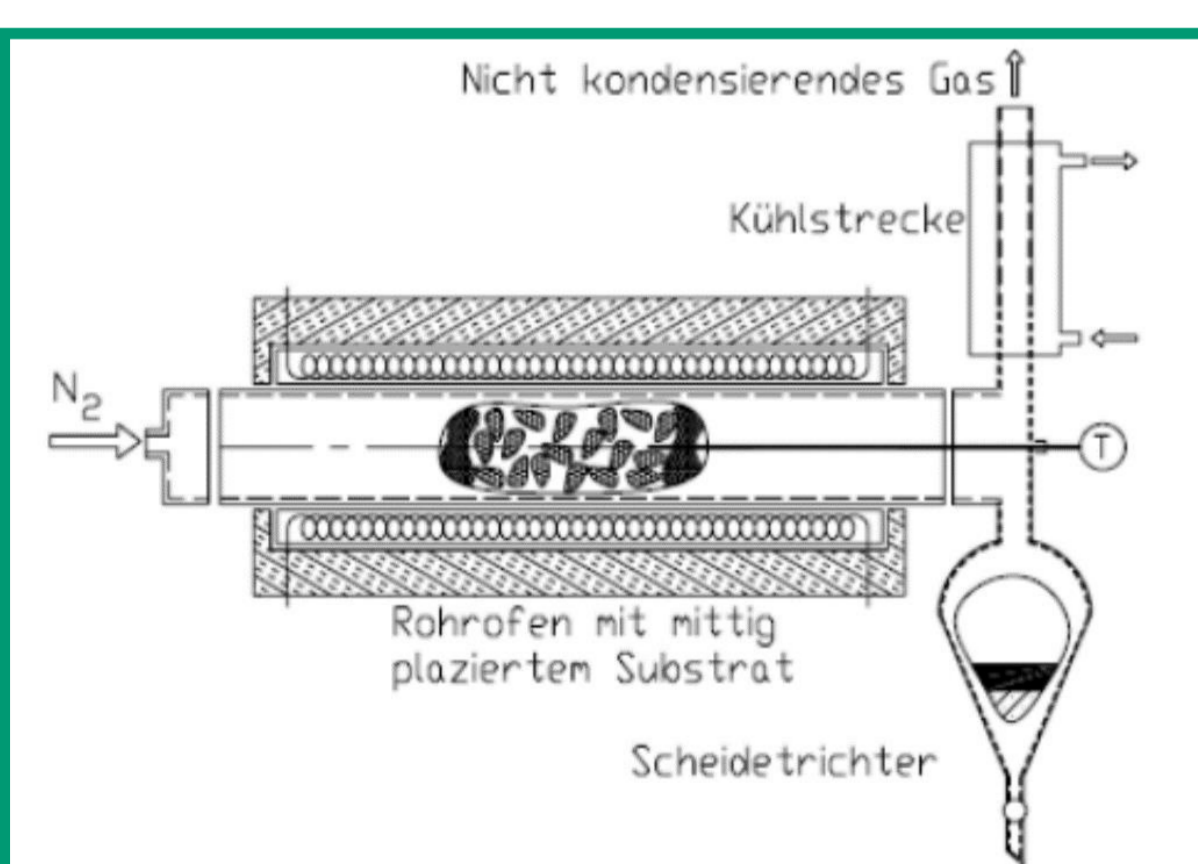


Fig. 1: Batch reactor for LTC at 400 or 500 r C, Weber (2010) [1].



Fig. 2: Rotary furnace for TPT with HCl and Na₂SO₄, BAM Berlin.

Results

Chem-P sludge

Chemical P elimination with Fe³⁺ resulting in high Fe concentration (Tab. 1).

P [%]	Al [%]	Fe [%]
4,69	0,83	6,30

Tab. 1: Total P, Al and Fe concentration

Bio-P sludge

Biological P elimination and second precipitation with Al³⁺ + Fe³⁺ (Tab. 2).

P [%]	Al [%]	Fe [%]
2,71	3,50	1,79

Tab. 2: Total P, Al and Fe concentration

Increase in **plant-P-uptake** via TPT. LTC had no positive effect.

