# Improving the phosphorus efficiency of organic farming systems

IMPROVE-P


*Differences in early root growth vigor in spring wheat*

**Organic farming systems rely on the efficient use and recycling of resources. Currently, nutrients like phosphorus (P) are used only once to produce food and subsequently, lost due to poor recycling. Current regulations concerning the use of alternative P fertilizers are strict, restricting e.g. the use of municipal organic wastes and hampering e.g. the use of sewage sludge due to concerns about heavy metals and other pollutants. However, there is an urgent need to improve the recycling of P from urban areas back to cropland, as the worldwide P reserves are very limited. Furthermore, improvement of agronomic P efficiency due to the choice of P efficient cultivars and agronomic methods (e.g. P mobilization by cover cropping, application of microorganisms suited to enhance plant P uptake) is the second pillar of improved P efficiency.**

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Over the past decades, mainstream P management in organic farming has focused on the use of already available soil P, on an efficient recycling of farmyard organic wastes and the use of rock phosphates and other mined P fertilizers to balance P losses via sold products. Often, P balances calculated for organic farming indicate that more P is removed with the products than applied as fertilizer. Consequently, this leads to decreasing amounts of plant available soil P. Moreover, P deficiencies may also feed-back through the system limiting other processes which indirectly impact on yield like symbiotic nitrogen ($N_2$) fixation.

Read more about IMPROVE-P: http://www.co-reorganic2.org/IMPROVE-P, for more information contact: kurt.moeller@uni-hohenheim.de

## Recycling of P necessary

Mineable high-quality P deposits are limited making it necessary to recycle P from waste streams as well as to increase the P-fertilizer efficiency in agriculture. Strategies to address the problem of negative P balances in organic farming systems include:

a) Enhanced use of permitted mineral P fertilizers (e.g. mined rock phosphates) or by-products of the steel industry.
b) Increased use of recycled P fertilizers as alternative P fertilizers by (i) improved recycling of organic wastes from consumer/urban areas back to the farm, and (ii) increased use of fertilizers derived from residues of the food processing industry.

Sewage sludge-P recovery currently represents the largest potential for P recycling, followed by P in food industry residues. In the past few years many different techniques to clean sewage were tested and implemented (e.g. incineration, slag production, crystallization). There is little data available on the characteristics of alternative P fertilizers in terms of chemical bonding of P and plant P bioavailability. There is a need to study the characteristics of alternative P fertilizers to determine their potential for use in organic farming systems, also in comparison to already allowed recycling P fertilizers, without compromising food quality, the environment and long-term soil fertility. The challenge in organic farming is to reduce the risk of pollution while utilizing as many P fertilizers as possible.

## How to improve P-uptake

The agronomic P efficiency can be improved through manipulation of biotic factors which improve P uptake. For example, there is strong evidence that different crop species have a different capability to mobilize and take up P, as plant species differ considerably in the exudation of organic acids such as citrate, malate and oxalate, which solubilize P in soil and fertilizers. Furthermore, differences in root architecture, such as root length, branching type, root hair length etc. can also influence crop P uptake efficiency.
Further possible measures to enhance P availability are green manuring with cover crops and the application of specialized Plant Growth Promoting Rhizobacteria (PGPRs) which are able to mobilize immobile soil and fertilizer P. Inoculation of crop plants with certain strains of PGPRs may improve biomass production through direct effects on root growth (and indirect effects as mycorrhizal helper bacteria) and may result in multiple effects on plant growth such as an improved P uptake.

## Strategies for increased recycling of P

The overall aim of the IMPROVE-P project is to develop and evaluate sustainable strategies for increased recycling of P and other nutrients, combined with the development of measures to enhance plant P availability due to agronomic

innovations (cover cropping, P efficient cultivars). Moreover, the challenge of soil P mobilization will be addressed by application of PGPRs. Furthermore, environmental burdens related to APF production and appropriate management of the risk of soil and plant pollution is a major challenge when introducing alternative P fertilizers, and the development of appropriate assessment tools to define high quality P fertilizers will therefore be a major target. ■