

German Society of Horticultural Sciences (DGG)
Lentzeallee 55/57
Humboldt-Universität zu Berlin
D-14195 Berlin



DGG-Proceedings, Vol. 5, 2015

Short Communications – Annual Conference DGG and BHGL
24.02. - 28.02. 2015, Weihenstephan, Germany

Peer Reviewed

Editorial Board

Dirksmeyer, Walter *Braunschweig*
Flachowsky, Henryk *Dresden*
Förster, Nadja *Berlin*
Geyer, Martin *Potsdam*
Hardeweg, Bernd *Hannover*
Mibus-Schoppe, Heiko *Geisenheim*
Michaelis, Gerlinde *Bad-Zwischenahn*
Rath, Thomas (Editor in Chief) *Osnabrück*
Richter, Ellen *Braunschweig*
Thomas, Jens *Osnabrück*
Winkelmann, Traud *Hannover*
Zinkernagel, Jana *Geisenheim*

Fabian Link, Dieter Lohr*, Elke Meinken

Compost as phosphorus fertilizer for organically grown potted herbs –
Characterisation of P availability

*Corresponding Author:

Dieter Lohr
Hochschule Weihenstephan-Triesdorf, Germany
Email: dieter.lohr@hswt.de

Compost as phosphorus fertilizer for organically grown potted herbs – Characterisation of P availability

Fabian Link, Dieter Lohr, Elke Meinken

Hochschule Weihenstephan-Triesdorf

1. Introduction, Knowledge, Objectives

Compost is a common constituent of growing media for organically grown potted herbs with amounts up to 40 % by volume. However, composts for this purpose must meet special requirements regarding nutrient levels, salt content and pH value. Due to the increasing thermal utilisation of woody biomass available volumes of suitable composts are decreasing. If compost as growing media constituent is substituted by other materials (e.g. wood fibre or coir pith) one question that arises is, how to ensure the phosphorus supply of plants. One option, besides the use of soft rock phosphates which are a finite resource, is the use of small quantities of phosphorus rich composts which are not suitable as growing media constituent in high percentages.

Use of compost as alternative phosphorus fertilizer for growing media raises the question of phosphorus availability to plants. For mineral fertilizers a set of methods exists to characterise the phosphorus solubility and plant availability. These fractions have to be declared on commercial fertilizers (EU, 2003, DüMV, 2012). Most of the extractants are quite suitable to distinguish fertilizers from different sources as (processed) rock phosphate, slag or sludge but plant availability is questionable (Prochnow et al., 1998, Römer, 2006, Kratz and Schnug, 2009). Issue of the current research was to test if the methods named in DüMV (2012) can be used for predicting plant availability of P derived from composts used in small quantities as amendment for peat based growing media.

2. Material and Methods

Two green waste composts (GWC_A and GWC_B) and one bio waste compost (BWC) were used. The three composts were dried at 70 °C in a forced-air oven until a constant weight was obtained, pulverised in a disc mill, stored in sealed plastic buckets and analysed for the following P fractions by ICP-OES:

- **P_{H2O}**: water-soluble P according to VDLUFA (2011), No. 4.1.4
- **P_{NAC}**: neutral ammonium citrate-soluble P acc. VDLUFA (2011), No. 4.1.4
- **P_{AAC}**: alkaline ammonium citrate-soluble P acc. VDLUFA (2011), No. 4.1.5
- **P_{CA}** : 2 % citric acid-soluble P acc. VDLUFA (2011), No. 4.1.3
- **P_{FA}** : 2 % formic acid-soluble P acc. VDLUFA (2011), No. 4.1.2
- **P_t** : total P after microwave digestion in HNO₃/H₂O₂ acc. VDLUFA (2011), No. 3.2.1.2
- **P_{CAT}**: CaCl₂/DTPA-soluble P acc. VDLUFA (2008), No. 3.7.2.2
- **P_{CAL}**: Calcium-Acetate-Lactate-soluble P acc. VDLUFA (2008), No. 3.7.2.2
- **P_{NaF}**: Na-formate-soluble P acc. Jungk (1961)

Dried and pulverized composts were mixed into a bog peat and the mixture limed to a pH(CaCl₂) of about 6.0 and fertilized up to 150 mg N/l with a P-free water soluble fertilizer (15+0+15+2+trace elements). P levels were 11, 22, 44 and 88 mg total P/l respectively. The following P fractions were analysed in growing media right after mixing by ICP-OES:

- P_{H₂O}: water-soluble P according to VDLUFA (2008), No. 2.4.1.1
- P_{CAT}: CaCl₂/DTPA-soluble P acc. VDLUFA (2008), No. 3.7.2.2
- P_{CAL}: Calcium-Acetate-Lactate-soluble P acc. VDLUFA (2008), No. 3.7.2.2
- P_{NaF}: Na-formate-soluble P acc. Jungk (1961)