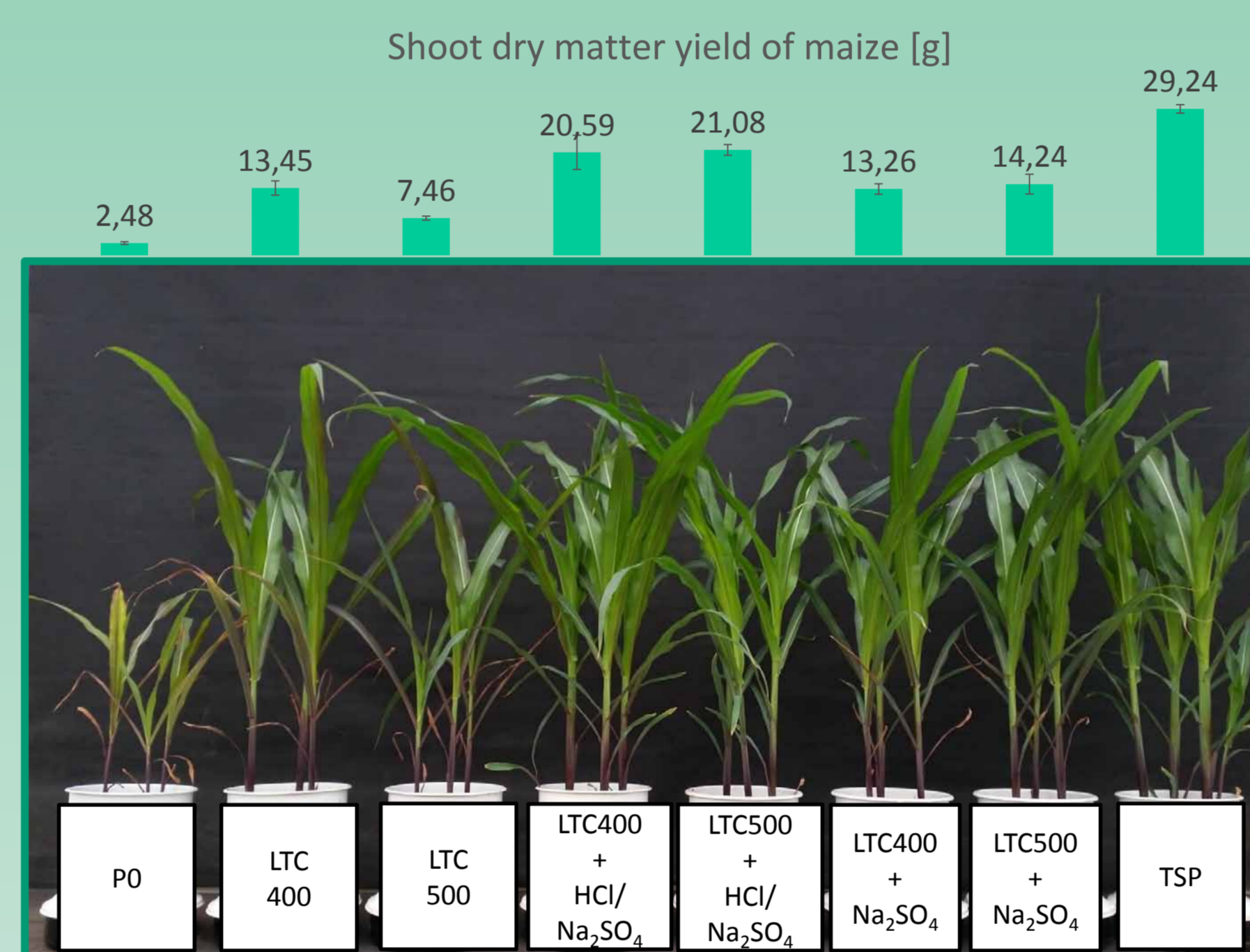


Fig. 3: Effect of a P-fertilization (100 mg/kg soil) in form of various recycling products compared to TSP on the growth and shoot dry matter yield of maize in [g]

