**Meeting P demand in European organic farms: is it time to change the standard?**

Julia COOPER 1 – Anne-Kristin LØES 2 – Stefan HÖRTENHUBER 3 – Paul MÄDER 4 – Jakob MAGID 5 – Astrid OBERSON 6  – Kurt MÖLLER 7

1 School of Agriculture, Food and Rural Development, Faculty of Science, Agriculture and Engineering, Newcastle University, Newcastle, UK NE1 7RU, Email: Julia.Cooper@ncl.ac.uk

2 Norwegian Centre for Organic Agriculture, Tingvoll, Norway

3 Research Institute of Organic Agriculture (FiBL), Austria

4 Research Institute of Organic Agriculture (FiBL), Frick, Switzerland

5 Dep. of Plant and Environmental Sciences, University of Copenhagen, Denmark

6 Institute of Agricultural Sciences, Group of Plant Nutrition, ETH Zürich, Switzerland

7 Institute of Crop Science, Fertilization and Soil Matter Dynamics, University of Hohenheim, Germany

**Introduction**

Organic farming standards regulate allowable nutrient inputs according to the core principles of: reliance on renewable resources, recycling of wastes and by-products of plant and animal origin, and feeding of plants through the soil ecosystem and not through soluble fertilizers, balanced against a goal to produce high quality products with a minimum level of contaminants. These criteria are applied to the list of currently permitted inputs in organic agriculture, known as "Annex 1" of the European Commission Regulation EC No. 889/2008. This list currently excludes some potentially useful sources of societal waste (e.g. some sources of household waste and digestate, sewage sludge), but allows other sources which may pose higher risks according to some criteria (e.g. conventional manure sources, mined rock P).

The IMPROVE-P project (CORE Organic II) sought to address the issue of P in organic farming through gathering evidence about systems that may be deficient in P, investigating recycled P fertilizers (RPFs) for use in organic farming systems, and collecting information on farmer and stakeholder attitudes to RPFs in organic farming.

**Materials and Methods**

The existing knowledge on the P status of organic farms in Europe was compiled. A "snapshot" of soil test P at a given time was used as an indicator of soil P status. Data was sourced from published studies in refereed academic journals as well as non-refereed "grey literature" (theses and reports). Unpublished data was also used in the analysis provided by individuals associated with the IMPROVE-P project. Farm type was defined according to the classes used by Watson *et al*. (2002) and included: arable, beef, dairy, horticulture and mixed. Additional classes for poultry farms and grassland were added to reflect the composition of the dataset. To allow comparison of results among studies which did not use the same P extractant, the results for each study were converted to P classes that ranged from 1 to 5 (lowest P to highest P) and were based on the division of the full normal range of P values expected for that extractant into 5 equally sized classes. The distribution of soil test values into the different P classes within a given farm type was investigated by generating frequency distributions in the R statistical software package ([www.r-project.org](http://www.r-project.org); R Development Core Team, 2011).

The benefits and risks associated with using RPFs such as sewage sludge precipitation products and meat and bone meal were investigated. This was based on detailed reviews of published literature, chemical characterization of RPFs, field and pot experiments on P-availability and use efficiency of RPFs, life cycle assessments and risk analysis.

Finally, the acceptability of RPFs among key stakeholders was assessed using questionnaires at a total of nine workshops that included various national conferences as well as workshops during the Organic World Congress in Istanbul, Turkey in 2014 and the international fair Biofach in Germany in 2015.

**Results and Discussion**

Compilation and analysis of soil test data from organic farms in several European countries indicated that organically managed soils are generally at the low end of the spectrum for P availability. This is particularly evident in German arable farms, Austrian dairy farms, and Swiss mixed farms. This suggests that more recycling of P back to organic land needs to take place.

RPFs were evaluated compared to existing allowable P sources in organic farming such as rock P. A heavy metal nutrient index was developed that relates the heavy metal load of an RPF to its P content: higher values indicate higher amounts of toxic element supply relative to P supplied by the fertilizer (Herter & Külling, 2001; Möller & Schultheiß, 2014). Sample results are shown in Table 1 which demonstrates that concentrations of some metals (e.g. Zn) are higher in precipitates than in rock P, while others (e.g. Cu, Cd, Cr) are much lower in precipitates than in rock P. When P supplying capacity of the RPF is taken into account, the risk from using precipitates overall is considerably lower than rock P.

*Table 1.* Available data on potentially toxic element contents (mg kg-1 DM) contained in Struvite (a wastewater precipitation product derived from sewage sludge) in comparison to Rock Phosphate showing mean and ranges. Figures adapted from Wollman & Möller (2015). HMNI=heavy metal nutrient index; LOD = Limit of detection

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Zn** | **Cu** | **Pb** | **Cd** | **Ni** | **Hg** | **Cr** | **HMNI** |
| **Struvite** |  |  |  |  |  |  |  |  |
| Stuttgart Process | 260-350 | 19.3-68.0 | 12.0-24.0 | 0.80 | 2.20-28.6 | 0.04-0.05 | 5.00-15.0 | 0.05 |
| Pearl Process | < 2.00 |  | < 8.00 | < 0.40-5.50 | < 2.00 |  | < 5.00 | 0.01 |
| Gifhorn process | 63.2 | 15.5 | 8.50 | 0.13 | 10.6 | < LOD | 5.08 | 0.03 |
| **Rock phosphates**  | 20.3(4-130) | 155(6-500) | 10(3-35) | 25(0.2-60) | 29(2-37) | 0.05(0.01-0.06) | 188(1-225) | 0.99(0.01-2.92) |

Workshops with farmers and stakeholders in several European countries indicated regional differences in attitudes towards RPFs. In the UK 70% of respondents considered sewage sludge products (e.g. biosolids) an acceptable RPF for organic farmers, in contrast to only 15% of respondents in Norway. P precipitates were considered an acceptable RPF by 70% of all respondents.

**Conclusions**

This project successfully broadened the debate within the organic sector on the need for RPFs in organic farming systems and the potential of some currently banned materials to supply P, with minimal risk to human health or the environment. In many cases stakeholders were open-minded and receptive when discussing RPFs. In light of the current EU initiative to develop and promote a circular economy within society, the time is ripe to revisit the current EU standard on allowable inputs to organic systems.

**Acknowledgements**

The authors are grateful for the financial support for the project “IMproved Phosphorus Resource efficiency in Organic agriculture Via recycling and Enhanced biological mobilization” (IMPROVE-P) from the CORE Organic II funding bodies of Austria, Denmark, Germany, Great Britain, Norway and Switzerland.

**References**

Herter U. – Külling D.: 2001. Risikoanalyse zur Abfalldüngerverwertung in der Landwirtschaft. Bericht Juli 2001, Eidgenössische Forschungsanstalt für Agrarökologie und Landbau FAL, Reckenholz, (Ed.), Zürich.

Möller K. – Schultheiß U.: 2014. Organische Handelsdüngemittel im ökologischen Landbau – Charakterisierung und Empfehlungen für die Praxis. KTBL-Schrift 499. 392 pp.

Watson C.A. – Bengtsson H. – Ebbesvik M. – Loes A-K. – Myrbeck A. – Salomon E. – Schroder J. – Stockdale EA.: 2002. A review of farm-scale nutrient budgets for organic farms as a tool for management of soil fertility. *Soil Use and Management*, **18**:264–273.

Wollman I. – Möller K.: 2015. *Assessment of alternative phosphorus fertilizers for organic farming: Sewage precipitation products.* Research Institute for Organic Agriculture (FiBL), Switzerland.