Pots (diameter 12 cm, volume 700 ml) were filled evenly with the growing media and 55 corn of Parsley 'Grüne Perle' (Hild, Germany) were sown per pot. The plant trial was carried out in four replicates with 15 pots per replicate. Plants were cultivated in a greenhouse from calendar weeks 13 to 18/2014. They were irrigated by hand on top of the pots with deionized water and fertigated with the P-free fertilizer four times (in total 105 mg N/pot). As control treatment plants were cultivated as above but P supply was done with 73 mg P/l as Ca(H₂PO₄)₂. At the end of the experiment plant fresh and dry mass per pot was measured and a pooled sample per treatment was analyzed for total P by ICP-OES after microwave digestion in HNO₃/H₂O₂. Correlations were calculated between the P uptake by plants per pot and amount of added P (based on the extraction of pure composts) and P extracted from the freshly mixed growing media respectively. For fresh and dry mass an ANOVA was done using the glm-procedure of Minitab V16 (Minitab Inc., State College PA). Followed by a Tukey-test (p ≤ 0.05) for significant differences.

3. Results

Solubility of P in the various extractants is quite variable for the three composts (Fig. 1). While with H₂O, AAC, CAT and CAL more or less the same percentage of P was extracted from the two green waste composts the differences raises up to 10 to 25 % for NAC, CA, FA and NaF. For each extractant percentage of extracted P was higher for BWC than for GWC_B. Comparing GWC_A and BWC P recovery in GWC_A was lower for H₂O, AAC, CAT, CAL and NaF, similar for NAC and higher for CA and FA respectively. Overall the extractants can be grouped in three classes. The weakest extractants are H₂O and CAT with a P recovery less than 20 % of P_t, followed by CAL and Na F with 30 to 40 % for the two green waste composts and 40 to 60 % for the bio waste compost. The third group are NAC, AAC, CA and FA which extracted about 60 % of P_t from GWC_B and about 80 % of P_t from the two others, except for AAC and GWC_A where recovery of P_t was below 60 %.

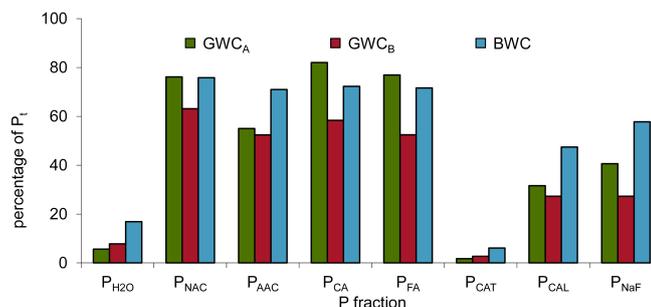


Fig. 1: Percentage of total P extractet from the three composts by different extractants

None of the P fractions extracted from the pure compost can predict plant availability for all three composts together as can be seen in Fig. 2 [a]. Only for P_{AAC} , P_{CAL} and P_{NaF} slopes of GWC_A and BWC match. For all other extractants the slopes of the three composts differ, with lowest slopes for GWC_B . Only for P_{H_2O} and P_{CAT} absolute amount of P application matched P uptake. For all other extractants P application was up to ten times higher than P uptake.

Better correlations were found between the amount of P extracted by H_2O and CAT from the freshly mixed growing media (Fig. 2 [b]). Also for the joint examination of the three composts coefficient of correlation was at least 0.98. However, a small but systematically difference between the slopes of the three composts is recognizable. The absolute amount of P which was extracted by H_2O and CAT from the growing media was similar and matched P uptake. For CAL and NaF correlation coefficients are noticeably less and similar to those obtained for P fractions extracted from the pure composts.