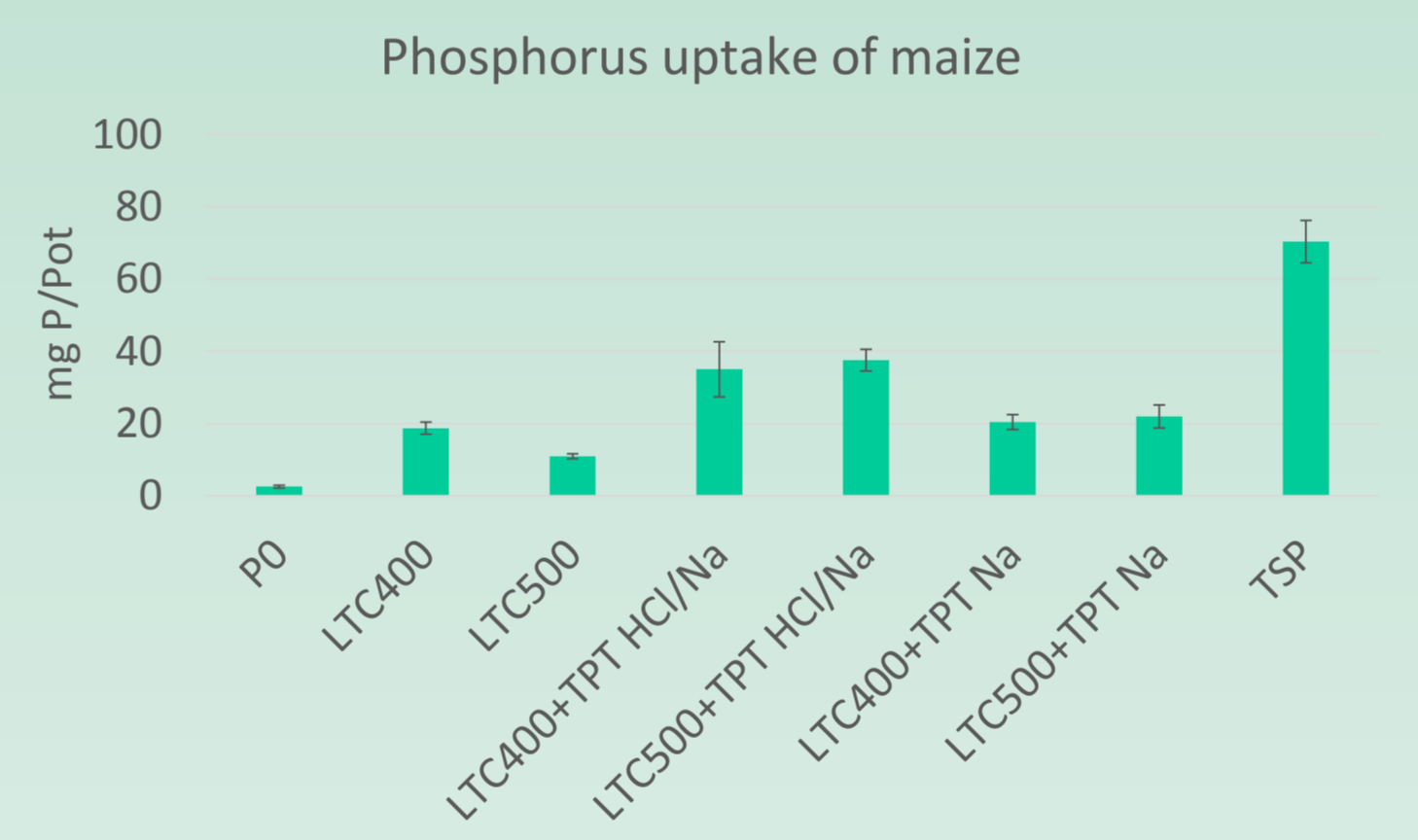


Fig. 5: Effect of LTC and TPT of Chem-P sludge on the P uptake of maize

Increase in **plant-P-uptake** via LTC. TPT had no positive effect.

