Farm level management of phosphorus: organic farmers need recycled fertilisers

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Organic farmers aim for self-sufficiency in nutrients, by optimal utilisation of locally available resources. Even in a milk production system with dairy cows, where relatively small amounts of nutrients per hectare and year leave the farm gate, soil concentrations of phosphorus (P) have been shown to decline over time. At Tingvoll farm (NW Norway), the average topsoil P concentration was reduced by about 50% over 25 years, from 203 mg P-AL kg^{-1} air-dried soil in 1989 to 100 in 2015 (Løes and Ebbesvik 2017). A field experiment on this farm, applying medium or high levels of animal manure corresponding to about 30 or 60 tons of slurry per hectare and year to a low-P soil since 2011, has shown that the soil P concentrations increased with manure application, but only slightly. From a starting value of 26, in 2018 the value had decreased to 23 with no manure application in the control treatment. With low application, it was still 26, and with high application it had increased to 35 (Rittl et al., 2019). In 2018, struvite was applied to half the experimental plots, and P concentrations were analysed in aboveground canopy of perennial ley. Mean values were 0.15% P in dry matter (DM) with no manure application, 0.19% with low and 0.21% with high manure application. With struvite, these numbers increased to 0.24, 0.22 and 0.23%. Struvite also increased soil concentrations of P significantly. The slow increase in soil P with high manure application shows that enhancing soil fertility may not be easy, since applied P may be taken up in the crop canopy instead of enriching the soil.

Organic farmers should monitor their soil regularly. Too high P concentrations should be avoided, to reduce negative effects from leaching and runoff on waterbodies (eutrophication). However, when soil P decreases below a medium level, actions should be taken to avoid a further decrease. In Norway, 70 mg P-AL kg^{-1} soil is considered as optimal. Traditionally, rock phosphate has been the solution to P depletion in organic farming. However, the dissolution of phosphate from this material occurs very slowly. Animal-derived fertilisers, such as meat and bone meal, and various type of manure, have a higher P availability, but are often from non-organic production and hence impacts the integrity of the organic farming system. Recycled fertilisers may be a better option, to close the currently widely open nutrient gaps from agricultural land towards more closed cycles between farms and the surrounding societies. Compost and digestates are well established soil amendment products made from organic waste. Compost from park and gardening residues is a fertiliser which most consumers easily accept, whereas digestate can only be applied with restrictions and hence is not so commonly used in organic growing. However, composting implies large losses of greenhouse gases. From this perspective, anaerobic digestion is a better solution. A drawback is that this technology is much more advanced and costly to establish and manage than a compost plant, hence forcing centralisation. Further, microplastic pollutions may be at least as difficult to control in digestates as in composts.

A large proportion of P available for recycling is found in human urine and faeces (HUF). Current regulations, e.g. in the EU, do not allow the use of HUF-derived products, but EGTOP proposed in 2016 that struvite and calcined P will be included in Annex 1. Struvite has many benefits and could be an excellent tool to close current P and N gaps. With a content of 5% ammonium (NH_4^+) following the 13 % of P, it challenges the ban on mineral nitrogen fertilisers. Stakeholders on organic regulations should find a way around this challenge, for the best of the environment and the long-term fertility of organically managed soil.

Løes & Ebbesvik 2017. Phosphorus deficits by long-term organic farming? In: Rahmann & Andres (Eds.) Innovative research for Organic Agriculture 3.0, pp 531-534.http://orgprints.org/32708/
Rittl et al 2019. Effects of struvite application on soil and plants: a short-term field study. NORSØK report 10(4) 2019. Tingvoll, Norway. http://orgprints.org/xxxxx/