Phosphate Signalling and Transport

Tony Palmer, Wanjun (Catherine) Qi, S.A. Ceasar, Stephen Muench and Stephen Baldwin

Introduction

Phosphorus (P) is an essential element for all cells as it is a non replaceable component of nucleic acids and phospholipids, a component of many key metabolic intermediates and plays a critical role in signal transduction and enzyme activity through protein phosphorylation. Animals acquire their P through their diet, plants from uptake from the soil. While P is a relatively abundant element its bioavailable form inorganic phosphate is not. In the environment it is complexed by metal ions in a pH dependent manner and bound by the soil particles rendering it immobile and inaccessible. Soil microorganisms compete with plants for inorganic phosphate. Indeed much soil P is locked in organic compounds. Sub optimal inorganic phosphate in soils limits crop production over much of the globe and consequently farmers apply inorganic fertiliser produced mainly from rock phosphate to boost yields. This is not a sustainable practice as rock phosphate reserves are finite, current predictions suggest depletion with 200 years, and much of what is applied is not taken up by crops but leaches into water bodies causing eutrophication. Plants have developed sophisticated sensing and signalling systems to detect and respond to phosphate deprivation. By understanding these we may be able to apply this knowledge to production of more P efficient crops by either transgenic or molecular marker assisted breeding approaches.

Results

We focussed on foxtail millet (Setaria italica) as an experimental system for several reasons. Millets are a staple crop of millions of food insecure people in Asia and Sub-Saharan Africa. They are one of the most drought resistant crops known and as an orphan crop it has received little breeding improvement. Thus we reasoned that large gains would be possible for this crop. Foxtail millet is a model for the biofuel grasses switchgrass and Napier grass and has a completely sequenced genome. We identified all the members of the PHT1 family of phosphate transporters, 12 in total and characterised their expression in response to phosphate deprivation and response to root colonisation by arbuscular mycorrhizal forming fungi. We identified phosphate transporters that are candidates for Pi acquisition from the soil and those which may play a role in fungal colonisation. We are currently seeking to carry out functional characterisation of these transporters. In addition we have been investigating the role of SPX domain containing proteins in phosphate signalling and the structure and function of Aluminium activated malate transporters which secrete malate to sequester Aluminium and increase inorganic phosphate availability at low pH.

Publications

Ceasar, S., Hodge, A., Baker, A. & Baldwin, S. (2014) Phosphate concentration and arbuscular mycorrhizal colonisation influence the growth, yield and expression of twelve PHT1 family phosphate transporters in foxtail millet (*Setaria italica*). *PLoS One* **9**: e108459.

Funding

This work was funded by the BBSRC, the European Union, Yorkshire Agricultural Society, and a University of Leeds International Research Scholarship.