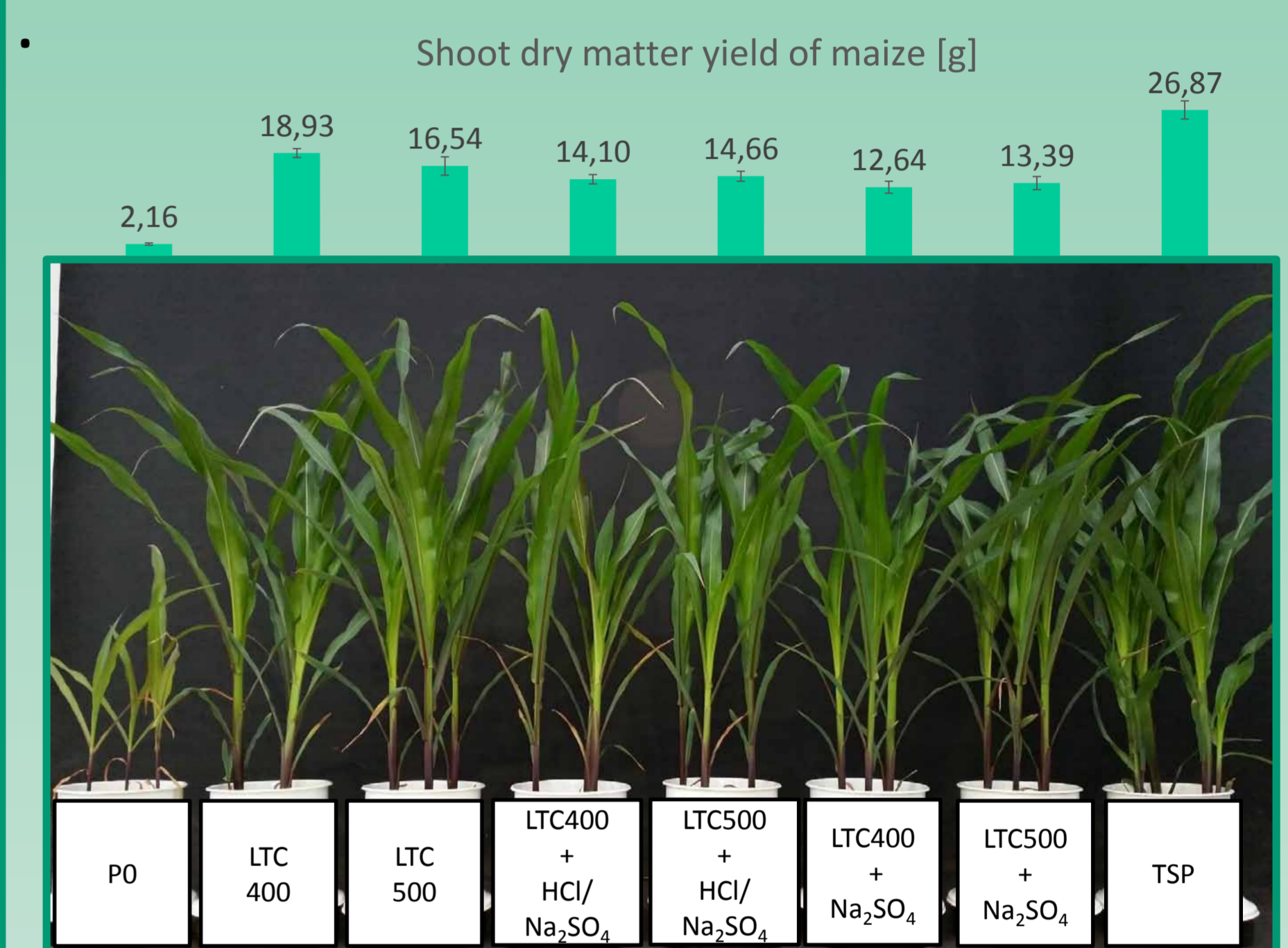


Fig. 4: Effect of a P-fertilization (100 mg/kg soil) in form of various recycling products compared to TSP on the growth and shoot dry matter yield of maize in [g]