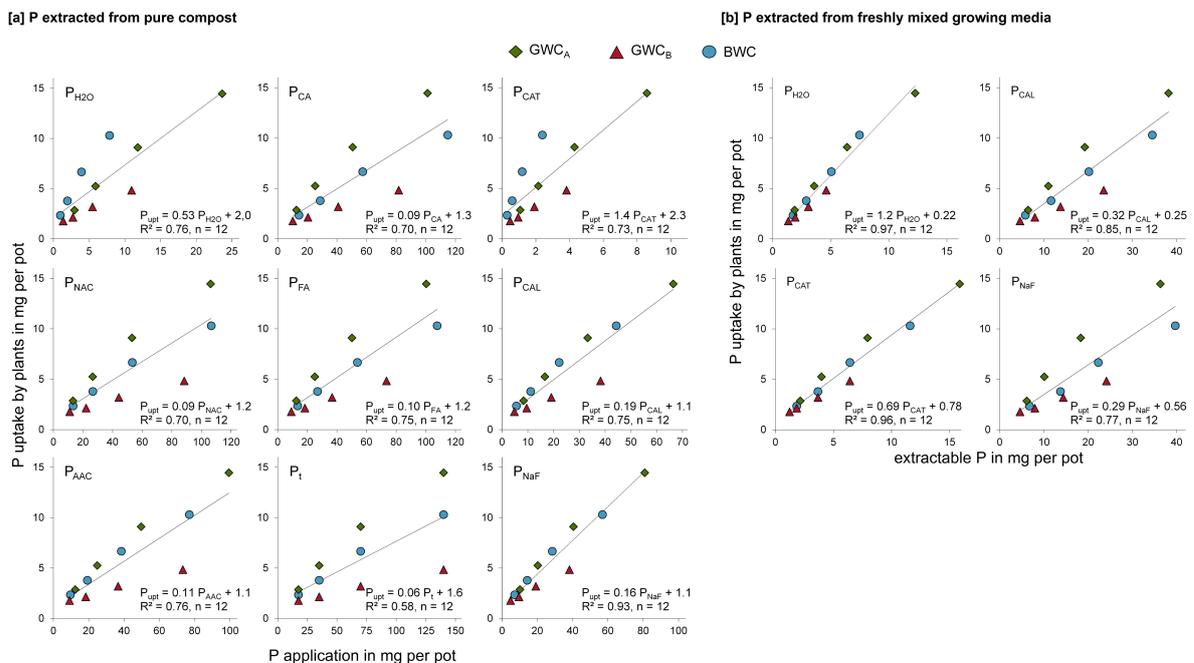


Fig. 2: Correlation matrix for P uptake by plants and amount of P extracted from pure composts [a] and freshly mixed growing media [b] with different extractants

Compared to the control, plant fresh and dry mass were similar or even higher in the 44 mg P_f/l and 88 mg P_f/l treatment using GWC_A and BWC. For GWC_B even 88 mg P_f/l were too low and plants suffer from P deficiency. However, only plant growth was reduced, but no symptoms of P deficiency (e.g. dark green or violet leaves) occurred (Fig. 3).

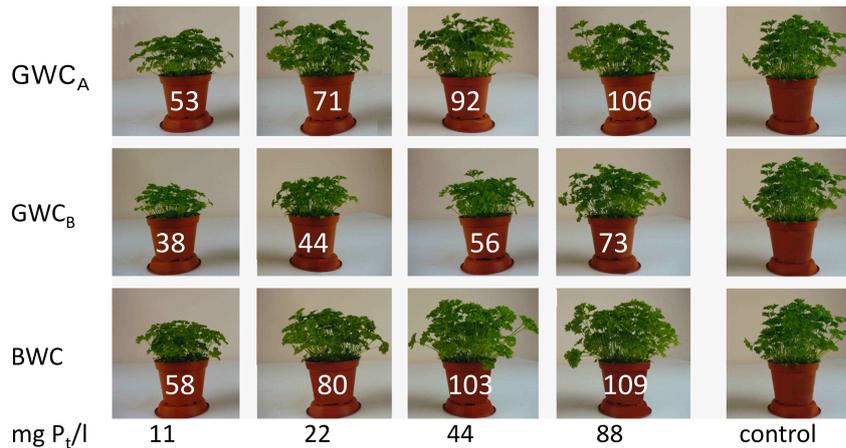


Fig. 3: Parsley plants at harvest date, numbers indicate relative fresh mass (control = 100)

4. Discussion

The poor correlations between P fractions extracted from pure composts and P uptake by plants coincide with findings for mineral P fertilizers as reviewed by Kratz and Schnug (2009). For water- and CAT-soluble P the content and reactivity of carbonates in the composts may be the reason, because both solutions are unbuffered and an increase of pH of the extraction solution leads to a decrease in solubility of calcium phosphate (Diaz et al., 1994, Zorn and Krause, 1999, Zhang et al., 2004). Though CAL is buffered at pH 4.1, buffer capacity will be exhausted if carbonate rich material is extracted, which leads to an underestimation of plant available P (Werner, 1974). Indeed, for mineral soils a correction procedure exists (Zorn and Krause, 1999), but this was not applied in the current study. Also for AAC, NAC, CA and FA an influence of carbonate on the amount of extracted P exists (Mackay et al., 1984). Additionally, a high amount of not plant available P, i.a. Al-/Fe-phosphate and apatitic calcium phosphate, is extracted (Kratz and Schnug, 2009). Thus in some cases these extractants may be useful to predict long term (Mackay et al., 1984) but not short term P availability as needed for pot grown herbs. Best results were obtained for sodium formiate extract although most of P_{NaF} is not readily plant available. Possibly because of the high buffer capacity side effects of carbonate might be minor (Jungk, 1961, Alt et al., 1994). The quite good correlation between P uptake by plants and P extracted by H₂O or CAT from freshly mixed growing media is in line with findings of Alt et al. (1994). These authors also report poor correlations if more acid and buffered solutions as CAL or sodium formiate are used. The absolute amount of P extracted by H₂O and CAT from growing media is similar to P uptake by plants. This is also true for extracting the pure compost, so these easily exchangeable fractions seem to reflect the short term plant available P in compost (Fossard et al., 2002).