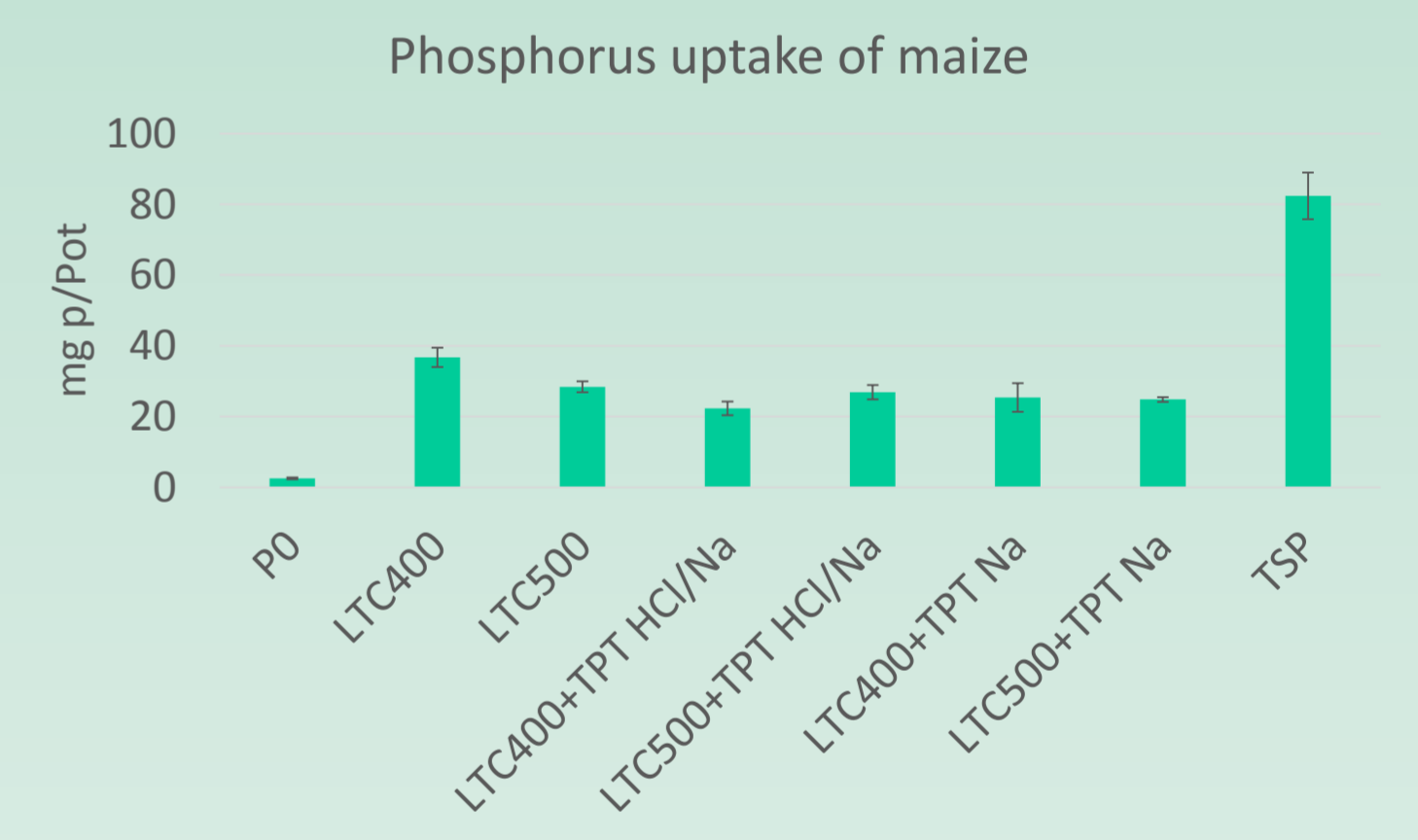


Fig. 6: Effect of LTC and TPT of Bio-P sludge on the P uptake of maize

Decrease of **heavy metals** via TPT. LTC seems to have no elimination effect (Fig. 7).

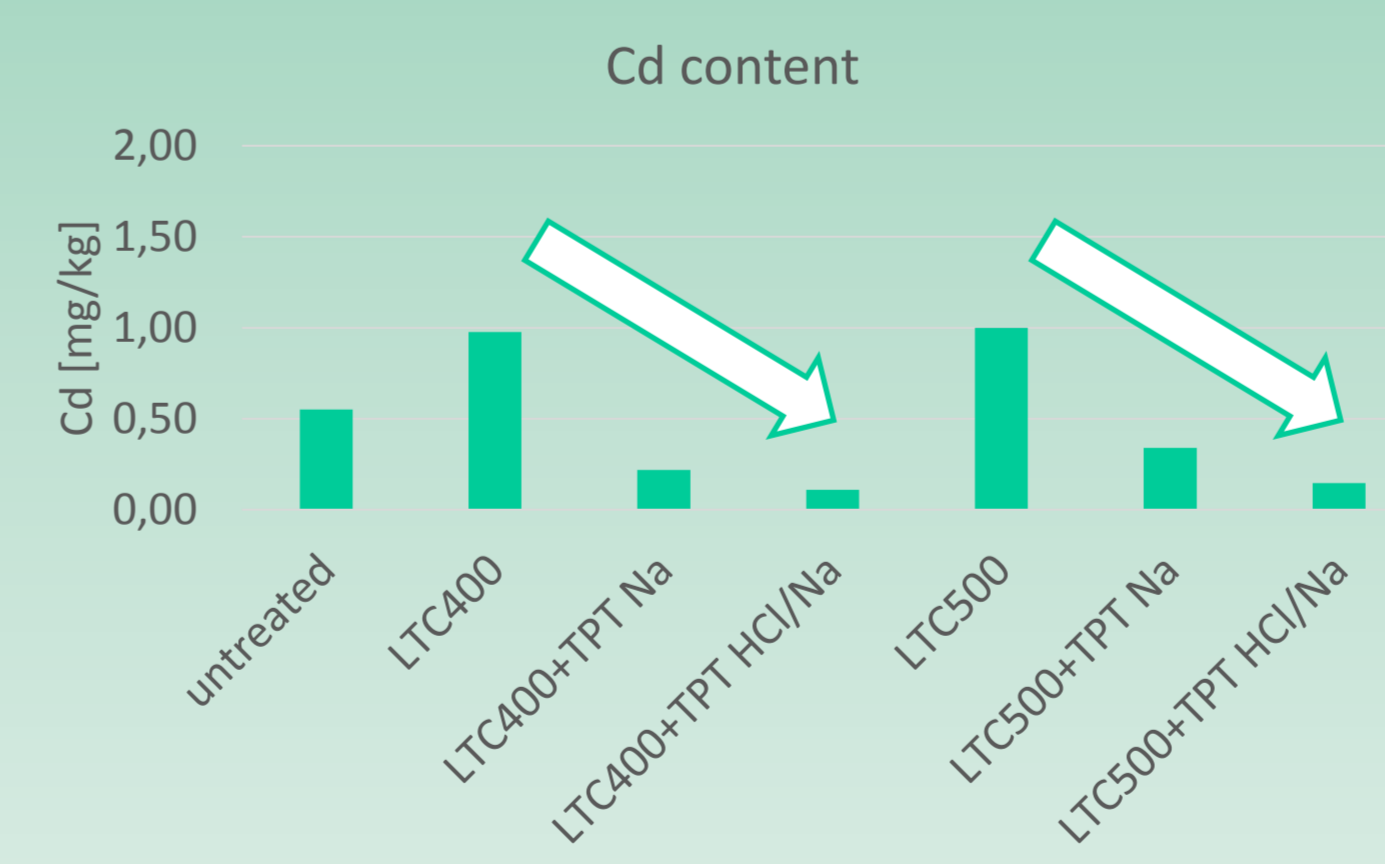


Fig. 7: Effect of LTC and TPT on the Cd elimination in the product of Chem-P sludge

Decrease of **heavy metals** via TPT. HCl + Na₂SO₄-treatment seems to be more effective than using only Na₂SO₄ (Fig. 8).