5. Conclusions

Nutrient rich composts can be used in small amounts as sustainable P source for potted herbs. However, established extractants for characterization of mineral phosphorus

fertilizers are not suitable for estimation of short term plant available P in composts. And also methods common in soils and growing media give only weak correlations. This might be caused by side effects of varying carbonate contents and reactivity. In contrast, plant available P can be estimated by extracting freshly mixed growing media with H₂O or CAT, but this approach is not feasible for classifying P availability of composts. Further research should focus on weak extraction solutions, consideration of pH changes of extractants and/or on determination of carbonate contents and reactivity to compensate possible carbonate side effects as it is done for CAL-soluble P in mineral soils.

6. Literature

Alt, D., Peters, I. and Fokken, H. (1994): Estimation of phosphorus availability in composts and compost/peat mixtures by different extraction methods. *Comm. Soil Sci. Plant Anal.* 25(11-12), 2063-2080.

Diaz, O.A., Reddy, K.R. and Moore Jr., P.A. (1994): Solubility of inorganic phosphorus in stream water as influenced by pH and calcium concentration. *Wat. Res.* 28(8), 1755-1763.

DüMV (2012): Verordnung über das Inverkehrbringen von Düngemitteln, Bodenhilfsstoffen, Kultursubstraten und Pflanzenhilfsmitteln (Düngemittelverordnung-DüMV).

EU (2003): Regulation (EC) No 2003/2003 of the European Parliament and of the Council of 13 October 2003 relating to fertilisers.

Fossard, E., Skrabal, P., Sinaj, S., Bangerter, F. and Traore, O. (2002): Forms and exchangeability of inorganic phosphate in composted solid organic wastes. *Nut. Cycl. Agroecosys.* 62(2), 103-113.

Jungk, A. (1961): Über eine Schnellmethode zur Bestimmung des Nährstoffgehaltes gärtnerischer Erden. *Z. Pflanzenern. Düng. Bodenk.* 95(1), 10-23.

Kratz, S. and Schnug, E. (2009): On the solubility and plant availability of phosphorus from mineral fertilizers – a review. *J. Kulturpfl.* 61(1), 2-8.

Mackay, A.D., Syers, J.K. and Gregg, P.E.H. (1984): Ability of chemical extraction procedures to assess the agronomic effectiveness of phosphate rock materials. *N. Z. J. Agri. Res.* 27(2), 219-230.

Prochnow, L.I., Kiehl, J.C. and van Raij, B. (1998): Plant availability of phosphorus in the neutral ammonium citrate fraction of Brazilian acidulated phosphates. *Nut. Cycl. Agroecosys.* 52(1), 61-65.

Römer, W. (2006): Plant availability of P from recycling products and phosphate fertilizers in a growth-chamber trial with rye seedlings. *J. Plant Nutr. Soil Sci.* 169(6), 826-832.

VDLUFA (2008): Methodenbuch Bd. II.2: Die Untersuchung von Sekundärrohstoffdüngern, Kultursubstraten und Bodenhilfsstoffen. 1st edition plus 1st supplementary sheets, VDLUFA publishing, Darmstadt.

VDLUFA (2011): Methodenbuch Bd. II.1: Die Untersuchung von Düngemitteln. 4th edition plus 1st-5th supplementary sheets, VDLUFA publishing, Darmstadt.

Werner, W. (1974): Der Einfluss des Kalkgehaltes auf das Lösungsvermögen der konventionellen Lactatlösungen für Düngerphosphate und deren Umwandlungsprodukte. *Die Phosphorsäure* 30(2), 189-198.

Zhang, M.K., He, Z.L., Stofella, P.J., Calvert, D.V. Yang, X.E., Xia, Y.P. and Wilson, S.B. (2004): Solubility of phosphorus and heavy metals in potting media amended with yard waste-biosolids compost. *J. Environ. Qual.* 33(1), 373-379.

Zorn W. and Krause, O. (1999): Investigations on the characterization of plant available phosphate in Thuringian calcareous soils. *J. Plant Nutr. Soil Sci.* 162(5), 463-469.