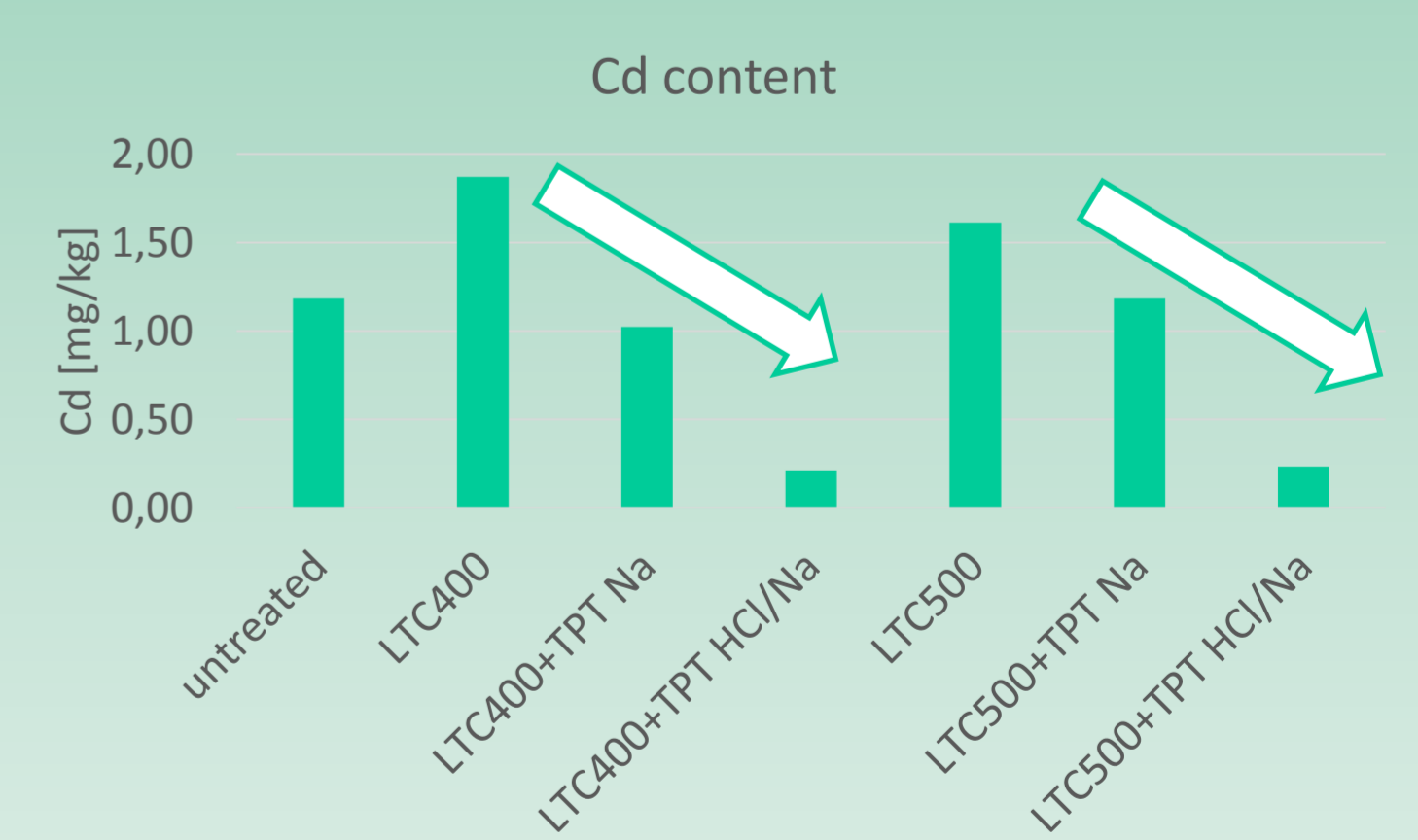


Fig. 8: Effect of LTC and TPT on the Cd elimination in the product of Bio-P sludge

Discussion and outlook

The success of P-recycling from sewage sludges is highly dependent on the P elimination due to precipitation by adding Fe and/or Al salts during waste-water-treatment. It is claimed that a chemically treated sludge (primarily Fe-Phosphates) should be recycled by TPT, whereas for biologically treated sludges lower temperatures (e.g. LTC at 400 r C) are sufficient. Concerning the elimination of heavy metals, TPT with HCl and Na₂SO₄ showed the highest decrease whereas LTC showed nearly no decrease. For a better understanding of fertilising effects of the recycling products more investigations concerning fate of P during pyrolyses and turnover in soils is needed.